4

TAMILNADU BUILDING PRACTICE

FOR USE IN THE PUBLIC WORKS DEPARTMENT OF THE TAMIL NADU STATE

VOLUME I

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TAMIL NADU BUILDING PRACTICE

FOREWORD.

The Madras Detailed Standard Specifications was evolved over fifty years ago for use in the State Public Works Department for execution of Government works. It embodies the preliminary specifications, covering the general conditions of piece work and lumpsum contracts, standard specifications, materials and items of works commonly in use and appendices detailing the tender forms, articles of agreement, etc., and technical data and tables for adoption in design and execution.

With the advancement in Science and Technology and in the design concepts of structures, varied development in construction techniques and the introduction of new construction materials, etc., it has become necessary to up-date the Madras Detailed Standard Specifications embodying the Specifications, standards and design principles contemplated as per the Indian Standard Codes.

The revised, enlarged and up-dated edition of Madras Detailed Standard Specifications is named as the Tamil Nadu Building Practice and is brought out in 2 volumes. In addition a separate volume to cover electrical work has been made.

The Indian Standards Institution has evolved a number of codes based on studies of the British Code of Practices and Research results from various Research Institutes in the country. The up-dating of the M. D. S. S. has necessarily to take into consideration the change over to Metric System in the country and also the above codes of practices evolved by the Indian Standards Institution including the latest concepts in the design of R.C.C. and masonry structures.

Meticulous care had to be bestowed in the revision and compilation of the Tamil Nadu Building Practice as the same has to be precise and specification oriented as there should be no ambiguity. Unlike the National Building Code which is advisory, it is mandatory to follow the specifications detailed in the Tamil Nadu Building Practice.

The special review cell created for revising the Madras Detailed Standard Specification has done commendable work in preparing the draft specifications and drawings. The Guiding Committee consisting of Superintending Engineers and Senior Executive Engineers with Superintending Engineer Planning and Designs Circle as convenor has also contributed in no small measure in bringing out the finalised "Tamil Nadu Building Practice". I offer my congratulations and felicitations to these talented Engineers.

MADRAS-600 005,
Dated 29th October 1983.

S. SHANMUGASUNDARAM,
Chief Engineer (Buildings),
Public Works Department.

CONTENTS.

466-3--B

SECTION I

MATERIALS

466—3—1

SECTION I

MATERIALS.

CONTENTS.

SECTION 1.

MATERIALS.

INDIAN STANDARDS EXTRACTS.

SECTION-I.

MATERIALS.

1. The relevant sections of the National Building Code and I.S may be referred to for materials, other than those in this section.

2. *Stack Measurements.*—(*a*) In the case of materials which are normally measured in the stack, the quantities of such materials as entered in the Public Works Department Standard Data Book and as entered in other departmental sanctioned data governing the work for which the supply of materials is made, shall be quantities arrived at by actual measurement of the stacks when properly formed. Materials normally measured in the stack are rough-stone of all kinds, broken stone and broken brick of all grades, gravel, sand, quarry rubbish, surki and lime. (*vide* also the instructions in clause 20·1 of the General conditions of contract, where the method of measurement for the purpose of mixing for certain materials is defined).

(*b*) Stacks shall not be considered properly formed when they will not yield the quantity of finished work, on the basis of the data referred to above in paragraph 2, for stack measurement of component materials.

(*c*) In cases where improper stacking is done by the contractor, the Executive Engineer shall have the right to either reject the stacks in part or full and take action as provided for in the relevant clause of the General conditions of contract of the Tamil Nadu Building Practice, in the case of rejected materials, or he may order complete restacking of the materials to specification at contractor's expense, or he may make an appropriate deduction to allow for the improper stacking with its attendant excess quantity of voids—as he may decide in each case.

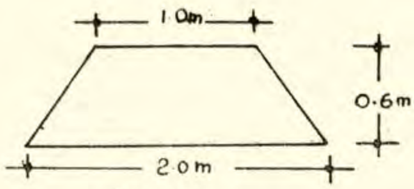
(*d*) The stacks shall be of the shape and size given in para 3-5-3-1 of I.S. No. 4082/67.

(*e*) Materials shall not be stacked on uneven ground or in any manner which does not permit correct and ready measurement

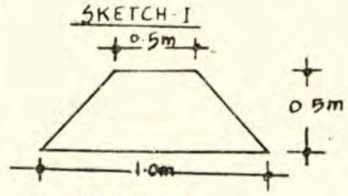
(*f*) Rough stone which is to be measured in the stack shall be packed so closely as to give the minimum quantity of voids possible.

3. *Templates and size of stacks.*—(*a*) Templates shall be provided at the contractor's expense unless otherwise specified, for stacks of size 2 m x0·5m for ensuring compliance with the specification for the size of stacks. The contractor must make such allowance in stacking as he finds necessary to ensure that the dimensions at time of measurement and check measurement are upto the specified stack dimensions.

(*b*) Road metal of all kinds and sand for road work shall be stacked in such size stack as may be specified. Where not otherwise specified and berm stacking space permits, the stacks shall be 1·0m wide at top 2·0m wide at base, 0·60m high—*vide* sketch 1 below and of length as specified or instructed by the Executive Engineer preferably in multiples of 1m. Where berm width is limited, the cross section of stack shall be in accordance with the sketch 2 below, unless otherwise specified.



SKETCH-I



SKETCH-2

(*c*) Rough stone stacks of all kinds shall not be of width greater than 1·5m nor of height less than 1·00m unless permission in writing is accorded by the Executive Engineer. (Low and wide stacks, having outer edges formed and the centre filled in loosely and trough like, shall not be permitted.)

SPECIFICATION No. 1.

BROKEN BRICK OR BRICK JELLY.

1. I.S. No. 3068/1965 for specification for broken bricks shall apply.

2. Broken brick shall not be obtained from the debris of old masonry, unless under orders of or by prior approval of the Executive Engineer. It shall then be taken from debris of hard, well or over burnt bricks. No brick-pieces containing mortar or from under burnt broken brick shall be used.

3. *Vide* instruction in paragraph 2 under " Mateirals " which shall apply.

SPECIFICATION No. 2.

SURKI.

1. I.S. No. 3182/1967 for broken brick (burnt clay) fine aggregate for use in lime mortar and for surki shall apply.

SPECIFICATION No. 3.

ROUGH STONE, JEDDY STONE, PAVEMENT STONE, ETC.

1. The size of the stone to be supplied for dry stone revetment and certain classes of masonry has been defined in the relevant standard specifications. For other cases and in, amplification as necessary, of the above relevant specifications, the size to be supplied will be defined in the tender notice, depending on the purpose for which the stone is required.

2. The stone shall be sound, free from cracks and decay and supplied from the quarry specified shall have abrasion value of 45 per cent and generally shall have a specific gravity of 2·5.

3. Stacking shall be done in conformity with the instructions in paragraph 2 and 3 under "Materials", and at the location specified or ordered by the Executive Engineer.

SPECIFICATION No. 4.

FLOORING STONE (75MM. TO 100MM. THICK).

1. Stone slabs for flooring should be obtained from the quarry defined in the descriptive specification sheet. They shall be of the best quality available in the specified quarry, haid, even, sound durable, free from cracks and flaws and of thickenss 75mm to 100mm. They should be of rectangular or square shapes as specified, with clean square edges. The bottom face of the stone may be left rough but the top surface shall be fine dressed and the joint faces shall be dressed back sqaure with the top surface for atleast 5 cm., without hollows or spalling off, to permit without further dressing, a finsihed thickness of joint, when the floor is laid, of not more than 1 cm. in width. The stone shall have abrasion value of 45 per cent and generally shall have specific gavity of 2·5. The limits of size of the flooring stone, depending on the particualr purpose for which it is required, will be specified. A sample shall be produced by the Contractor to the Executive Engineer for his approval before supply is made. Stone unsuitable for the particular class of work shall be rejected, and shall be removed at once from the work site.

SPECIFICATION No. 5.

BROKEN STONE FOR CONCRETE.

1. I.S. 383—1970 for broken stone shall apply.

2. The location from which the stone is to be obtained will be given in the agreement descriptive specification sheets.

3. For sizes of aggregates I.S. 383—1970 shall apply.

SPECIFICATION No. 5-A.

BROKEN STONE FOR ROAD WORK.

1. Clause 2 and 3 of the preceding specification shall apply.

2. The relevant specification of the Indian Roads Congress for specification for Road and Bridge work (1973) shall apply.

SPECIFICATION No. 6.

GRAVEL.

1. Gravel shall be obtained from the quarry defined in the descriptive specification sheet. It shall be composed of large coarse grains, thoroughly free from dirt and foreign material. It shall not contain any lumps or stones larger than 20 mm. guage. A small natural formation admixture of clay is not objectionable. A sample shall be produced to the Executive Engineer for prior approval, before supply.

2. The gravel shall have the following general qualities :—

(i) The material shall be well graded from coarse to fine particles.

(ii) When sample of the material is wetted and squeezed in the hand, the following characteristics shall be noted.

(a) The material is extremely gritty.

(b) It can be formed into definite shapes that retain their forms even when dried.

(c) If the clay in the material, above, adheres to the hands, it should only be enough to discolour them slightly. A natural formation admixture of clay upto 10 per cent is not objectionable.

(d) If more than enough soil, to discolour the hand, adheres, it must consist of both sand and clay instead of clay alone.

(e) When the wetted sample is patted in the palm of the hand it will compact into a dense cake that cannot be penetrated readily with a blunt stick—the size of a lead pencil.

3. Instruction in paragraph 1 and 2 under "Materials" shall apply.

SPECIFICATION No. 7.

SAND.

1. The sand shall be obtained from the source defined in the descriptive specification sheet and shall be screened before use. If the sand brought to site is not clean it must be washed clean in water. Fine drift sand, or sea sand, or sand containing saline impurities shall on no account be used, except with the prior approval of the Executive Engineer, who will instruct the contractor regarding the treatment to be given to the sand before use at the contractor's expense.

2. For sand for mortar, concrete and ordinary plaster, brick work or masonary, I.S. 2116-1965 ; shall apply. Sand for plastering, pointing and for fine work, I.S. 1542-1960 shall apply.

3. For sand or fine aggregate for cement concrete, I.S. 383-1970 shall apply.

4. Sand for bituminous concrete in road work, relevant extract of I.R.C. shall apply.

5. Instructions in paragraph 1 and 2 under "Materials" shall apply.

SPECIFICATION No. 8.

CUDDAPAH SLABS.

1. Ordinary slabs shall be accurately rectangular or square with edges chisel dressed all round to a depth of 6mm. plumb from the surface. The surface shall be quite even, without any veins, cracks or flaws and with a uniform slate colour. Earthy flaky stones shall be rejected. The stones shall be of the thickness defined in the relevant scheduled item.

NOTE.—Further chisel dressing of edges is required when using ordinary slabs to comply with the joint thickness demanded in the standard specification for cuddapah slab flooring.

2. Semi-polished and high polished cuddapah slabs shall conform to the standard specification for ordinary slabs with the further requirement that the edges shall all be dressed at right angels to the surface for the full thickness of the slab. The polished surface and the quality of the polish shall be executed to a high standard of workmanship.

3. Engraving [illegible] in highly polished cuddapah slabs for "year stones", "Foundation stones", "Name Boards", etc., shall be done as specified in the tender documents.

SPECIFICATION No. 9.

LIME.

1. For classification of lime—I.S. 712-1973 shall apply.

2. I.S. 1861—1961 and 1849—1967 shall apply for the manufacture of lime, the type of lime kilns, etc.

3. In all cases, the lime shall be delivered fresh at the site of the mortar mill, *i.e.*, within seven days of the date on which it was drawn fresh from the kiln. In cases where compliance herewith is not possible due to seasonal closure of kilns, written permission of the Executive Engineer is necessary before stored slaked lime can be used.

4. The lime shall be slaked if so required, in the presence of a departmental representative before being put into the mill. All impurities, ashes or pieces improperly or carelessly burnt shall be screened or picked out before slaking and removed at once from the work site.

5. Lime which has perished, or which has been damaged by damp, rain, for intermixture of dirt, or which has become partially air-slaked, shall on no account be used on the works but shall be removed at once from the site. For physical and chemical requirements of lime I. S. 712—1973 shall apply.

6. Lime is to be obtained from the source defined in the descriptive specification sheet.

7. For storage of lime, paragraph 6 of I.S. 712-1973 shall apply.

8. For tests for different classes of lime I.S. 712-1964 and I.S. 1624-1960 shall apply.

The Executive Engineer shall have the right to reject any lime which does not satisfy the physcial and chemical requirements and the contractor shall then remove the rejected materials atonce from the worksite.

9. *Vide* instructions in Note-1, under "Materials" which shall apply.

SPECIFICATION No. 10.

PORTLAND CEMENT.

1. For specification of ordinary, rapid hardening and low heat Portland cement I.S. 269-1967 shall apply.

2. In cases where the contractor is required to procure Portland cement for the work he shall always purchase Portland cement as fresh as possible after manufacture, and he shall, on demand by the Executive Engineer, furnish a laboratory test certificate of a character meeting with the approval of the Executive Engineer. This should be demanded in every case where there is reason to believe that the cement has been long stored and may have thereby deteriorated in quality.

3. The Executive Engineer shall reject any cement which is proved to be not according to standards.

4. For storage of cement paragraph 5 of I.S. 269-1967 shall apply. In cases where the contractors required to procure Portland cement for the work he shall notify the Executive Engineer of the arrival of each consignment of Portland cement on the work, informing him at the same time of the brand, agent from whom obtained and age of the Cement. Cement which has become caked or perished by moisture or other causes shall on no account be used on the work.

5. The following precautions should be observed in storage :—

(*a*) Avoid storage for long periods, do not store at all, if possbile during the rainy season.

(*b*) Prevent circulation of air through the cement by close packing and cover with a tarpaulin.

(*c*) For other precautions in this regard I.S. 4082-1967 shall apply.

6. *Storing Portland Cement*: Portland cement is a very finely ground material. It is hygroscopic and is affected by moisture present in air. It is, therefore, necessary to protect it from dampness before it is used.

Every year, and particularly in the monsoon, large quantities of cement are spoilt due to neglect in keeping the cement bags absolutely dry. The following points on the correct storage of portland cement should be kept in mind.

6.1 The cement should be stored in a building or shed which is leak proof and as moisture proof as possible.

6·2. *Precautions in storing*.—After the building is made leak proof and moisture proof, certain precautions shall then be observed in storing the bags with a view to prevent them from any possible contact with moisture and to ensure systematic working of the warehouse.

If the warehouse is to be newly put into service, make sure that sufficient time has been allowed for the interior to dry thoroughly.

Bags shall not be stacked against the wall. A space of 300 mm. all round shall be left between the outer walls and the stacks.

Bags shall be stacked off the floor on wooden planks.

Bags should be kept close together in the stack to reduce circulation of air as much as possible.

Cement bags shall not be stacked more than 12 bags high, otherwise it becomes cumbersome to stack or remove them. The maximum width of stack should be not more than about 3 m.

If the stack is to be more than 7 or 8 bags high, bags shall be arranged in header and stretcher fashion, that is, alternately lengthwise and crosswise so as to tie the stack together and lessen the danger of toppling over.

For extra safety during the monsoon, or when it is expected to store the cement for an unusually long period, enclose the stack completely by a water proofing membrane such as polythene, asbestos sheet, etc., This can be conveniently done by making a large loose stack of the material and arranging the bags within it. The flaps will close on the top of the stack. Care shall be taken to see that the polythene is not damaged any time during use.

Owing to pressure on the lower layer of bags, "warehouse pack" may be developed in the bags which may be removed by rolling the bags when the cement is taken out for use. The bags shall not be moved or restacked on account of warehouse pack. There is no advantage in doing so.

When removing bags for use "first in, first out" rule shall be applied.

That is take the oldest cement out first. For this purpose, each consignment as it comes in, should be stacked separately and a placard bearing the date of arrival should be pinned into the pile.

Cement which has fully or partially set shall not be used.

6·3. *Temporary storage at site*.—Very often bags of cement have to be stored in the works site out in the open, for use on work for one or more days. In such cases the bags shall be laid on a dry platform made of wooden planks resting on a brick masonry, concrete, or dry sand or aggregate platform about 150 mm. above the ground.

The number of bags shall be kept to a minimum, preferably just sufficient for the day's consumption.

Care shall be taken to see that every point in the pile is well covered by tarpaulin or polythene sheet and protected against the moisture in the air. The tarpaulin shall overlap each other properly.

SPECIFICATION No. 10-A.

PORTLAND POZZOLANA CEMENT.

1. For specification of Portland Pozzolana Cement I.S. 1489—1976 shall apply.

1·1. Portland pozzolana cement is manufactured by using pozzolanic raw materials in addition to the ordinary raw materials for Portland Cement.

2. Portland Pozzolana Cement can be adopted in the same proportion as that of ordinary cement.

3. Portland Pozzolana Cement is ground finer and hence it produces denser and better concrete.

4. Portland Pozzolana Cement has got low heat of hydration and consequently improved resistance to cracking.

5. For precautions in storing , temporary storage at site etc. specification 10 of T.N.B.P. which relates to ordinary portland cement shall apply.

SPECIFICATION No. 11.

LIME MORTAR.

1. For different proportions of lime mortar to be used in various items of work, I.S. 1625—1971 shall apply. Quantities of materials and labour required for the various items of work shall be as given in the standard data and relevant specification.

2. For mixing of lime mortars I.S. 1625—1971 shall apply. The mortar is to be ground for not less than 60 revolutions of the mill for concrete, 80 revolutions for brick work, and 180 revolutions for plastering, pointing and terracing works. A satisfactoty method of counting the revolutions must be followed.

3. "Mechanical mortar mill may be used for grinding. The ingredients shall be mixed on water tight masonry platforms or in troughs. The mix shall then be fed into a mechanical mortar mill with the required addition of water, which shall be first sufficient to make the mortar of a workable consistency. The mortar shall be mixed at least for three minutes after addition of water, when it shall be emptied from the mill."

4. For precautions in use of mortars I.S. 1625—1971 shall apply. All mortar remaining unused for more than the period stipulated for its category or mortar hardended or set before being used, shall be removed from the work site at once.

SPECIFICATION No. 12.

SURKI MORTAR.

1. Surki mortar shall consist of lime, surki and sand each complying with its respective standard specification, mixed in the proportions noted below, or such other proportions as may be defined in the relevant schedule item for the various items of work :

Item of work.	*Lime.*	*Surki.*	*Sand.*
(1)	(2)	(3)	(4)
(i) Concrete	1	½	1½
(ii) Masonry (Brick or stone) ..	1	½	1½
(iii) Plastering-First coat	1	½	1½
Second coat	1	½	1
(iv) Pointing	1	½	1

2. Surki mortar is included in lime mortar specifications and relevant portions in I.S. 1625/1971 and I.S. 2394/1965 shall apply.

SPECIFICATION No. 13.

CEMENT MORTAR.

1. The quantities of materials and labour required for the various items of work shall be given in the standard data and relevant specification.

2 and 3. Water is to be added to the mixture, only when the mortar is required for use. For preparation of plaster I.S. 1661—1972 shall apply.

SPECIFICATION No. 13-A.

COMBINATION MORTAR.

In order to increase the strength and rapidity of gaining strength Portland cement may be mixed with lime. Combination mortar ranging from 1:1:6 (Cement:Lime:Sand) to 1:3:12 (Cement: Lime: Sand) may be prepared. The 1:1:6 mix shall be used where loads are fairly heavy and/or the conditions of exposure are severe and the 1:3:12 mix shall be used for light loads under sheltered conditions.

The Table 4 given under section VI-4 of National Building Code specifies the basic compressive stresses for masonry members and the same shall be adopted while selecting appropriate combination mortar, for masonry.

SPECIFICATION No. 14.

BAMBOOS.

N.B. :—The classes are as defined in river conservancy data.

1. *First Class* : The bamboos shall be free from attacks of weavels, not older than about two to three years, well seasoned, and of over 15 cm., girth and 3·65 m to 4·25 m., long or more. The girth measurement shall be taken at the centre of the length of each bamboo.

2. *Second Class* : Same as above but girth at centre shall be over 13 cm.

3. *Third Class* : Same as above but girth at centre shall be over 10 cm.

4. The proportion of the three classes of bamboos required for the work shall be specified in the tender documents.

SPECIFICATION No. 15.

SHEETS—MILD STEEL, GALVANIZED FLAT, CORRUGATED AND RIDGING SHEETS IN THE BLACK.

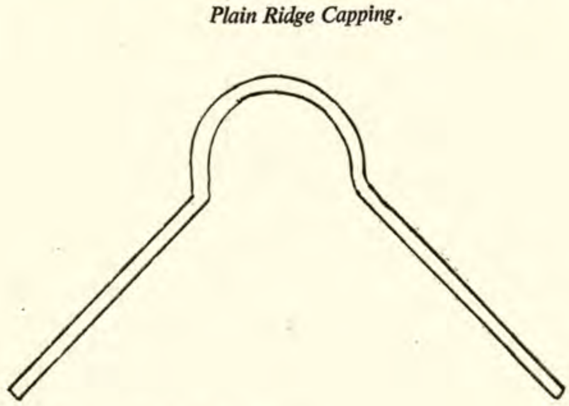
1. The relevant specifications from I.S. 1993—1974 and 1692-1960 shall apply.

Sheets after Galvanizing.

2. The relevant specifications from I.S. 277—1969 shall apply.

3. *Ridging*—The foregoing shall also apply to ridging. Unless otherwise required by the Schedule, ridging shall be 76 cm., in girth with 23 cm., laps, having an included angle equal to the pitch of the roof ; the shape being in accordance with the sketch below :

Plain Ridge Capping.



4. For packing timplate or black plate—I.S.1993—1974 shall apply.

EXTRACT FROM I.S. 1993—1974

Specification for cold-reduced tinplate and cold-reduced blackplate.

2. *Terminology* :—

2·1. *Cold-reduced blackplate*,—Low carbon mild steel strip/sheet produced by continuous or semi-continuous cold-reduction of hot-rolled steel strip/sheet.

2·2. *Cold-reduced hot-dipped tinplate*—Cold-reduced low carbon mild steel sheet which has been tinned by the hot-dip tinning process.

2·3. *Cold-reduced electrolytic tinplate*—Low carbon mild steel cold-reduced strip, which has been tinned by the electrolytic process.

5. *Grades.*

5·0. Tinplate and blackplate shall be supplied in the following grades :—

5·1. *Blackplate*—

5·1·1·. *First grade (prime)*:—Blackplates which at the time of despatch are free from defects readily visible to the unaided eye. Under normal conditions of storage and use, they are suitable for lacquering and printing over the whole surface.

5·1·2. *Second grade*.—Blackplates which at the time of despatch have visible imperfections of moderate magnitude or frequency, Lacquering or printing over the whole surface of the sheet cannot be guaranteed.

5·1·3·. *Standard grade (Unassorted)*.—Blackplates which are inspected during processing and from which material not of the, first or second grade is rejected. The accepted material, however is not segregated into first and second grades.

5·1·4. A list of common defects is given in Appendix B. The level of such defects shall be subject to agreement between the purchaser and the manufacturer.

5·2. *Hot dipped tinplate*—

5·2·1. *First grade (Prime)*.—Tinplate which at the time of despatch are free from defects readily visible to the unaided eye. Under normal conditions of storage and use, they are suitable for lacquering and printing over the whole surface of the sheet.

5·2·2·. *Second grade*.—Tinplates which at the time of despatch have visible imperfections of moderate magnitude or frequency. Lacquering or printing over the whole surface of the sheet cannot be assured.

5·2·3. *Standard grade* : *(Unassorted)*.—Shall consist of first grade (Prime) and second grade.

5·2·4. A list of common defects is given in Appendix B. The level of such defects shall be subject to agreement between the purchaser and the manufacturer.

5·3. *Electrolytic tinplate (Equality or Differentially coated)*.

5·3·1. *Standard Grade*. –Electrolytic tinplates which represent the normal production of lines employing the usual inspection and classification procedures. Under normal conditions of storage and use, standard grade electrolytic tinplate permits lacquering and printing over the whole surface.

NOTE : If heavy oil coatings are ordered, these may affect the suitability for lacquering and printing.

5·3·2. *Second grade*.—Tinplates which at the time of despatch have visible imperfections of moderate magnitude or frequency. Lacquering or printing over the whole surface of the sheet cannot be assured.

5·3·3. A list of common defects is given in Appendix B. The level of such defects shall be subject to agreement between the purchaser and the manufacturer.

5·4. *Defective tinplates hot-dipped or electrolytic*. –Tinplate with surface defects and which after inspection do not come under any of the above categories. The material is not suitable for normal lacquering or printing.

7. *Finish*.—

7·1. Hot-dipped tinplate shall have bright surface. The surface of the electrolytic tinplate shall have either bright or matt finish as specified by the purchaser. However, other finishes. such as stone finish, silver finish, shot blast finish. may also be supplied by mutual agreement between the purchaser and the manufacturer (see Appendix C for details of surface finishes). There shall be no visible variation on the finish over the entire surface of the sheet.

12. *Test Methods and verification* :

12·3. *Alternating bend test*.—The Jenkins bend test shall be carried as described in Appendix D.

APPENDIX B

(Clauses 5·1·4·, 5.2.4 and 5·3·3.)

LIST OF COMMON DEFECTS IN BLACK PLATE AND TINPLATE.

B.1. Black plate—

B. 1.1. The most common surface defects encountered in black plate are given below. The degree of acceptance shall be subject to agreement between the purchaser and the manufacturer keeping in view the ultimate use of blackplate :

(*a*) Roll Marks and visible scratches ;
(*b*) Rust spots ;
(*c*) Bran, dirt and excessive oil ;
(*d*) Small bent corners ;
(*e*) Lamination and sand spots ;
(*f*) Small indentation and pinholes, and
(*g*) Transit abrasion.

B·2. *Hot dipped tinplate.*

B·2·1. The most common surface defects encountered in hot dipped tinplate are given below. The degree of acceptance shall be subject to the agreement between the purchaser and the manufacturer keeping in view the utilimate use of tinplate ;

(*a*) Blackspot, tinpot, dirt and mill grease
(*b*) Scruff bead/line ;
(*c*) Untinned area and rust ;
(*d*) Roll marks and visible scratches ;
(*e*) Bran, dirt and excessive oil ;
(*f*) Dull patches ;
(*g*) Small bent corners ;
(*h*) Excessive list edge ;
(*j*) Tin blisters ;
(*k*) Grey top ;
(*m*) Lamination, sand spots ;
(*n*) Small indentation and pinholes
(*p*) Transit abrasion ; and
(*q*) Slight edge corrugation.

B-3. *Electrolytic tinplate.*

B-3.1. The most common surface defects encountered in electrolytic tinplate are given below. The degree of acceptance shall be subject to the agreement between the purchaser and the manufacturer keeping in view the ultimate use of tinplate ;

(*a*) Inclusion, lamination, silvers and surface breaks ;

(*b*) Indentation and pinholes ;

(*c*) Scratches and transit abrasion marks ;

(*d*) Unfused area ;

(*e*) Oil spots ;

(*f*) Roll marks ;

(*g*) Bent corners ;

(*h*) Staining ;

(*j*) Orange peel effect ;

(*k*) Rust spot ;

(*m*) Eye holes ;

(*n*) Woodgrain pattern ;

(*p*) Woodgracked edges ; and

(*q*) Tin blisters.

APPENDIX C.

(*Clause* 7·1)

SURFACE FINISHES.

C-0. *General.*

C-0·1. There are five recognized commercial finishes, that is bright, matt, silver, stone and shot-blast, all of which are achieved by use of workrolls of controlled surface textures during the final stages of temper rolling. With the exception of matt finish, each requires flow-brightening after electrotinning.

C-1. *Bright finish.*

C-1·1. Bright finish is achieved by using polished rolls and is the finish customarily supplied for the bulk of container manufacture.

C-2. *Matt finish.*

C-2·1. A low reflectivity surface which offers particular benefits for application, such as crown corks, in as much as it avoids the necessity of a base coat in some decorative systems.

C-3. *Silver finish.*

C-3·1. A lustrous surface, the steel base of which posseses highly roughened surface texture. A particularly attractive finish or used, such as domestic ware, where no soldering operation are involved.

C-4. *Stone finish.*

C-4·1. A bright surface, characterized by a strong directional surface pattern, achieved by use of specially ground rolls. The geometry of the surface profile affords a greater resistance to abrasion than the customary bright finish tinplate, particularly during can manufacture.

C-5. *Shot blast finish.*

C-5·1. A smoother variety of silver finish. The surface texture of the steel base, however, more closely approximates to that of matt finish. The particular advantage of this finish is that its improved resistance to abrasion effectively reduces hazards of selective internal food can discolouration that would otherwise occur with certain packs, particularly soup products. In view of its smoother surface texture it is much more readily soldered and lacquered than silver finsih.

APPENDIX D.

(*Clause* 12·3.)

ALTERNATING BEND TEST VALUES.

D-0. *General.*

D-0·1. Alternating bend test values serve to give an indication of the " directionality " or grain direction of the plate (customarily expressed by the ratio of strong ; weak way values). Directionality is a useful consideration for the tinplate user,for example in assessing the ability to form a good flange. It is influenced by a number of factors including chemical composition, cleanness of steel structure grain size and shape.

D-1. *Procedure.*

D-1·2. The hand lever is then brought backwards and forwards alternately bending the projecting end of the specimen through about, 180°. The end point is reached at the first sign of fracture thorugh the plate, and the test is not continued to the point at which the protruding piece of metal is completely severed. The number of bends (180°) to produce this fracture is recorded as the Jenkins bend value, the first half bend (90°) is ignored.

D-1·3. A complete test involves taking two specimens cut with their long edges parallel and perpendicular to an edge of the tin plate sheet. The band values for these two test specimens will generally be different. In view of the difficulty of standardizing alternating bend test machines the test values should not be interpreted to rigorously.

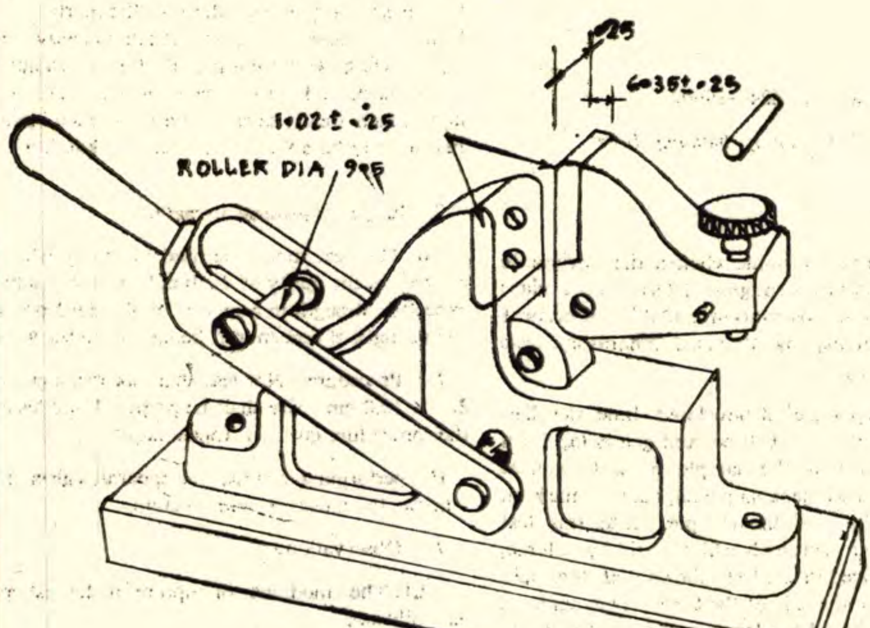


FIG 1. TYPICAL JENKINS BEND TESTING MACHINE

ALL DIMENSIONS IN MILLIMETRES.

EXTRACT FROM I.S. 1861—1961.

Code of practice for manufacture of lime in vertical mixed feed type kilns.

4·2. Sizes of Limestone and fuel and their distribution.

4·2.1. Size of Lime stone—The larger the size of limestone the larger will be the time taken for heat to reach the centre of the lump and completely calcine it. The size of stone fed to the kiln shall be carefully selected after taking into account the capacity, the draft and the requirements for size of the final product, namely lime The size of stone shall generally be as in 4·2·1·1· and 4·2·1·2.

4·2·1·1. In kilns working with natural draft, the size of stone shall be as given below :—

Description of kiln.	*Size of limestone.*
(*a*) For high shaft kilns, namely those with effective heights of about 12 m.	10 to 15 cm.
(*b*) For low shaft kilns, namely those with effective heights of about 7·5m.	7·5 to 10 cm.

4·2·1·2. In vertical kilns working **with forced draft, the size o limestone shall be as specified by the designer.**

4·2·2. *Size of fuel.*

4·2·2.1. The size of coal or coke used shall **be such that** it burns at the required rate in the calcination zone. If too small, the fuel will not last till it reaches the end of the calcination zone, and if too large, it will not complete its burning in the calcination zone and unburnt pieces will pass into the cooling zone and sometimes out with the drawn lime.

4·2·2·2. The Size of coal or coke used for burning lime may generally be half of the size of limestone, unless specified otherwise by the designer.

NOTE.—The ratio of the sizes of fuel and limestone will depend very much on the chemical nature and density of the fuel. For free burning non-caking coal, the ratio will be even as large as one. On the other hand, it will sometimes be possible to use hard coke, around 10 mm. in size, with lime stone ten times as large in size.

4·2·2·3. In addition to the nature and density of the fuel as in 4·2·2.1. the type of packing to be obtained within the kiln shall also be considered in choosing the ratio of the sizes of stone and fuel. The distribution of their sizes will determine the degree of compactness of the packing and consequently the resistance of the bed to the flow of gases through it. A tight packing will, therefore, require more power for maintaining the draft, if forced draft is used for the kiln, or where only natural draft is depended upon the capacity of the kiln will be considerably reduced as a result of tight packing.

EXTRACT FROM I.S. 1624—1960.

Code of practice for field testing of building lime

4. *Hydrochloric acid test.*

4·0. This test should be used to determine whether the carbonate content in the lime is excessive and to roughly determine the class of lime. The necessity for the observation should not occur if the lime has been tested for quality by standard laboratory tests before accepteance of the supply.

4·1. *Procedure.*—Place a teaspoonful of powdered lime (levelled flat to the rim of the spoon) in a test tube and gently tap for a period of about two minutes, so that the sample presents a neat surface on the top. With a glass marking pencil, make a mark on the test tube to indicate the volume of the sample. Into this test tube, add about 10ml. of 50 per cent hydrochloric acid by volume, preferably along a glass rod placed in the test tube so that the acid does not get smeared all over the side of the tube. The contents after stirring with a glass rod, should not leave much inert material at the bottom of the test tube. The quantity of acid may be increased, if necessary to ensure that none of the inert material is in the form of calcium carbonate ; and the contents shall be well shaken to ensure that all effervescence ceases. The test tube with its contents shall then be kept standing in a test-tube stand for about 24 hours.

4·2. *Observation.*

4·2·.1 If the effervescence indicating the liberation of carbon dioxide is abundant, it may be inferred that the lime has a substantial proportion of calcium carbonate, because the lime has not been burnt adequately and/or stored properly.

4·2·2. The volume of insoluble residue at the bottom of the tube compared with the original volume of lime will indicate the proportion of inert material and give an idea if it is excessive or not.

4.2.3. In the case of hydraulic lime, a good thick gel will be formed and below it inert material will be deposited. If the gel is so thick as not even to flow when the test tube is turned upside down, the inference may be that the lime is eminently hydraulic. If the gel formed is not quite thick and tends to flow on being titled, the lime is feebly hydraulic. If there is no gel formation, the lime is non-hydraulic or fat.

6. *Test for workability.*

6·0. This test should be used to determine whether the proportioning and mixing of the various ingredients in lime mortar namely lime, sand and water with or without addition of surki, cement, etc. facilitate easy handling and application in the work.

NOTE.—In addition to workability, the mortar should have the required strength. Hence it is essential that tests for transverse strength as described in 7 are also performed frequently. It is to be emphasized here that workability is generally a facility for application, but is quite difficult to measure physically as it involves several performance characteristics, such as adhesion, plasticity etc.,

6.1 Procedure.—The Procedure is largely a matter of judgement and is entirely left to the practical knowledge and experience of the mason or plasterer who uses the mortar. The test shall be performed on the same mortar as is subsequently used in the construction. By throwing, with the same effort as for rough-cast work, a handful of the mortar on the surface on which it is to be used, and by noting how much area is covered and how much mortar is picked up, the mason may be able to judge the workability.

7. *Test for transverse strength.*

7.0. This test should be used to check whether the hydraulicity as well as the purity of the building lime is sufficient to develop the expected strength in a mortar of standard proportions; and to find the strength of lime mortar being used in the work.

7.1. Procedure— Not less than six rectangular specimens of 2.5 × 2.5 × 10.0 cm. size shall be prepared and tested in accordance with the procedure given in Appendix C.

For performing the test, the apparatus given in Fig. 1 may be found simple to construct and operate.

7.2. Observation.

7.2.1. The modulus of rupture of the test specimen is obtained as follows :

$$m = \frac{3\ WS}{2\ bd^2} = \ ..\ 0.768\ W$$

Where — m —Modulus of rupture in kg per cm²

W—breaking load in Kg.

S – Span = 8 cm.

b —breadth of specimen = 2.5 cm.

d —depth of specimen = 2.5 cm.

7.2.2. The average of the six test specimens shall be taken as the modulus of rupture of the mortar and the result shall be expressed to the nearst Kg./cm². If the individual value of any test differs from the average value by more than 15 per cent, a new average shall be found rejecting such values.

APPENDIX C.

(*Clause* 7-1.)

TEST FOR DETIRMINATION OF TRANSVERSE STRENGTH OF BUILDING LIMES,

C–1. ***Preparation of standard lime sand mortar* (1: 3).**

C–1.1. The sand employed for the preparation of mortar shall conform to I.S. 650—1955.

C–1.2. The lime used for the preparation of the mortar shall be either hydrated lime or quicklime.

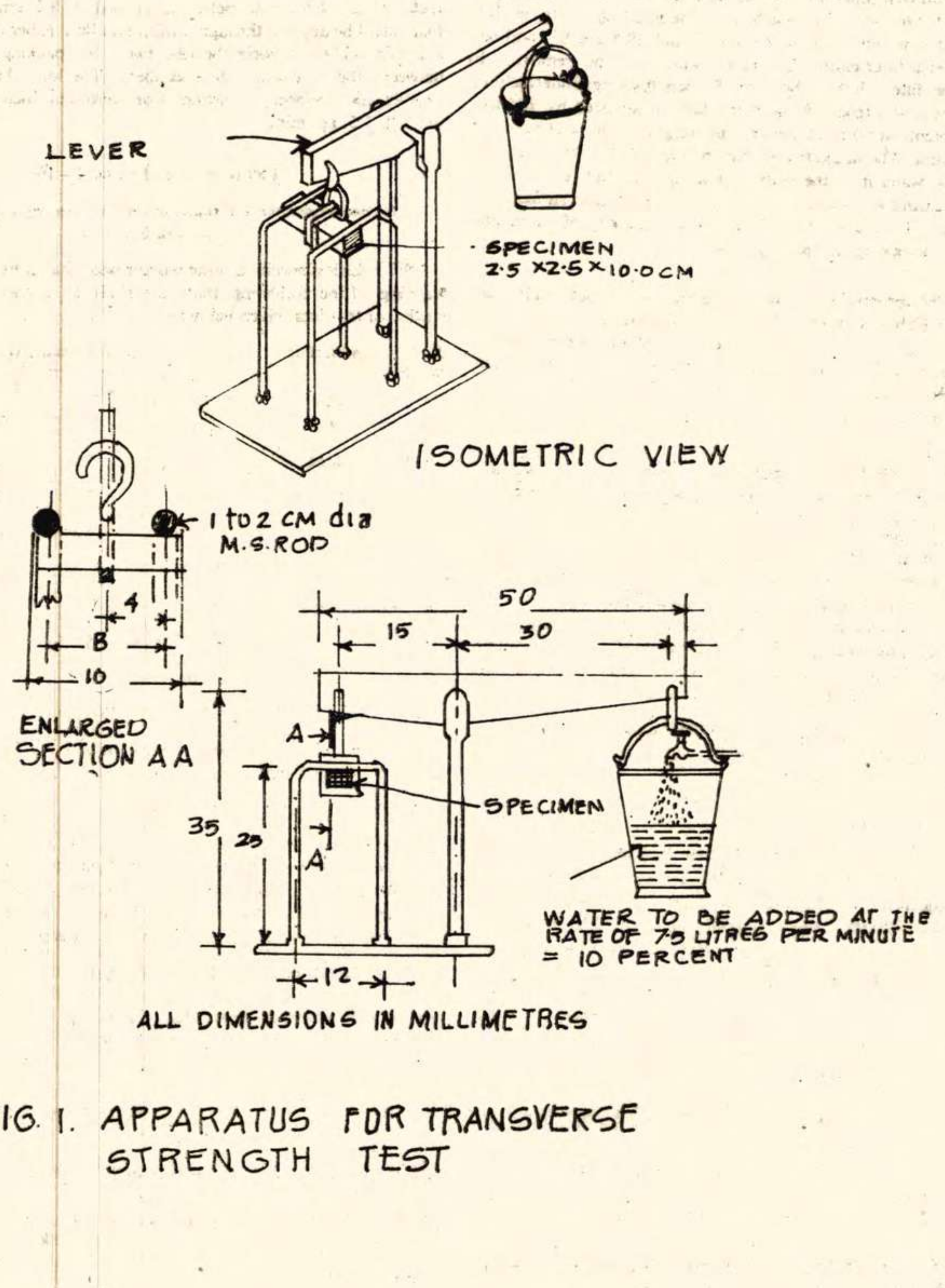


FIG. 1. APPARATUS FOR TRANSVERSE STRENGTH TEST

C-1.3. *Adjusted lime putty.*

C-1.3.1. When hydrated lime is used 500 g of the sample shall be thoroughly mixed with 60 to 65 per cent of water by weight (that is 300 to 325 ml) for 5 minutes, for obtaining putty.

C-1.3.2. When quicklime is used about one Kilogram of the sample shall be crushed to pass through IS Sieve 240 and slaked in the field for not less than one hour. The resulting putty shall be stirred with a wooden rod and sieved through IS Sieve 85 and collected over a filter cloth. The excess water shall be removed by folding the filter cloth in the form of a bag pressing moderately by hand. The consistency of the putty shall be adjusted by trial to a water content of 60 to 65 per cent by weight on the weight of dry hydrated lime. The adujustment shall be carried out by extracting any excess water from the putty by placing it, after removal from the filter cloth for a short time on a clean absorbant surface, or alternatively, if overdry, by adding a small quantity of water and mixing and knocking up thorougly.

C-1.4. The proportion of water present may be determined by drying a weighed portion rapidly in a drying oven at 100°±10° C so that no significant amount of carbon dioxide is absorbed in he process, and by weighing the dry residue. The loss in weight should be 60 to 65 per cent of the weight of the dry residue. Any other convenient method may be used for this purpose.

C-1.5. The adjusted lime putty shall be thoroughly mixed and knocked-up and passed twice, through a pugmill and used immediately for preparing the mortar.

C-1.6. Mix thoroughly 350 g of the putty with an amount of standard sand (conforming to IS. 650—1955) equal to thrice the weight of the dry hydrate contained in it, namely, 635 to 655 g. The remaining putty shall be discarded. The lime putty and sand shall be throughly mixed and knocked-up continuously for 10 minutes so as to form a uniform plastic mortar. The mortar so prepared shall be used immediately for filling the moulds for strength tests.

The whole operation starting from the slaking of the quicklime upto the filling of the moulds shall be carried out as expeditiously as possible.

C-2. *Preparation of test specimen.*

C-2.1. Six test specimens each 2.5x2.5 cm. in cross section and 10.0 cm in length shall be prepared using the standard lime and mortars specified under C-1. The mould used shall be an individual or gang mould of bronze or other suitable non-corrodible metal, and of internel dimensions of 2.5 x 2.5 x 10.0 cm, the inner surface of the mould shall be carefully machined to a tolerance of ±0.002 cm and the mould shall be so constructed that it is possible to remove the specimens without the mould being tapped. The mould shall be well greased with petroleum jelly before use, and shall rest on a well greassd non-corrodible plate during the filling operations. The mould shall be filled by hand, the mortar being pressed in with the thumb, lightly tamped, and then smoothed off with two or three strokes of palette knife.

C-2.2. The filled mould together with its base plate and covered on the top with a similar plate, shall be stored for a period of 28 days undisturbed in a suitable container in an atmosphere of at least 90 per cent relative humidity and a temperature ranging from 24° to 32° C. A record shall be kept of the temperature of the storage on at least 24 days of the 28 days period. The maximum and minimum temperatures shall be read from time to time in order to check any possible wide variations of temperature that may have occurred whilst he apparatus was not under direct observation.

C.2.3. *Test procedure.*

C-2.3.1. After the expiry of the period of storage specified under C-2.2. the specimens shall be removed from the mould, care being taken not to injure them in any way during this process and immersed in water for a period of half an hour. They shall be then removed and tested immediately for transverse strength. The specimens to be tested shall rest symmetrically on their sides on two parallel metal rollers 4 cm in diametre and spaced at 8.0 cm centres. The load shall be applied through a third parallel. roller of the same size at a point midway between the other two. No packing shall be used between the rollers and the specimen. The load shall be applied steadily and uniformly, starting from zero, and increased at a rate of 15 ± 1.5. kg. min.

EXTRACT FROM I.S. 4082—1967.

Recommendations on stacking and storage of construction materials at site.

3.5.3.1 Unless specified otherwise or necessitated by site conditions stacking of the following materials shall be carried out in regular stacks of the sizes given below:—

Serial number.	*Meterials.*		*Size of stack (in metres).*		
			Length.	*Breadth*	*Height.*
(1)	(2)		(3)	(4)	(5)
1	Soling stone ..	.. ..	5.0	2.0	0.50
2	Coarse aggregate	.. ..	2.0	2.0	0.50
		or	5.0	5.0	1.50
		or	5.0	1.0	0.50
3	Fine aggregate	.. .. ..	2.0	2.0	0.50
		or	5.0	5.0	1.00
		or	5.0	5.0	0.50

EXTRACT OF I.S. 3068—1965

Specification for broken brick (burnt clay) coarse aggregate for use in lime concrete.

3. *Quality of aggregates.*

3.1. General:—Broken brick coarse aggregate shall be prepared from bricks corresponding to atleast class L II mentioned in I.S. 3102—1965 classification of burnt clay bricks. It shall be free from under burnt particles and adherent coating of soil or salt. As far as possible flaky and elongated pieces shall be avoided.

NOTE.—Repeated handling of brick aggregate can result in breaking up and rounding up of the edges of the particles and production of excessive finer dust. The dust raises the proportion of finer sized particles in concretes, which if not accounted for would result in excessive water demand for concrete. Brick aggregate should therefore, be handled the least number of times before being used in concrete and preferably produced close to construction site.

3.2. Deleterious Materials—Aggregate shall not contain any harmful material such as clay unburnt or under-burnt particles, alkali soft fragments, organic impuraties, etc., in such quantity as to affect adversely the strength and durability of concrete.

4. *Size of aggregates.*

4.1. The aggregate shall be well graded and shall pass in any direction through 50 mm I.S. sieve. It shall be screened over a 4.75 mm I.S. Sieve to remove rubbish and dust.

EXTRACT FORM I.S. 3182—1967

Specification for broken brick (burnt clay) fine aggregate for use in lime mortar.

3. *Quality of aggregate.*

3.1. *General.*—Broken brick fine aggregate shall be prepared from Class I or Class II bricks conforming to I.S. 3102—1965 It shall be free from underburnt particles and adherent coatings of soil or silt.

NOTE.—Appendix A provides guidance regarding manufacture of broken brick fine aggregate.

3.2. *Deleterious material.*—Broken brick fine aggregate shall not contain any harmful impurities, such as iron pyrites, salts, coal, mica, shale or similar laminated or other materials in such form or in such quantities as to affect adversely the hardening, the strength, the durability or the appearance of the mortar.

3.2.1. Unless found satisfactory as a result of further tests as may be specified by the Engineer or Architect or unless evidence of general performance is offered to him, the maximum quantities of clay, fine silt, fine dust and organic impurities in the broken brick fine aggregate (all taken together) determined in accordance with I.S. 2386—(Part—II) 1963 shall not exceed 5 per cent by weight.

4. *Grading.*

4.1. The particle size grading of broken brick fine aggregate for use in lime mortars for masonry work shall be within the limits specified in Table 1.

TABLE—1 REQUIREMENTS OF GRADING FOR BROKEN BRICK FINE AGGREGATE FOR USE IN LIME MORTAR.

(1) [I.S. *Sieve designation* (*See* I.S. 460—1962)]	(2) *Percentage passing* (*By weight*)
4.75 mm	100
2.36 mm	96–100
1.18 mm	70–100
600 micron	40–100
300 micron	5–70
150 micron	0–15

4.1.1. The various sizes of particles of which the broken brick fine aggregate is composed of shall be uniformly distributed throughout the mass.

4.2. Broken brick fine aggregate whose grading falls outside the specified limits due to excess or deficiency of coarse or fine particles may be processed to comply with this standard by screening through a sized sieve and blending with required quantities of suitable sizes of broken brick fine aggregates. Any deviation may be left to the discretion of the Engineer or Architect in charge of the work in the light of practical experience with the use of local aggregates.

APPENDIX A.

(*Clause* 3–1)

NOTE ON MANUFACTURE OF BROKEN BRICK FINE AGGREGATE.

A. 1. *Raw materials.*

A. 1.1. Brick clays shall be well suited for manufacturing broken brick (burnt clay) fine aggregate as judged by past experience or by experimental investigations. The clays shall be free from organic impurities like peat wood, leaves, etc., and lumps and coarse gravel Clays which have the following constituents are useful for the manufacture of broken brick fine aggregate:—

Constituents.	*Percentage of content.*
Silica+Aluminium+Iron oxide	Not less than 70.
Silica	Not less than 40.
Calcium Oxide	Not more than 10
Magnesium Oxide	Not more than 3.
Sulphur trioxide	Not more than 3
Soda and Potash	Not more than 3.
Water soluble alkali	Not more than 0.1.
Water soluble material	Not more than 1.0.
Loss on ignition	Not more than 5

A–2. *Manufacture.*

A-2.1. The broken brick fine aggregate shall be obtained by calcining processed clay at suitable temperature and grinding the resulting product to required fineness or by grinding broken bricks.

EXTRACT FROM I.S. 1344—1968.

Specification for burnt clay pozzolana.

2. *Raw materials.*

2·1. In selecting clay for the manufacture of burnt clay Pozzolana, past experience of the use of the particular clay under service conditions and any experimental investigation are good guides.

2.2. A number of clays, which have been investigated in India and have given satisfactory results, conform generally to the following chemical requirements on an over dry basis (at 105° C).

Constituents.	*Contents.*
Silica+Alumina +Iron Oxide ($SiO_2+Al_2+FC_2 O_3$)	Not less than 70 per cent.
Silica (SiO_2)	Not less than 40 per cent.
Calcium Oxide (Ca 0)	Not more than 10 per cent.
Magnesium Oxide (Mg 0)	Not more than 3 per cent.
Sulphuric an hydride (SO_3)	Not more than 3 per cent.
Soda and potash (Na_2O+K_2O)	Not more than 3 per cent.
Water—soluble alkali	Not more than 0.1 per cent.
Water—soluble material	Not more than 1 per cent
Loss on ignition	Not more than 5 per cent.

NOTE.—For Chemical analysis of clays, reference may be made to I.S. 1727—1967.

3. *Manufacture*,

3.1. Burnt clay pozzolana shall be obtained by calcining processed clay at suitable temperature and grinding the resulting product to required fineness.

3.2. *Preparation of raw materials*.—The clay may be prepared with suitable additions of water into a plastic mass weeding out gritty materials, pebbles, sticks, etc.

NOTE.—The method of manufacture of burnt clay pozzolana currently practised in India, is to burn clay after moulding it into bricks or balls and then to powder it.

3.3. *Burning*.—The clay prepared as in 3.2. shall be burnt at a temperature suitable to the type of clay used in the manufacture.

3.3.1. The exact degree of burning for each day shall be determined after making necessary experiments with samples prepared at different temperatures and ground to specified fineness and testing for strength and other properties with lime and cement.

NOTE.—The optimum temperature of burning is presumed to be that at which the crystal structure of the clay mineral just collapses and the oxides of silicon, aluminum and iron are in fine active form Generally, the optimun temperature of burning of different clays at which maximum reactivity is produced have been found to be the following:—

For montmorillonite type of clay 600° to 800° C.

For Kaolinite type of clay .. 700° to 800° C.

3.4. *Grinding*.—The burnt clay shall be pulverized to the fineness specified in 4.1.

4. *Physical Requirements*.

4.1. Burnt clay pozzolana shall conform to the physical requriements given in Table 1.

TABLE 1.—PHYSICAL REQUIREMENTS OF BURNT CLAY POZZOLANA

(*Clause* 4.1.)

Serial No. (1)	*Characteristic.* (2)	*Requirement.* (3)	*Use.* (4)	*Methods of test.* (5)
1	Fineness : (*a*) Specific surface	3,200 Cm^2/g, Min, lower value upto 2,250 cm^2/g may be accepted provided requirements of strength and other properties are met satisfactorily.	As Pozzolana and as admixture	6.1. of I.S. 1727–1967 "Methods of test for Pozzolanic Materials" (first revision).
	(*b*) Residue by weight on 45-Micron I.S. sieve after wet sieving.	12 per cent Max.	Do. ..	6.2. of I. S. 1727–1967.
2	*Reactivity* : (*a*) Lime reactivity compressive strength at 10 days (specimen kept in mould with cover plates under wet gunny bags for 48 hours and 8 days in incubator at 90 to 100 per cent relative humidity and at 50°±2°c obtained by testing at least three mortar cubes.	50 kg./cm^2 Min.	As Pozzolana, and as admixture and aggregate for mortar and concrete.	9 of I.S. 1727–1967.
	(*b*) *Compressive strength***— (i) At the age of 28 days.	Not less than 80 per cent of the strength of corresponding plain cement mortar cubes at 28 days.	As Pozzolana . ..	10 of I.S. 1727–1967.
	(ii) At the age of 90 days	Not less than the strength of the corresponding cubes cast from the same mix tested at 28 days.	Do. ..	Do.

7. *Storage*.

7.1. The burnt clay pozzolana shall be protected from rain and dampness and shall be stored in such a manner as to permit easy access for proper inspection and identification of each consignment.

9. *Delivery*.

9.1. The burnt clay pozzolana may be supplied in bags (gunny multiply paper or cloth) bearing the manufacturer's name or registered trade-mark, and the net weight of each bag shall be 50 kg.

9.2. The permissible tolerance of the weight of burnt clay pozzolana supplied in bags shall be ± 2½ per cent per bag with an overall tolerance of ± ½ per cent per wagon load of 20 to 25 tonnes.

EXTRACT FROM I.S. 383–1970.

Specification for coarse and fine aggregates from natural sources for concrete.

2.1. *Fine aggregate*.—Aggregate most of which passes 4.75 mm I.S. Sieve and contains only so much coarse material as permitted in 4.3.

**Average compressive strength obtained by testing at least three mortar cubes.

2.1.1. *Natural sand.*—Fine aggregate resulting from the natural disintegration of rock and which has been deposited by streams or glacial agencies.

2.1.2. *Crushed stone sand.*—Fine aggregate produced by crushing hard stone.

2.1.3. *Crushed gravel sand.*—Fine aggregate produced by crushing natural gravel.

3. *Quality of aggregates.*

3.1. *General.*—Aggregate shall consist of naturally occuring (crushed or uncrushed) stones, gravel and sand or combination thereof. They shall be hard, strong, dense, durable, clear and free from veins and adherent coating, and free from injurious amounts of distintegrated pieces, alkali, vegetable matter and other deleterious substances. As far as possible, flaky, scoriaceous and elongated pieces should be avoided.

NOTE.—Enough data to specify the limits for the flaky and elongated aggregates are not yet available. The limits may therefore as mutually agreed to between the purchaser and the supplier. I.S. : 2386—(Part—I) 1963, however, lays down the methods for the determination of the flakiness index and the elongation index of aggregates.

3.2. *Deleterious materials.*—Aggregates shall not contain any harmful material, such as pyrites, coal, lignite, mica, shale, or similar laminated material, clay, alkali, soft fragments, sea shells and organic impurities in such quantity as to affect the strength or durability of the concrete. Aggregates to be used for reinforced concrete, shall not contain any material liable to attack the steel reinforcement. Aggregates which are chemically reactive with alkalies of cement are harmful as cracking of concrete may take place.

NOTE.—Aggregate petrographically similar to known reactive types, or aggregates which on the basis of service history or laboratory experiments, are suspected to have reactive tendency should be avoided or used only with cements of low alkalis [not more than 0.6 per cent as Sodium ozide (Na_2O), after detailed laboratory studies. Use of pozzolanic cement and certain pozzolanic admixtures may be helpful in controlling alkali aggregate reaction.

3.2.1. *Limits of deleterious materials.*—The maximum quantity of deleterious materials shall not exceed the limits specified in Table 1 when tested in accordance with I.S. : 2386–1963. However, the Engineer-in-charge at his discretion may relax some of the limits as a result of some further tests and evidence of satisfacotry performance of the aggregates.

TABLE 1.—LIMITS OF DELETERIOUS MATERIALS (CLAUSE 3·2·1).

Serial number and deleterious substance.	*Method of test.*	*Fine aggregate percentage by weight, max.*		*Coarse aggregate percentage by weight, max.*	
		Uncrushed.	*Crushed.*	*Uncrushed.*	*Crushed.*
(1)	(2)	(3)	(4)	(5)	(6)
1 Coal and lignite	I.S.; 2386 (Part II) 1963.	1·00	1·00	1·00	1·00
2 Clay lumps	Do. ..	1·00	1·00	1·00	1·00
3 Materials finer than 75/u I.S. sieve.	I. S. 2386 (Part I) 1963.	3·00	15·00	3·00	3·00
4 Soft Fragments	I. S. 2386 (Part II) 1963.	..	..	3·00	..
5 Shale	Do. ..	1·00	..	..	..
6 Total of percentages of all deleterious materials (except mica) including Serial numbers (i) to (v) for columns 4, 6 and 7 and Serial numbers (i) and (ii) for Col. 5 only.	..	5·00	2·00	5·00	5·00

NOTE.—(1) The presence of mica in the fine aggregate has been found to reduce considerably the durability and compressive strength of concrete and further investigations are underway to determine the extent of the deleterious effect of mica. It is advisable, therefore to investigate the mica contents of fine aggregate and make suitable allowances for the possible reduction in the strength of concerte or mortar.

(2) The aggregate shall not contain harmful organic impurities [tested in accordance with I.S. 2386 (Part II) 1963] in sufficient quantities to affect adversely the strength and durability of concrete. A fine aggregate which fails in the test for organic impurities may be used provided that when tested for the effect of organic impurities on the strength of mortar, the relative strength at 7 and 28 days reported in accordance with 7 of I.S. 2386 (Part VI) 1963 is not less than 95 per cent.

3·6. *Soundness of aggregate.*—For concrete liable to be exposed to the action of frost, coarse and fine aggregates shall pass a sodium or Magnesium sulphate accelerated soundness test specified in I.S.: 2386 (Part V)—1963, the limits being set by aggrement between the purchaser and the supplier, except that aggregates failing in the accelerated soundness test may be used if they pass a specified freez ing and thawing test satisfactory to the user.

NOTE.—As a general guide, it may be taken that the average loss of weight after 5 cycles shall not exceed the following:—

(*a*) *For fine aggregates.*—10 per cent when tested with sodium sulphate (Na_2SO_4) and 15 per cent when tested with Magnesium sulphate ($Mg\ SO_4$).

4. *Size and grading of aggregates.*

4·1. *Single-sized coarse aggregates.*—Coarse aggregates shall be supplied in the nominal sizes given in Table 2. For any one of the nominal sizes, the proportion of other sizes, as determined by the method described in I.S. 2386 (Part 1) 1963 shall also be in accordance with Table 2.

TABLE—COARSE AGGREGATES.

(*Clauses* 4·1. *and* 4·2.)

I. S. Sieve designation.	*Percentage passing for single sized aggregate of nominal size.*						*Percentage passing for grade aggregate of nominal size.*			
	63 mm.	40 mm.	20 mm.	16 mm.	12·5 mm.	10 mm.	40 mm.	20 mm.	16 mm.	12·5 mm.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
80 mm.	100	..	..	..	..	..	100	..	..	..
63 mm.	85 to 100	100	..	..	..	..	..	..	..	..
40 mm.	0 to 30	85 to 100	100	..	..	..	95 to 100	100	..	..
20 mm.	0 to 5	0 to 20	85 to 100	100	..	..	30 to 70	95 to 100	100	100
16 mm.	..	..	..	85 to 100	100	..	..	..	..	..
12·5 mm.	..	..	..	..	85 to 100	100	..	..	..	..
10 mm.	0 to 5	0 to 5	0 to 20	0 to 30	0 to 45	85 to 100	10 to 35	25 to 55	30 to 70	40 to 85
4·75 mm.	..	..	0 to 5	0 to 5	0 to 10	0 to 20	0 to 5	0 to 10	0 to 10	0 to 10
2·36 mm.	..	..	..	..	..	0 to 5	..	..	..	..

4·1·1. *Coarse aggregate for mass concrete.*—Coarse aggregate for mass concrete works shall be in the sizes specified in Table 3.

TABLE 3.—SIZES OF COARSE AGGREGATES FOR MASS CONCRETE (CLAUSE 4·1·1.)

Class and size.	*I.S. Sieve designation.*	*Percentage passing.*
(1)	(2)	(3)
Very large, 150 to 80 mm.	160 mm.* ..	90 to 100
	80 mm. ..	0 to 10.
Large, 80 to 40 mm.	80 mm. ..	90 to 100.
	40 mm. ..	0 to 10.
Medium, 40 to 20 mm.	40 mm. ..	90 to 100.
	20 mm. ..	0 to 10.
Small, 20 to 4·75 mm.	20 mm. ..	90 to 100.
	4·75 mm. ..	0 to 10.
	2·36 mm. ..	0 to 2.

* There being no I.S. sieve having an aperture larger than 100mm. a perforated plate complying with I.S. 2405-1963 and having a square aperture of 160 mm. may be used.

4.2. *Graded aggregates.*—Graded coarse aggregate may be supplied in the nominal sizes given in Table-2.

4·3. *Fine aggregates.*—The grading of fine aggregates, when dertermined as described in I.S. 2386 (Part I) 1963 shall be within aggregates, grading zones I, II, III and IV. Where the grading falsl outside the limits of any particular grading zone of sieves other than 600—micorn I.S. sieve by a total amount not exceeding 5 per cent, it shall be regarded as falling within the grading Zone. This tolerance shall not be applied to percentage passing the 600—Micron I.S.—Sieve or to percentage passing any other sieve size on the coarse limit of Grading Zone I or the finer limit of Grading Zone IV.

TABLE—4. FINE AGGREGATES

(*Clause* 4.3)

I. S. sieve designation.	*Percentage passing for.*			
	Grading Zone I.	*Grading Zone II.*	*Grading Zone III.*	*Grading Zone IV.*
(1)	(2)	(3)	(4)	(5)
10 mm	100	100	100	100
4.75 mm	90–100	90–100	90–100	95–100
2.36 mm	60– 95	75–100	85–100	95–100
1.18 mm	30– 70	55– 90	75–100	90–100
600 micron	15– 34	35– 59	60– 79	80–100
300 micron	5– 20	8– 30	12– 40	15– 50
150 micron	0–10	0– 10	0– 10	0– 15

NOTE 1.—For crushed stone sands, the permissible limit on 150 micron I.S. Sieve is increased to 20 per cent. This does not affect the 5 per cent allowance permitted in 4.3 applying to other sieve sizes.

NOTE 2.—Fine aggregate complying with requirements of any grading Zone in this table is suitable for concrete but the quality of concrete produced will depend upon a number of factors including proportions.

NOTE 3.—Where concrete of high strength and good durability is required, fine aggregate conforming to any one of the four grading zones may be used, but the concrete mix should be properly designed. As the fine aggregate grading becomes progressively finer, that is, from Grading Zones I to IV, the ratio of fine aggregate to coarse aggregate should be progressively reduced. The most suitable fine to coarse ratio to be used for any particular mix will, however, depend upon the actual grading, particle shape and surface texture of both fine and coarse aggregates.

NOTE 4.—It is recommended that fine aggregate conforming to grading Zone IV should not be used, in reinforced concrete unless tests have been made to ascertain the suitablity of proposed mix proportions.

4.4. *All-in-aggregates*—If combined aggregates are available they need not be separated into fine and coarse, but necessary adjustments may be made in the grading by the addition of single-sized aggregates. The grading of the all-in-aggregate, when analysed, as described in IS. 2386 (Part I) 1963 shall be in accordance with Table 5.

TABLE 5—ALL-IN-AGGREGATE GRADING.

(*Clause* 4.4)

I.S. Sieve designation.	*Percentage passing for all-in-aggregate of*	
	40 mm nominal size.	*20 mm nominal size.*
(1)	(2)	(3)
80 mm	100	....
40 mm	95 to 100	100
20 mm	45 to 75	95 to 100
4.75 mm	25 to 45	30 to 50
600 micron	8 to 30	10 to 35
150 micron	0 to 6	0 to 6

EXTRACT FROM I.R.C. (1973)

Specification for road and bridge works.

403.2.7. *Grading requirements of coarse aggregates*—The coarse aggregates shall conform to one of the gradings given in Table 400-4 as specified.

TABLE 400-4.—GRADING REQUIREMENTS OF COARSE AGGREGATE.

Grading number and size range. (1)	*Sieve designation.* (2)	*Percentage by weight passing the sieve.* (3)
1. 90 mm to 40 mm..	100 mm	100
	80 mm	65–85
	63 mm	25–60
	40 mm	0–15
	20 mm	0–5
2. 63 mm to 40 mm..	80 mm	100
	63 mm	90–100
	50 mm	35–70
	40 mm	0–15
	20 mm	0–5
3. 50 mm to 20 mm..	63 mm	100
	50 mm	95–100
	40 mm	35–70
	20 mm	0–10
	10 mm	0–5

EXTRACT FROM I.S. 2116—1965.

Specification for sand for masonry mortars.

3. *Quality of sand.*

3.1. The sand shall consist of natural sand, crushed stone or crushed gravel sand, or a combination of any of these.

3.2. The sand shall be hard, durable, clean and free from adherent coatings and organic matter and shall not contain any appreciable amount of clay balls or pellets.

3.3. The sand shall not contain any harmful impurities, such as iron pyrites, alkalis, salts, coal, mica, shale or similar laminated or other materials in such form or in such quantities as to affect adversly the hardening, the strength, the durability or the appearance of the mortar applied or to attack any reinforcement used in the masonry work.

3.4. Unless found satisfactory, as a result of further tests as may be specified by the Engineer or Architect in charge of the work, or unless evidence of such performance is offered which is satisfactory to him, the maximum quantities of clay, fine silt, fine dust and organic impurities in the sand shall not exceed the following limits.

(*a*) Clay, fine silt and fine dust (determined in accordance with Appendix C of I.S. 383-1963 and also I.S. 2386 (Part II–1963.	Not more than 5 per cent by weight.
(*b*) Organic impurities (determined in accordance with IS 2386 (Part II) 1963	Below that indicated by comparison with the standard solution specified in 6.2.2 of IS 2386 (Part II) 1963

NOTE :—In particular cases crushed stone sand with even higher proportions of fine dust than specified above, may be satisfactory and the limit so permitted may be subject to the aggreement between the supplier and the purchaser.

4. *Grading.*

4.1. The particle size grading of sand for the use in mortars for unreinforced masonry work shall be within the limits specified in Table 1.

TABLE 1 : REQUIREMENTS OF GRADING FOR SANDS FOR UNREINFORCED MASONRY WORK.

I.S. Sieve designation (see IS 460—1962) @	*Percentage by weight passing I.S. sieve.*	
4.75 mm	100	
2.36 mm	90–100	@ Specification for test sieves (revised)
1.18 mm	70–100	
600 micron	40–100	
300 micron	5–70	
150 micron	0–15	

4.2. The particle size grading of sand for use in mortar for reinforced masonry work shall be within the limits specified in Table

TABLE 2:—REQUIREMENTS OF GRADING FOR SANDS FOR REINFORCED MASONRY WORK.

I.S. Sieve designation. see IS (460—1962)	*Percentage passing by weight.*
4.75 mm..	100
2.36 mm	90–100
1.18 mm	70–100
600 micron	40–80
300 micron	5–40
150 micron	0–10

4.3. A sand whose grading falls outside the specified limits due to excess or deficiency of coarse or fine particles may be processed to comply with the standard by screening through a suitably sized sieve and/or blending with required quantities of suitable sizes of sand particles. Any deviation may be left to the discretion of the Engineer or Architect in charge of the work in the light of practical experience with the use of local materials.

4.4. The various sizes of particles of which the sand is composed shall be uniformly distributed throughout the mass.

4.5. The required grading may often be obtained by screening and/ or by blending together either natural sands or crushed stone screenigs, which are by themselves, unsuitable.

EXTRACT FROM I.S. 1542—1960.

Specification for sand for plaster.

3. *Quality of sand.*

3.1. The sand shall consist of natural sand, crushed stone sand or crushed gravel sand, or a combination of any of these.

3·2. The sand shall be hard, durable, clean and free from adherent coatings and organic matter and shall not contain any appreciable amount of clay balls or pellets.

3.3. The sand shall not contain any harmful impurities, such as iron pyrites, alkalis, salts., coal, mica, shale or similar laminated or other materials in such form or in such quantities as to affect adversely the hardening, the strength, the durability or the appearance of the plaster or applied decoration, or to cause corrosion of metal lathing or other metal in contact with the plaster.

4. *Grading.*

4.1.1. For purpose of indicating suitability for use, the sand is classified as Class A and Class B in accordance with the limits of grading, class A sands shall be used generally for plaster work but where they are not available, class B sands may be used.

4.1.2. A sand whose grading falls outside the specified limits due to excess or deficiency of coarse or fine particles may be processed to comply with the standard by screening through a suitably sized sieve and / or blending with required quantities of suitable sizes of sand particles. Deviation of about 5 per cent from the specified limits in he grading for fractions passing IS sieve 120 and 60 only, may be allowed subject to agreement between the purchaser and the supplier. Any other deviation may be left to the discretion of the Engineer or Architect in charge of the work, who shall be solely responsible for the defects in work, if any, due to this change.

4.1.3. The grading of sand for internal wall and ceiling plaster shall be within the limits specified in Table 1.

TABLE 1—REQUIREMENTS OF GRADING FOR SANDS FOR INTERNAL WALL AND CEILING PLASTERING.

IS Sieve designation (*See IS* 460–1953).	*Corresponding B.S. sieve designation.*	*Percentage by weight passing I.S. sieve.*	
		Class A.	*Class B.*
(1)	(2)	(3)	(4)
240	7	98–100 for under coats.	98–100 for under coats.
		100 for finishing coats.	100 for finishing coats.
120	14	80–95 for under coats.	80—100 for under coats.
		95—100 for finishing coats.	95—100 for finishing coats.
60	25	30—85	30—95
30	52	5—50	5—65
15	100	0—10	0—15

4.1.4. The grading of sand for external plaster coats and renderings shall be within the limits specified in Table II.

TABLE II—REQUIREMENTS OF GRADING FOR SANDS FOR EXTERNAL PLASTERING AND RENDERING.

I.S. Sieve designation (*See I.S.* 460—1953).	*Corresponding I.S. sieve designation.*	*Percentage by weight passing I.S. sieve.*	
		Class A.	*Class B.*
(1)	(2)	(3)	(4)
480	3/16 in	100	100
240	7	90—100	90—100
120	14	70—100	70—100
60	25	40—85	40—95
30	52	5—50	10—65
15	100	0—10	0—15

NOTE.—The most suitable grading of sand for an external rendering will depend to some extent, upon the finishing treatment. The grading specified will, in general, be suitable for the under coats and for some finishing coats, such as the smooth (floated) finishing coats, the scraped finishes, and for pebble-dash or dry-wash. For some textured finishes, such as those produced by treatment of the freshly applied final coat with a tool, it may be desirable to remove the coarser particles (for example by screening through I.S. Sieve 240), while for others, such as the torn texture some proportion of material coarser than the size corresponding to I.S. Sieve 480 (B.S. Sieve 3/16 in) may be needed. For rough-cast (wet dash or harling) the grading and maximum size of particles will vary according to the texture required and the type of aggregate used. The proportion of coarse materials (over the size corresponding to I.S. Sieve 480) to fine may generally be about 1 : 2.

4.2. The various sizes of particles of which the sand is composed shall be uniformly distributed throughout the mass.

4.3. The required grading may often be obtained by screening and/or by blending together either natural sands or crushed stone screenings, which are, by themselves, unsuitable.

EXTRACT FROM I.S. 712—1964.

Specification for building limes.

3. *Classification.*

3.1. Building limes shall be classified as follows :—

Class A—Eminently hydraulic lime used for structural purposes.

Class B—Semi-hydraulic lime used for masonry mortars.

Class C—Fat lime used for finishing coat in plastering white washing, etc., and with addition of pozzolaic material for masonry mortar.

Class D—Magnesium lime used for finishing coat in plastering, white washing, etc.

Class E—Kankar lime used for masonry mortars.

4. *Chemical and physical requirements.*

4.1. Building limes as classified in 3.1. shall comply with chemical and physical requirements specified in Tables 1 and 2 respectively.

6. *Storage.*

6.1. The lime shall be stored in such a manner as to permit easy access for proper inspection and in a suitable building to protect the lime from dampness and to minimize warehouse deterioration.

NOTE.—Quicklime deteriorates rapidly and therefore should be used as quickly as possible.

Serial number and type of test.	*Requirements for building limes.*								*Method of tests (Ref. to I.S. 6932—1973).**
	Class A Hydrated.	*Class B.*		*Class C.*		*Class D.*		*Class E Hydrated.*	
		Quick.	*Hydrated.*	*Quick.*	*Hydrated.*	*Quick.*	*Hydrated.*		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1 Calcium and magnesium oxides, per cent, Min.	60	70	70	85	85	85	85	25	Part I.
2 Magnesium Oxides per cent Max.	5	5	5	5	5	..	..	5	Part I.
Min.	..	..	..	..	..	5	5	..	
3 Silica, alumina and Ferric Oxide, per cent Min.	25	15	15	..	..	..	..	..	Part I.
4 Unhydrated oxides, per cent .. Max.	..	..	..	..	..	8	8	..	Part V.
5 Insoluble residue in Hydro-choloric acid less the silica, per cent — Max.	2	3	2	..	..	..	..	..	Part V.
6 Insoluble matter in Sodium carbonate solution, per cent — Max.	5	5	5	5	5	5	5	5	Part I.
7 Loss on ignition, per cent — Max.	..	5 for large lump, 7 for lime other than large lump.	—	5 for large lump,7 for lime other than large lump.	—	5 for large lump 7 for lime other than large lump	—	5	Part I.
8 Carbon dioxide, per cent .. Max.	5	5	5	5	5	5	5	..	Part II.
9 Cementation value .. (+) Min.	0·6	0·3	0·3	..	..	..	..	..	Part I.
(—) Max.	..	0·6	0·6	..	..	..	..	..	

NOTE.— (1) Percentages shall be expressed on ignited basis in respect of items (1) to (6).
(2) The sign (—) means no requirements for the test.

* Methods of tests for building limes —

Part I—Determination of insoluble residue, loss on ignition, insoluble matter, silicon dioxide, ferric and aluminium oxide, calcium oxide and magnisium oxide.

Part II—Determination of carbon dioxide content.

Part V—Determination of unhydrated oxide of quicklime.

\+ The value is equal to $\dfrac{2.8\,P + 1.1\,Q + 0.7\,R}{1.0\,S + 1.4\,T}$

T—Magnesium Oxide (Mg. 0) per cent by weight.

S—Calcium Oxide (Cao) per cent by weight.

P — Silica (Si 0) content per cent by weight.

Q—Aluminium Oxide ($Al_2\ O_3$) content per cent by weight.

R—Fonic Oxide ($Fe_2\ O_3$) content per cent by weight.

Requirements for

Serial number and Type of Test.	Class A.	Class B.		Class C.	
	Hydrated.	Quick.	Hydrated.	Quick.	Hydrated.
(1)	(2)	(3)	(4)	(5)	(6)
1 Fineness	Shall leave no residue on 2·36 mm. I.S. sieve, not more than 5 per cent on 850 micron I.S. sieve and the fraction passing through 850 micron I.S. sieve shall leave not more than 10 per cent (of this fraction) on 300 micron I.S. sieve.	....	Shall leave no residue on 2·36 mm. I.S. sieve, not more than 5 per cent on 850 micron I.S. sieve and the fraction passing through 850 micron I.S. sieve shall leave not more than 10 per cent (of this fraction) on 200 micron I.S. sieve.	....	Shall leave not residue on 850 micron I.S. sieve not more than 5 percent on 300 micron I.S. sieve and the fraction passing through 300 micron I.S. sieve shall leave not more than 10 per cent (of this fraction) on 212 micron I.S. sieve.
2 Residue on slaking (on the basis of quick lime taken (max, per cent by weight).	....	10 on 850 micron I.S. sieve.	....	5 on 850 micron I.S. sieve, the fraction passing through this sieve when further passsd through 300 micron I.S. sieve shall leave residue 5.	....
3 Setting time	In the putty of standard consistency as prepared in 3·2·2. of I.S. 6932 (Part VIII) 1973 ‡ initial set shall take place in not less than 2h and final set within 48h.	....	....	....	....
4 Compressive strength Min.	17·5 Kg./cm^2 after 14 days and 28kg./cm^2 after 28 days shall, however, shown an increase over that at 14 days.	....	12·5 Kg./cm^2 after 14 days and 175 kg./cm^2 at 28days shall, however, show an increase over that at 14 days.	....	....
5 Transverse strength ..	Modulus of rupture not less than 10·5 kg./cm^2 at 28 days.	....	Modulus of rupture not less than 7·0 kg./mm^2 at 28 days.	....	....
Workability	....	....	.. ..	Shall require not less than 12 bumps to attain an average spread of 19 cm from an initial spread of 11 cm. on the flow table.	Shall require not less than 10 bumps to attain an average spread of 19 cm. from an initial spread of 11 cm. on the flow table.
7 Volume yield	....	....	....	1·7 ml. per g. or as agreed to between the purchaser and the supplier.	....
8 Soundness	The Le Chatelier moulds shall not exhibit more than 10 mm. expansion.	....	The Le Chatelier moulds shall not exhibit more than 10mm. expansion.	....	..
9 Popping and Pitting ..	....	....	....	....	Shall not exhibit any disintegration popping the pitting on or surface.

*Methods of tests for building limes ; Part—IV Determination of Fineness.

†Methods of tests for building limes ; Part III—Determination of residue on slaking of quicklime.

‡Methods of tests for building limes ; Part VIII—Determination of workability.

§Methods of Physical tests for hydraulic cement.

building limes.

Class D. Quick. (7)	Class D. Hydrated. (8)	Class E Hydrated. (9)	*Methods of Tests Reference to.* (10)
....	Shall leave no residue on 850 micron I.S. sieve not more than 5 per cent on 300 micron I.S. Sieve and the fraction passing through 300 micron I.S. sieve shall leave not more than 10 per cent (of this fraction on 212 micron I.S. Sieve.)	Shall leave no residue on 2·36 mm. I.S. Sieve, not more than 5 per cent on 850 micron I.S. Sieve and the fraction passing through 850 micron I.S. Sieve shall leave not more than 10 per cent (of this fraction on 300 mircon I.S. Sieve).	I.S. : 6932 (Part IV) 1973.*
5 on 860 micron I.S. Sieve the fraction passing through this sieve when further passed through 300 micron I.S. Sieve shall leave residue 5.	....	....	I.S. 6932 (Part III) 1973†.
....	....	In the putty of standard consistency as prepared in 3·2·2. of I.S. 6932 (Part VIII) 1973‡ initial set shall take place in not less than 2h and final set within 48h.	I.S. 4031-1978 §
....	....	10·5 kg./cm². after 14 days and 17·5 kg./cm² after 28 days shall, however, show an increase over that at 14 days.	I.S. 6932 (Part VII) 1973 ‖.
....	....	Modulus of rupture not less than 7·00 kg./cm² at 28 days.	Do.
Shall require not less than 12 bumps to attain an average spread of 19cm. from an initial spread of 11 cm. on the flow table.	Shall require not less than 10 bumps to attain an average spread of 19 cm. from an initial spread of 11 cm. on the flow table.	....	I.S. 6932 (Part VIII 1973 ¶.
1·4· ml. per g. or as agreed to between the purchaser and the supplier.	....	....	I.S. 6932 (Part VI) 1973††.
....	....	The Le Chatelier moulds shall not exhibit more than 10 mm. expansion.	I.S. 6932 (Part IX) 1973‡‡.
....	Shall not exhibit any disintegration popping or pitting on the surface.	....	I.S. 6932 (Part X) 1973. ‡‡

NOTE.—The sign (—) means no requirements of the tests.

‖ Methods of tests for building limes ; Part VII—Determination of compressive and transverse strength

¶Methods of tests for building limes ; Part VIII—Determination of workability.

**Methods of tests for building limes ; Part VI—Determination of volume yield of quicklime

††Methods of tests for building limes ; Part IX—Determination of soundness.

‡‡Methods of tests for building limes ; Part X—determinat.on of popping and pitting.

EXTRACT FROM I.S. 269–1967.

Specification for ordinary, and low heat portland cement.

4·3. Setting time—The setting time of the cements, when tested by the Vicat apparatus method described in IS 4031* shall conform to the following rsquirements :—

	Ordinary.	Rapid Hardening.	Low Heat.
(1)	(2)	(3)	(4)
(a) Initial setting time in minutes, not less than.	30	30	60
(b) Final setting time in minutes, not more than.	600	600	600

5. *Storage* :

5·1. The cement shall be stored in such a manner as to permit of easy access for proper inspection and in a suitable weather tight building to protect the cement from dampness and to minimize warehouse deterioration.

5·2. The net weight of each bag shall be 50 kg. The permissible tolerance on the weight of cement supplied in bags shall be ± 2.5 per cent per bag with an overall tolerance of ± 0·5 per cent per wagon load of 20 to 25 tonnes.

NOTE.—The weight of a gunny bag to hold 50 kg. of cement is about 500 to 550 g. and the weight of a 6-ply paper bag to hold 50 kg. of cement is approximately 400 g.

EXTRACT FROM I.S. 4082—1967.

Recommendations on stacking and storage of construction materials at site.

3·2. *Cement.*

3·2.1. Cement shall be stored at the work site in such a manner as to prevent deterioration due to moisture.

3·2·2. Cement shall be stored and stacked in bags above ground level in dry and waterproof sheds. Adequate precaution shall be taken to ensure stacking of cement bags in such a way as to keep about 15 to 20 cm. clear above floor and 25 to 35 cm. clear of walls. Cement bags shall be kept free from the possibility of any dampness or moisture coming in contact with them. The height of stack shall be 8 to 12 bags to prevent the possibility of lumping up under pressure. Cement bags shall be stacked in a manner to facilitate their removal and use in the order in which they are received.

EXTRACT FROM I.S. 1489—1976 (SECOND REVISION)

Specification for portland pozzolana cement.

Scope :

1·1. This standard covers the manufacture and physical and chemical requirements of portland pozzolana cement.

(2) *Terminology* :

2·0. For the purpose of this standard, the definitions given in IS : 4845-1968 and the following shall apply.

2·1. *Pozzolana* :—An essentially silicious material which while in itself possessing little or no cementitious properties will, in finely divided form and in the presence of water, react with calcium hydroxide at ambient temperature to form compounds possessing cementatious properties. The term includes natural volcanic material having pozzolanic properties as also other natural and artificial materials, such as diatomaceous earth, calcined clay and flyash.

2·2. *Portland clinker* :—Clinker, consisting mostly of calcium silicates, obtained by heating to incipient fusion, a predetermined and homogeneous mixture of materials principally containing lime (CaO) and silica (SiO_2) with a smaller proportion of alumina (Al_2O_3) and iron oxide (Fe_2O_3).

2·3. *Portland Pozzolana Cement* :—An intimately interground mixture of portland clinker and pozzolana with the possible addition of gypsum (natural or chemical) or an intimate and uniform blending of portland cement and fine pozzolana.

(3) *Raw Material*—

3·1. Pozzolana—

3·1·1. Pozzolana used in the manufacture of portland-pozzolana cement may include such natural materials as diatomaceous earths, opaline cherts and shales, tuffs and Volcanic ashes or pumicites : materials processed by calcination of soil ; that is burnt clay pozzolona and of clays and shales of the kaolinite, montmorillonite and also illitic types ; and artificial materials, such as precipitated silica and flyash.

3·1·2. Pozzolana that is to be blended with finished portland cement to produce portland pozzolana cement shall conform to the following physical requirements.

(*a*) Fineness—specific surface determined in accordance with the procedure specified in IS : 1727-1967 shall not be less than 3200 cm^2/g.

(*b*) Lime reactivity—The average compressive strength obtained by testing at least three mortar cubes prepared and tested in accordance with the procedure specified in IS : 1727-1967 shall be not less than 50 kg/cm^2.

3·1·3. Pozzolana that is to be interground with portland cement clinker for the manufacture of portland-pozzolana cement may not satisfy the requirements specified in 3·1·2(*a*) but shall nevertheless, satisfy the lime reactivity requriements specified in 3·1·2(*b*).

3·1·4. The lime reactivity test on the pozzolana shall be carried out at the same fineness at which the pozzolana is to be blended with finished portland cement in the case of blended portland pozzolana cement. In the case of interground portland pozzolana cement, the lime reactivity of the pozzolana shall be tested at the fineness, at which the final portland pozzolana cement will be supplied except that where the pozzolanic material used in the intergrinding process is in a state finer than the finished pozzolana cement, the lime reactivity test may be carried out at that fineness.

3·1·4·1. The purchaser shall have the right, if he so desires to obtain sample of pozzolana used in the manufacture of portland pozzolana cement, for purposes of checking its conformity to the requirements specified in 3.1.1 to 3.1.3.

3.2. Portland cement clinker :—The portland cement clinker used in the manufacture of portland pozzolana cement shall comply in all respects with the chemical requirements of IS : 269-1976 and the purchaser shall have the right if he so desires, to obtain samples of the clinker used in the manufacture for purposes of checking its conformity to IS : 269-1976 in this respect.

3.3. Portland cement—When pozzolana cement is obtained by blending pozzolana with portland cement, the portland cement used shall comply with the requirements of IS : 269-1976.

3·4. *Other Admixures.*—When portland pozzolana cement is obtained by grinding pozzolana with portland cement clinker, no material other than gypsum (natural or chemical) or water or both, shall be added. Such air-entraining agents or surfactants which have been proved not harmful, may be added in quantities not exceeding one per cent.

4. *Manufacture* :

4.1. Portland pozzolana cement shall be manufactured either by intimately intergrinding portland cement clinker and pozzolana or by intimately and uniformly blending portland cement and fine pozzolana (see 0·2) Gypsum (natural or chemical) may be added if the portland pozzolana cement is made by intergrinding portland cement clinker with pozzolana. The pozzolana constitutent shall not be less than 10 per cent and not more than 25 per cent by mass of Portland pozzolana cement. The homogeneity of the mixture shall by guaranteed within ± 3 per cent within the same consignment.

NOTE.—Chemical gypsum shall be added provided that the performance requirements of the final product as specified in this standard are met with.

5. *Chemical Requirements* :

5·1. Portland pozzolana cement, when tested in the manner described in IS : 4032—1968 shall comply with the chemical requirements given in Table 1.

5·2. Portland pozzolana cement shall also comply with the requirements of pozzolanicity test specified in IS : 4032—1968.

6. *Physical Requirements* ;

6.1. *Fineness*.—When tested by the air permeability method described in IS : 4031–1968 the specific surface of portland pozzolana cement shall be not less than 3000 cm²/g.

6·2. *Soundness* :

6·2.1. When tested by the 'Le Chatelier' method described in IS : 4031-1968 unaerated portland pozzolana cement shall not have an expansion of more than 10 mm.

6·2·1·1. In the event of the cement failing to comply with the above requirements, a further test shall be made by the 'Le Chatelier' method described in IS : 4031–1968 from another portion of the same sample after aeration, by being spread out to a depth of 75 mm at a relative humidity of 50 to 80 per cent for a total period of 7 days, and the expansion so found shall not be more than 5 mm.

TABLE 1—CHEMICAL REQUIREMENTS OF PORTLAND POZZOLANA CEMENT.

(*Clause* 5·1)

Serial number and Characteristic.	*Requirement.*
(1)	(2)
(i) Loss on ignition, per cent, max.	5·0
(ii) Magnesia (MgO), per cent by Mass, mix.	6·0
(iii) Insoluble material, per cent, max.	$X + \frac{2 \cdot 0(100-X)}{100}$ Where X is the declared percentage of pozzolana in the given portland pozzolana cement.
(iv) Sulphuric anhydride (SO_3) per cent by mass.	Not more than 2·75 and 3·0 when tricalcium aluminate, per cent by mass (see Note) is 7 or less and greater than 7 respectively.

466—3—4

NOTE.—The tri-calcium aluminate content (C_3A) is calculated by the formula :

$$C_3A = 2 \cdot 65\ (Al_2O_3) - 1 \cdot 69\ (Fe_2O_3)$$

Where each symbol in brackets refers to the percentage (by mass of total cement) of the oxide, excluding any contained in the insoluble residue referred to at Sl. No. (iii).

6·2·2. Unaerated portland pozzolana cement having a magnesia content of more than 3 per cent shall be tested for soundness by autoclave test described in IS : 4031–1968 and shall not have an expansion of more than 0·8 per cent.

6·3. Setting Time: The setting time of portland pozzolana cement when tested by the Vicat apparatus method described in IS : 4031-1968 shall be as follows :—

Initial setting time	.. ..	30 min. Min.
Final setting time	.. ..	600 min. max.

6·4. *Compressive strength* :

6·4·.1. The average compressive strength of not less than three mortar cubes (area of face 50cm²) composed of one part of cement, three parts of standard sand (see Note 2) by mass, and $\frac{P + 3 \cdot 0}{4}$ per cent (of combined mass of cement and sand) water, and prepared, stored and tested in the manner described in IS : 4031-1968 shall be as follows :

(*a*) At 168 ± 2*h*	220 kgf/cm², Min.
(*b*) At 672 ± 4*h*	310 kgf/cm², Min.

NOTE 1.—P is the percentage of water required to produce a paste of standard consistency (see 11·3)

6·4·2. Notwithstanding the cubes satisfying the strength requirements specified in 6·4·1 they shall also show a progressive increase in strength from the strength at 168 *h*.

6·5. *Drying shrinkage*—The average drying shrinkage of mortar bars prepared and tested in accordance with IS: 4031-1968 shall not be greater than 0·15 per cent.

7. *Storage*:

7·1. The pozzolana cement shall be stored in such a manner as to permit easy access for proper inspection and identification and in a suitable weather-tight building to protect the cement from dampness and to minimise warehouse deterioration.

8. *Manufacturer's Certificate*:

8·1. The manufactuer shall satisfy himself that cement conform to the requirements of this standard. If requested by the purchaser, the manufacturer shall also furnish wihin ten days of despatch of cement, a certificate indicating the per centage of pozzolana : the manufacturers shall also state in the certificate that the amount of pozzolana in the finished cement will not vary more than ± 3 per cent from the declared amount.

9. *Delivery* :

9·1. The cement shall be packed in bags (jute, jute laminated (CRI type) multi-ply paper, or polyethylene lined) bearing the manufacturer's name or his 'registered trade-mark, if any. The words 'Portland pozzolana cement' or a bright colour band to distinguish portland pozzolana cement from other cements and the number of bags (net mass) to the tonne or the approximate net mass of the cement shall be legibly and indelibly marked on each bag. Bags shall be in good condition at the time of inspection.

9.1·1 Similar information shall be provided in the delivery advices accompanying the shipment of packed or bulk cement (See 9·3.).

9.1·2. The bags or packages may also be marked with the ISI Certification mark.

NOTE.—The use of the ISI Certification mark is governed by the provisions of the I.S.I. (Certification marks) Act and the Rules and Regulations made thereunder. The ISI mark on products covered by an I.S. conveys the assurance that they have been produced to comply with the requirements of that standard under a well-defined system of inspection, testing and quality control which is devised and supervised by ISI and operated by the producer. ISI marked products are also continuously checked by ISI for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the ISI Certification mark may be granted to manufacturers or processors, may be obtained from the ISI.

9·2. The net mass of each bag shall be 50 kg.. The permissible tolerance on the mass of cement supplied in bags shall be $\pm$ 2.5, per cent per bag with an overall tolerance of $\pm$ 0·5 per cent for wagon load of 20 to 25 tonnes.

NOTE.—The mass of a jute bag to hold 50 kg. of cement is about 500 to 550 g. mass of a 6-ply paper bag to hold 50 kg. of cement is approximately 480g.

9·3. Supplies of cement in bulk may be made by agreement between the purchaser and the supplier (manufacturer or stockist)

10. *Sampling*—

10.1. Samples for Testing and by whom to be taken.—A sample or samples for testing may be taken by the purchaser or his representative, or by any person appointed to superintend the works for the purpose of which the cement is required, or by the latter's representative.

10.1.1. The samples shall be taken within one week of the delivery and all the tests shall be commenced within one week of sampling.

10.1.2. When it is not possible to test the samples within one week, the samples shall be packed and stored in air-tight containers till such time that they are tested.

10.2. In addition to the requirements of 10.1. the methods and procedure of sampling shall be in accordance with IS : 3535-1965.

10.3. *Facilities for Sampling and Identifying*—The manufacturer or supplier shall afford every facility, and shall provide all labour and materials for taking and packing the samples for testing the cement and for subsequent identification of the cement sampled.

11. *Tests*—

11·1. The sample or samples of pozzolana cement taken as described in 10 shall be tested in the manner described in the relevant clauses.

11.2. The temperature range within which physical tests are carried out shall, as far as possible, be 27 $\pm$ 2°C. The actual temperature during the testing shall be recorded.

11.3. *Consistency of standard Cement Paste*.—The quantity of water required to produce a paste of standard consistency to be used for determination of the water content of mortar for the compressive strength test and for the determination of soundness and setting time, shall be obtained by the method described in IS: 4031-1968.

11. 4. *Independent Testing*—

11.4.1. If the purchaser or his representative requires independent tests, the samples shall be taken before or immediately after delivery at the option of the purchaser or his representative, and the tests shall be carried out in accordance with this standard on the written instruction of the purchaser or his representative.

11.4.2. *Cost of Testing*.-The manufacturer shall supply, free of charge the cement required for testing. Unless otherwise specified in the enquiry and order, the cost of the tests shall be borne as follows:

(*a*) By the manufacturer if the results show that the cement does not comply with this standard, and

(*b*) By the purchaser if the results show that the cement complies with this standard.

11.4.3. After a representative sample is drawn, tests on the samples shall be carried out as expeditiously as possible.

12. *Rejection*—

12. 1. Cement may be rejected if it does not comply with any of the requirements of this specification.

12.2. Cement remaining in bulk storage at the mill, prior to shipment, for more than six months, or cement in bags in local storage in the hands of a vendor for more than 3 months after completion of tests, may be retested before use and may be rejected if it fails to conform to any of the requirements in this specification.

EXTRACT FROM I. S. 1625-1971.

Code of practice for preparation of lime mortar for use in buildings.

TABLE 1. MIX PROPORTIONS FOR LIME MORTARS (Clauses 5.3.2 and 5.8.1.)

Serial number and description of mortar.	*Maximum Part (by volume)* Lime.	Cement.	Lime Pozzolana mixture (See note).	Pozzolana.	Sand.	*Compressive strength of mortar at 28 days kg/cm².*	*Hardening Time after completion of work days.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1 Lime-Cement	1C	1	..	..	6	30 to 50	14
2 Lime-Cement	2B	1	8	..	9	20 to 30	14
3 Lime pozzolana Mixture ..	..	..	1	..	1.5	30 to 50	14
4 Lime cement	3B or 3C	.. 1	..	..	12	7 to 15	14
5 Hydraulic lime	1A	..	..	..	2	....	14
6 Lime pozzolana	1C	..	..	1	2	7 to 15	14
7 Lime	1B	..	..	..	3	5 to 7	28

NOTE.—For mortar in SL. No. 3 line pozzolana mixture shall be grade LP 40 conforming to I.S. 4098-1967 " Specification for lime pozzolana mixutre ".

6.2. *Mixing of plain lime Mortars* :

6.2.1. Putty and sand in the specified proportions shall be mixed with or without the addition of water on a dry water proof platform or in a mixer. The mix shall then be fed into a mortar mill with the required additions of water.

6.2.1.1. The mortar shall be raked continuously during grinding particularly in the angular edges of the mortar mill. Water may be added during grinding as required, but care shall be taken not to add more water than to bring the material being mixed to the working consistency. The mixing shall be done till every particle of aggregate is coated uniformly with the cementitious material.

6.2. 2. Dry hydrated lime and sand in specified proportion shall be mixed dry first and shall then fed into a mortar mill with required addition of water. The mixing shall be done in accordance with the 6.2.1.1. When factory made dry hydrated lime is used for making lime mortar, grinding of mortar in mortar mill is not necessary, the grinding may however help in thorough and intimate mixing and thus may not be harmful.

6.2.3. Generally, only as much quantity of mortar as would be sufficient for the day's work shall be mixed at a time.

7. *Precautions in use of mortars* :

7.1. Time of use.

7. 1.1. All lime mortars (prepared for masonry work) shall be used as soon as possible subject to the further provisions mentioned in 7.1.2. and 7.1.3.

7.1.2. If eminently hydraulic lime (Class A) is present as an ingredient, the mortar shall be used within four hours after grinding.

7.1.3. Lime mortar made with burnt clay pozzolanic materials shall be used within 24 hours of grinding.

7.2. All lime mortars after grinding shall be kept damp and shall never be allowed to go dry. This may be ensured by covering the ground mortar with wet sacks or by any other suitable means.

7.3. Partly set and dried mortar shall not be retempered for use.

EXTRACT FROM I.S. 2394—1965.

Code of practice for application of lime plaster finish.

TABLE 2—RECOMMENDED MIX PROPORTIONS.

Serial number.	*Type of coat.*	*Mix proportion.*	*Class of lime.*
(1)	(2)	(3)	(4)
1	Dubbing and first coat (Both for external and internal surfaces).	1 Lime : 2 to 3 sand	A and B
		or	
		1 Lime : 1 Surki : 1 to 2 sand.	
		or	
		1 lime : 2 to 3 Surki (for first coat in the case of two coat work).	C
2	Second coat ..	1 lime 2 to 3 sand ..	C
3	Neeru finishing coat ..	Fat lime and fine sand ground in equal proportions.	C

NOTE.—Lime plastered finishes are not suitable for external surface in areas of heavy rainfall.

466—3—4A

EXTRACT FROM I.S. 1661—1972

Code of practice for application of cement and cement lime plaster finishes.

11. *Preparation of Plaster* :

11.1. *Proportioning.*

11.1.1. The material used in the preparation of plastering mixes may be measured by volume using gauge boxes.

11.1.2. Cement shall be measured by weight. For the purpose of proportioning one cubic metre of cement shall be taken to weight 1440 kg. approximately.

11.1.3 *Quantity of water*—For general cement plaster work with 1:3 proportion the quantity of water required is about 70 per cent by weight of cement. This may however, vary depending on the following factors and adjustment shall be done as explained in IS. 2250—1965*.

11.1.4. (*a*) The nature and condition of the fine aggregates.

(*b*) The temperature and humidity at the time of working.

(*c*) Richness of the mix, namely whether richer or leaner than 1:3.

(*d*) The varying quantities of lime in composite mortars; and

(*e*) The use of admixtures added for improving the workability.

11.2. *Mixing* :

11.2.2. *Cement Plaster.*—Cement and sand shall be mixed dry in the required proportions to obtain a uniform colour. Water shall then be added to get the required consistency for the plaster.

11.2.4. Mixing may be done either manually or mechanically. "Hand mixing" shall be carried out on a clean, water-tight platform. During mixing, the mortar shall be heed back and forth for 10 to 15 min. after the water is added. In "Machine Mixing" the mixer shall run at least 5 min. after placing all the ingredients in the drum.

11.2.4.1. Machine mixing is preferable to hand mixing for all mortars.

*Code of practice for preparation and use of masonry Mortars.

EXTRACT FROM I.S. 2541—1965.

Code of practice for use of lime concrete in buildings.

4.3. *Mix proportions.*

4.3.1. The mix proportions for use in the preparation of lime concrete for different situations of use shall be as given in Table 1.

TABLE 1 : RECOMENDED MIXES FOR USE IN LIME CONCRETE.

(*Clauses* 3.4.2, 4.3.1, 4.4.1, *and* 4.6.2.)

Serial number and Situations.	*Types of Mortar (all Proportions by volume).*	*Class of lime as in I. S. 712-1964*†	*Type of coarse aggregate*	*Minimum size of coarse aggregate.*	*Proportion of mortar to coarse aggregate (by volume.)*	*Remarks.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1. In foundations	1 Lime, 2 Sand 1 Lime, 1 Surkhi, or cinder 1 sand. I Lime, 2 Surkhi or cinder. 1 Cement, 3 lime 12 Sand.	A B or C or A B or A or C B or C	Stone or broken brick.	50 mm 50 mm 50 mm 50 mm	40 to 50 parts of mortar to 100 parts of aggregate depending upon the grading aggregate.	*
2. Base concrete under floor finishes on ground.	1 Lime. 2 sand 1 Lime, 1 Surkhi or cinder, 1 sand 1 Lime, 2 Surkhi or cinder 1 Cement, 3 lime, 12 sand.	A B or C or A B or C or A B or C	Stone or broken brick.	50 mm 50 mm 50 mm 50 mm	40 to 50 parts of mortar to 100 parts of aggregate depending upon the grading of aggregate.	Suitable for dry and tolerably wet sub-grades.

Remarks : Suitable for dry and tolex wet sub-grades.

3. Levelling course or cushioning layer under floor finishes laid on structural slabs.	1 Lime, 2 sand 1 Lime, 1 Surkhi or Cinder, 1 sand 1 Lime, 2 Surkhi or cinder 1 Cement, 3 lime 12 Sand.	A B or C or A B or C or A B or C	Broken brick or cinder.	20 to 25 mm Do. Do. Do.	40 to 50 parts of mortar to 100 parts of aggregate.	....
4. Filling over haunches of masonry arch work.	1 Lime, 2 Surkhi 1 Lime, 1 Surkhi, 1 Sand.	B or C or A B or C or A	Broken Brick.	25 mm 25 mm	45 parts of mortar to 100 parts of aggregate.	....
5. Roof terracing	1 Lime, 2 Surkhi	C	Broken brick.	25 mm	40 parts of mortar to 100 parts of aggregate.	....
6. Light filling over tructural slab.	I Lime, 2 Sand 1 Lime, 1 Surkhi or cinder, 1 sand 1 Lime, 2 Surkhi or cinder. 1 cement, 3 lime, 12 sand	A, B or C B or C or A B or C	Broken brick or cinder	Any suitable size but usually not more than 25 mm.	40 to 50 parts of mortar to 100 parts of aggregate.	....

* Normally suitable for buildings not more than three storeyes high and in places with dry subgrade, that is sub-soil water level no with in 2.5 metres of foundation level.

NOTE 1.—The mixes given in the table are for general guidance and may be modified to suit the strength requirements for various uses to which the concrete is put to.

NOTE 2.—Surkhi and cinder need not be used where class A lime is used.

† Specification for building limes (revised).

EXTRACT FROM I.S. 1692–1960.

Method for simple bend testing of steel sheet and strip less than 3 mm thick.

1. *Scope.*

1.1. This standard prescribes the method of conducting simple bend test on steel and strip less than 3 mm thick.

2. *Principle of test.*

2.1. A straight test piece is submitted to plastic deformation by bending without reversing the direction of flexure during the test.

2.2. The bending is carried out until one leg of the test piece makes, under load a specified angle with the extension of the other (*See* Fig. 1). The axis of the two legs of the specimen remain in a plane perpendicular to the axis of bending.

2.3. In the case of 180° bend, the two surfaces may depending on the requirements of the specification, i.e. flat against each other or may be paralled at a specified distance. An intermediate piece may be used for the control of this distance (*See* Fig. 2).

3. *Reference numbers and symbols.*

3.1. The following reference numbers and symbols have been used in this standard.—

Reference number (*See* Figs. 1 to 4).	*Symbol.*	*Description.*
1	a	Thickness of test piece.
2	b	Width of test piece.
3	..	Distance between support rollers (*See* Fig. 1).
4	oc	Angle of bend.
5	R	Radius of support rollers.
6	D	Diameter of mandrel
7	r	Internal radius of test piece after bending.

4. *Test Piece.*

4.1. The thickness of the test piece shall be that of the sheet from which the sample is taken, the skin remaining intact.

4.2. The width of the test piece shall be 20 ± 0·5 mm (or 3/4 in ±3/16 in.) strip material of a smaller width may be tested with the full width as supplied.

4.3. The test piece shall be prepared so that the edges are free from burrs and cracks. Cold worked zones may be removed by machining or filing. However, the test shall be acceptable, whether or not the edges have been prepared, provided the resultant bend is satisfactory.

5. *Method of test.*

5.1. The test piece shall be tested either hot or cold as specified in the materials specification.

5.2. A common method of carrying out the test is to lay the test piece on two parallel supports and bending it in the middle by means of a mandrel (*See* Fig. 1).

5.3. The legs of the test piece may be.

(*a*) brought to a specified angle (*See* Fig. 1).

(*b*) brought parallel to each other at a given distance apart (*See* Fig. 2) or

(*c*) brought into contact with each other (*See* Fig. 4) according to the material specification.

5.4. Another method of test is by holding one end of the test piece between two blocks and bending the specimen over one of the blocks which is rounded to the specified radius (*See* Fig. 3) and is of sufficient hardness.

5.5. In both the methods the bending force shall be applied slowly with the object of permitting free plastic flow of the material.

6. *Test Requirements.*

6.1. After bending, the outside, of the bent portion should be examined.

6.2. The interpretation of the appearance of the outside of the bent portion shall be done in accordance with material specification

EXTRACT FROM I.R.C. (1973).

Specification for road and bridge works.

For Bituminous courses.

Fine aggregates : The fine aggregates shall consist of crusher run screenings, natural sand or a mixture of both. These shall be clean, hard, durable, uncoated, dry and free from injurious, soft or flaky pieces and organic or deleterious substances.

For asphaltic concrete.

Fine aggregates : The fine aggregates shall be the fraction passing 2.36 mm sieve and retained on 75 micron sieve, consisting of crusher run screenings, natural sand or a mixture of both. These shall be clean, hard, durable, uncoated, dry and free from any injurious soft or flaky pieces and organic or deleterious substances.

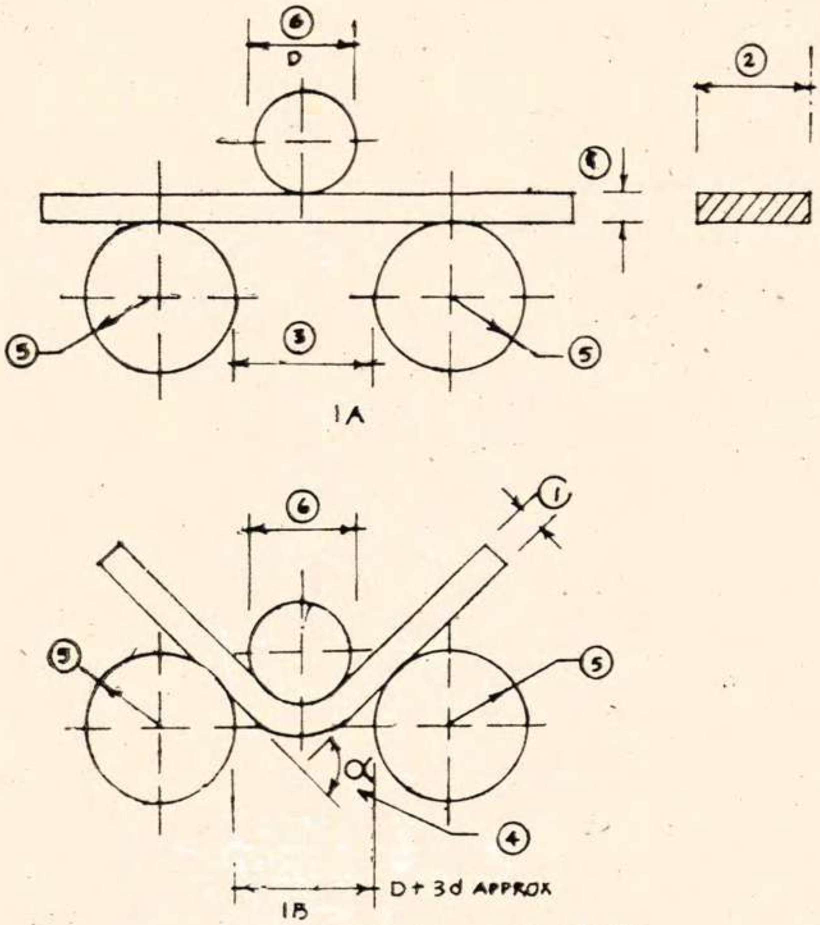


FIG. 1. SIMPLE BEND TEST

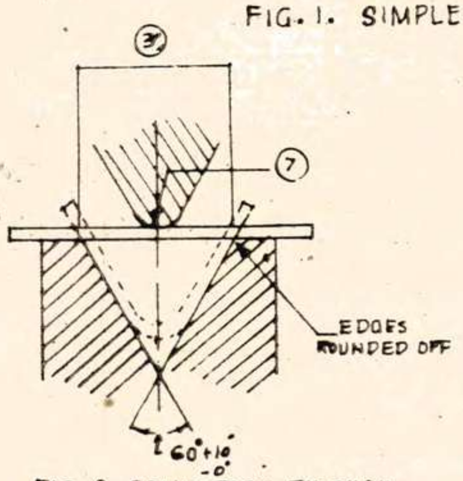


FIG. 2. BEND TEST THROUGH AN ANGLE OF 120°

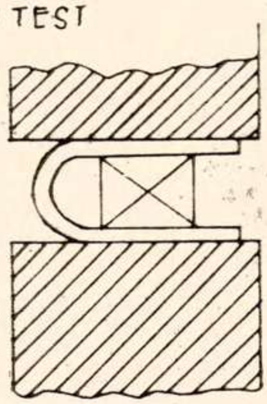


FIG. 3. BEND TEST THROUGH 180° OVER A SPECIFIED RADIUS

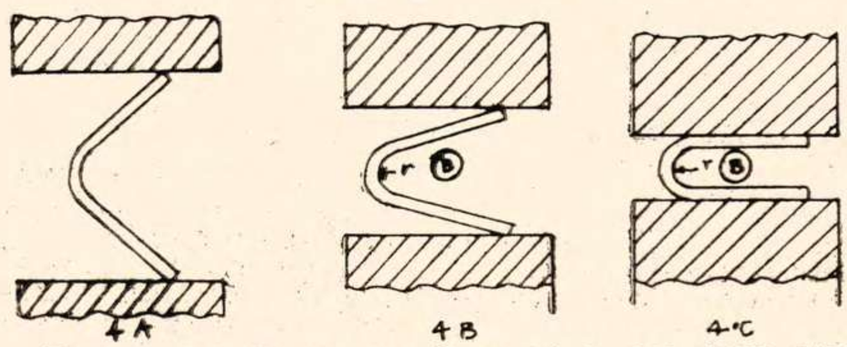


FIG 4. FREE BEND TEST THROUGH A SPECIFIED ANGLE

EXTRACT FROM I. S. 1849—1967.

Code of practice for design and installation of lime kilns.

4.0. *Installation of vertical mixed feed shaft kilns.*

4.1. A Vertical mixed feed shaft kiln shall consist of the following :—

(*a*) Foundation for the kiln ;

(*b*) Base of the kiln ;

(*c*) The superimposed structure made up of :

(1) discharging place,

(2) discharging device, and

(3) the shaft of the kiln ;

(*d*) The chimney ;

(*e*) Roof and platforms ; and

(*f*) Stairways.

4.2. *Foundation for the Kiln* :—A strong foundation shall be laid depending on the nature of soil, taking into consideration the total pressure over it of the kiln and its contents when fully charged.

4.3. *Base of the Kiln* :—The base of the kiln shall be of solid brick work platform or pillars of brickwork, masonry or RCC or rectangular tunnelled base (*see* Fig. 1-A to 1-C).

4.3.1. *Solid brickwork platform* (Fig. 1-A) :—This is specially suited for short or low shaft kilns. The platform shall consist of filled rubble and stone aggregate and shall be several centimetres above ground level. This would facilitate easy removal of lime by workers without bending and collection into bins conveniently.

4.3.2. *Pillars of brickwork, masonry or R.C.C.* (Fig. 1-B) :—This type of base is suited to both low and high shaft kilns. The pillar should be sufficiently strong to bear the entire pressure of superimposed kiln and its contents. The pillars shall be so arranged as not to interfere with the discharge and removal of lime.

4.3.3. *Rectangular Tunnelled Base* (Fig. 1-C) :—For high shaft kilns at rectangular tunnelled base of concrete secures a better distribution of load and is very strong. The width of the tunnels shall be such that trucks may easily pass through for being loaded with manufactured lime. This arrangement is very convenient and saves on costs considerably.

4.4. *Discharging place* :

4.4.1. The discharging place is the part of the lime kiln which is at the bottom of the shaft, and into which lime falls through the discharging device. It may be of the same diameter as the shaft and has one or two openings through which the lime is removed.

4.4.1.1. The opening shall be of convenient size and shall be fitted with mild steel plate doors of flood gate type with counter weight balancing for facility of easy operation (*see* Fig. 2.).

4.4.2. The floor of the discharging place shall be hard and smooth finished and sufficiently sloping for easy removal of lime.

NOTE :—In case of shaft kilns where a discharging device is not used but lime is tapped out through discharging holes at the bottom of the shaft there shall be no separate discharging place.

4.5. *Discharging device* :—A discharging device is used to discharge lime from the cooling zone of the kiln, and it is fitted to the bottom of the shaft. The lime passing through the discharging device is collected in the discharging place.

NOTE :—Mention is made of a particular type of discharging device in 4.5.1. to 4.5.8. For suitability of other types of devices, advice may be sought from an equipment manufacturing firm or practising consultant.

4.5.1. The discharging device may be only a discharging grate, or a circular sloping grate below which a discharging grate is attached. When the diameter of the kiln is about 1.5 m, only a discharging grate may be fitted. For larger diameters a sloping grate attached to a discharging grate shall be used.

4.5.2. The discharging grate shall consist of a mild steel circular angle iron frame of diameter corresponding to the bottom of the kiln, subject to a maximum diameter of about 1.5. m. Pairs of movable curved bars shall be suitably fixed to the frame, the distance between the bars in a pair being 4.5 to 8 cm. The curved bars shall have projections outside the circular mild steel frame and the ends shall be shaped as handles. The space between two curved bars in a pair at rest position shall be nearly half the size of the limestone.

4.5.2.1. In normal or rest position the curved bars cannot allow the limestone pieces to fall, through as the gap is half the size of the stone pieces. When lime has to be discharged, the curved bars may be turned opposite by means of handles so that the gap between the concave faces becomes double and lime may easily pass through. (*See* Fig. 3).

4.5.2.2. The lime can be discharged through the entire bottom of the kiln uniformly by the device.

4.5.3. In case of kilns diameter 1 to 1.5 m. the discharging grate which shall have the same internal diameter as the bottom of the shaft may be fitted over the discharging place. The handles connected to the curved bars shall be positioned on either side of the kiln.

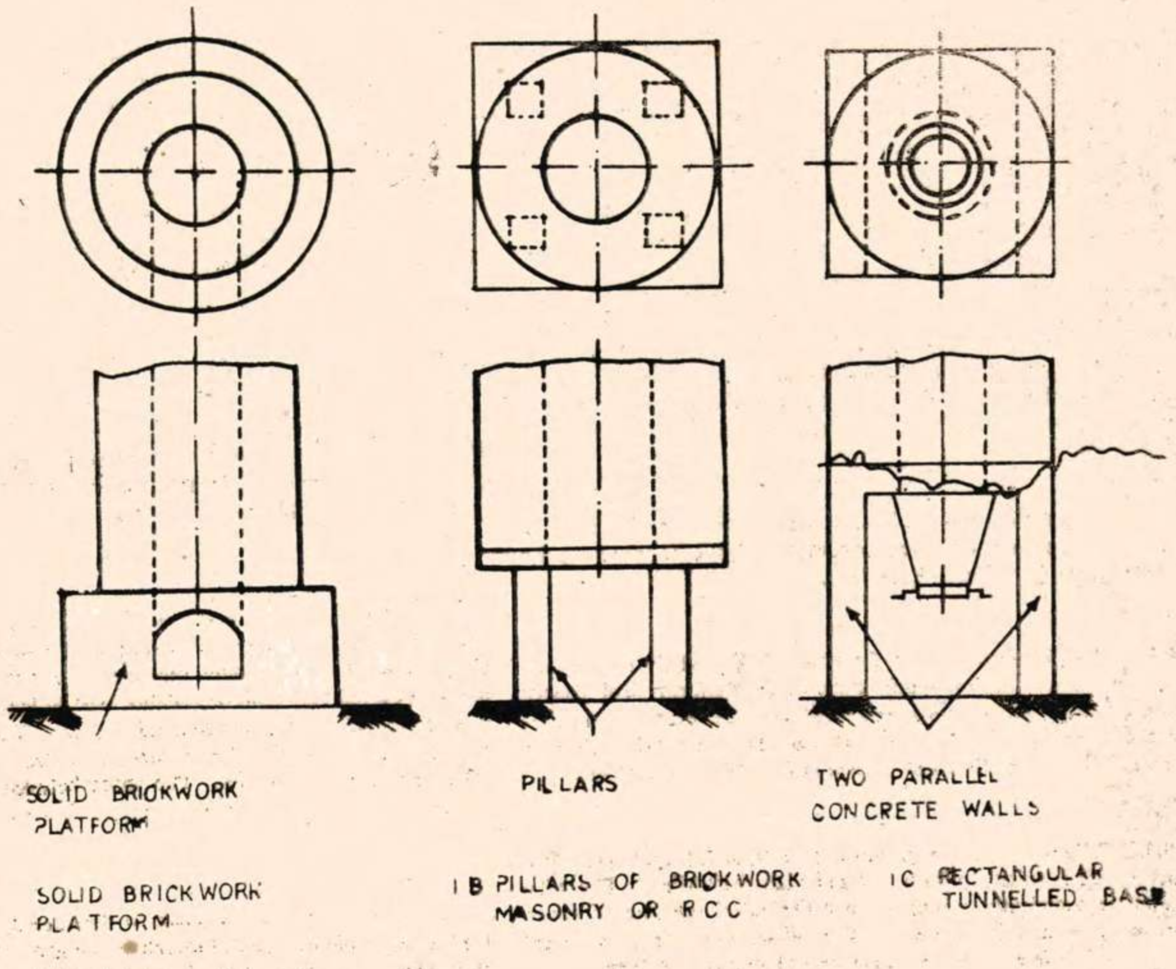


FIG. 1. TYPICAL CONSTRUCTIONS FOR BASE OF LIME KILN.

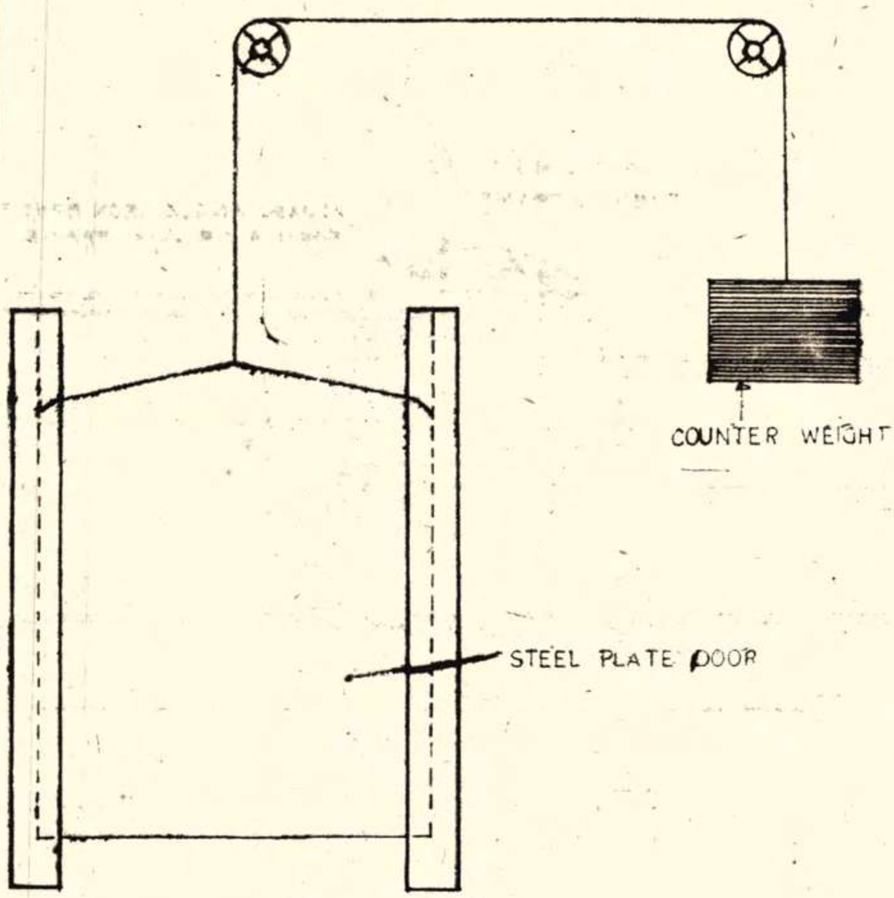
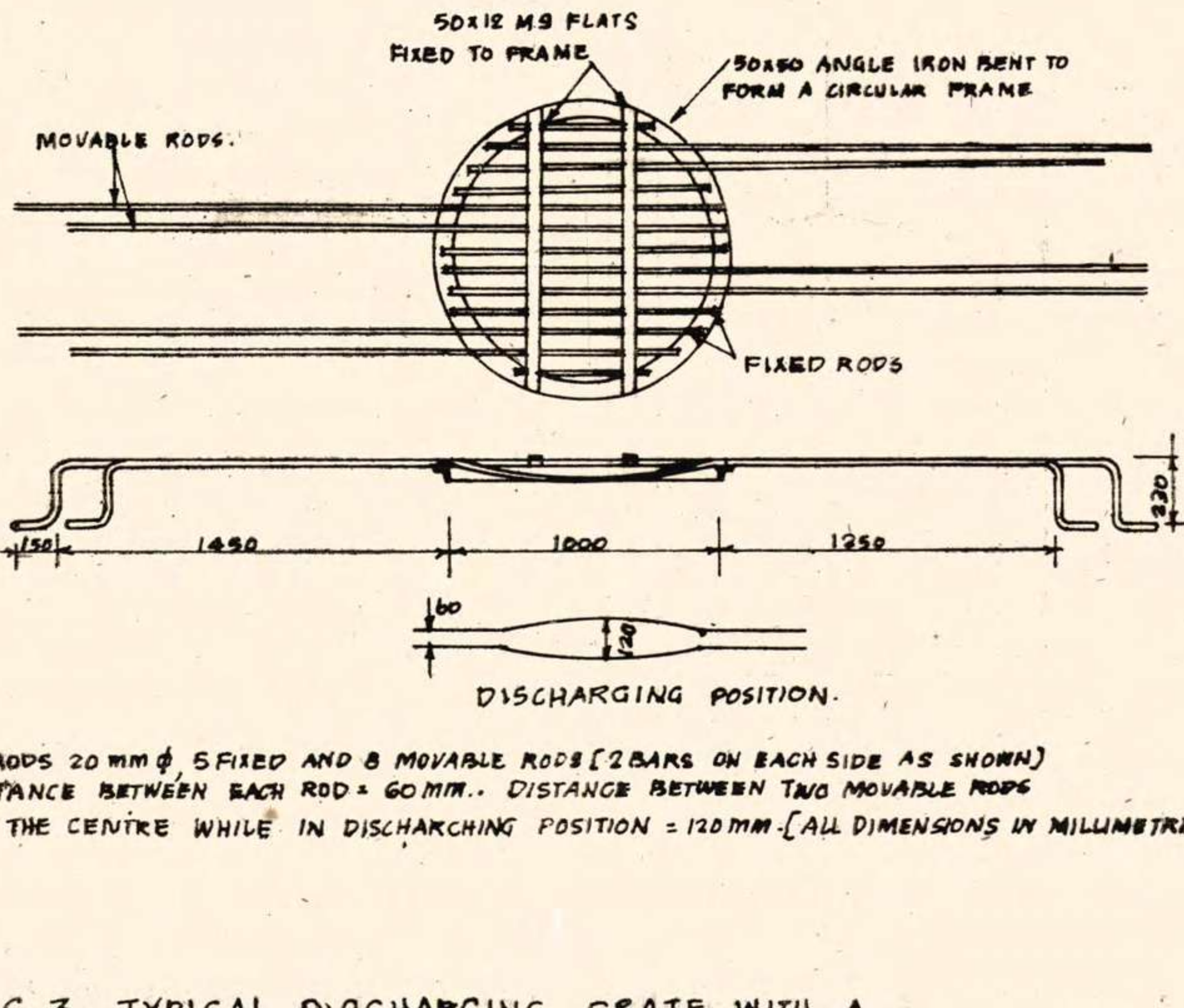


FIG 2 TYPICAL DISCHARGING GRATE FLOOD GATE TYPE

466—3—5



13 RODS 20 mm ϕ, 5 FIXED AND 8 MOVABLE RODS [2 BARS ON EACH SIDE AS SHOWN]
DISTANCE BETWEEN EACH ROD = 60 mm.. DISTANCE BETWEEN TWO MOVABLE RODS
AT THE CENTRE WHILE IN DISCHARCHING POSITION = 120 mm. [ALL DIMENSIONS IN MILLIMETRES]

FIG. 3. TYPICAL DISCHARGING GRATE WITH A CIRCULAR FRAME FOR LIME KILN.
(MOVABLE RODS IN REST POSITION)

4.5.3.1. In a discnarging grate mild steel bars of same diameter shall be used and its size shall be from 25 mm. to 50 mm.

4.5.4. In case of kilns with large diameters the tapping of lime is facilitated by fixing a cooler to the bottom of the shaft. It consists of a circular sloping grate formed of thick mild steel plates having the same diameter as the bottom of the shaft and sloping down to an angle of about 60° leading to an opening of about 1·5 m. to which a discharging gtate is fitted. The handles of the curved bars are confined within the discharging place, which may be operated by levers outside.

4.5.4.1. The thickness of plates of sloping grate and diameter of mild steel bars shall be as specified by a mechanical engineer.

NOTE.—The cooler facilitates the discharge of lime through smaller area and at the same time allows the cooling of lime by cold air.

4.5.5. The cooler shall be fixed over a stand on the discharging floor-see. fig. (4).

4.5.6. The cooler which shall be an accessory to the kiln shall not be tightly attached to the bottom of the shaft to make allowance for expansions and contractions.

4.5.7. The over all height of the cooler shall preferablv be one to two metres.

4.5.8. The cooler shall be sufficientlv strong to withstand the weight of the contents above.

4.6. *Shaft of the kiln*.—The shaft is the part of the lime kiln in which lime stone is calcined and from which cooled lime is withdrawn. If discharging holes are built within kiln wall, then they form a part of the shaft, otherwise the shaft is the part constructed over the discharging device.

4.6.1. The shaft shall generally be cylindrical and in case a taper is required the tapering shall be 15 cm. for every 3 m. height of the shaft.

NOTE.—The shaft of this nature is very easy to construct and works very satisfactorily.

4.6.2. *Construction of the shaft*.—The shaft of the kiln shall consist of :

(*a*) lining,

(*b*) insulation,

(*c*) outer wall or the shell, and

(*d*) steel casing or metal bands.

4.6.2.1. The lining of the shaft shall be suitable to withstand satisfactorily high temperature , chemical action of lime and products of cumbustion and the abrasive action of the descending stone and lime.

4.6.2.2. The upper part of the lining, corresponding roughly by one-fourth the height of lining from top, shall be constructed in hardstone, granite, sandstone or fire bricks. When sandstones are used they shall be so placed that their laminations are horizental, but not vertical, to avoid spalling. The rest of the lining up to the bottom shall be fireclay bricks. They shall preferably be of high alumina content and of uniform texture and smooth surface.

466—3—5A

4.6.2.3. The laying of the fire bricks shall be done with thin joints. (Thicker joints are readily attacked by hot lime and soon fire bricks begin falling out).

4.6.2.4. For better durability and performance, fewer joints of fireclay blocks may be used. They may be tapered to suit the internal diameter of the kiln which renders laying very easy and avoids "spaces" when bricks are used.

4.6.2.5. The lining when constructed shall present a monolithic appearance.

4.6.2.6. The thickness of the lining shall be 22.5 mm. or more, if desired.

4.6.3. *Insulation of the kiln*.—To reduce the loss of heat by radiation the kiln shall be insulated between the lining and the outer wall. The insulation may be done by suitable means, such as by filling about 10 cm. of fireclay in a dry state or by filling with thick burnt paddy husk.

NOTE.—Where the outer wall thickness is about one metre or more, excluding the lining separate insulation is not necessary.

4.6.4. *Outer wall or the shell*.—Outer wall or the shell shall be constructed with common burnt clay bricks conforming to Class 1 of I. S. 3102—1965£ or locally available stone, which ever is economical and convenient, to give strength and stability to the kiln.

4.6.4.1. The thickness of the outer wall shall preferably be 70 cm, exclusive of the lining, when steel casing is not used.

4.6.4.2. When steel casing is used the thickness of the outer wall may be only 50 cm., exclusive of the lining. If a lining of 50 cm. is used instead of 25 cm., the thickness of the outer wall may not exceed 25 cm.

4.6.4.3. If the kiln has a taper, the outside wall shall also correspond to the tapering.

4.6.4.4. The bricks or the stones in the outer wall shall be well inter-locked with lime mortar (*see* I. S. 1025—1962 *) for better strength. The joints shall be thin and firm.

4.6.4.5. *Steel casing for steel-shell kiln*.—A steel casing may be used for lime kilns for strength and to render them gas-tight. The casing shall be built of sheets of steel 1 m^2 and 7 to 10 mm. thick and fastened together by means of rivets. The casing shall be first erected on the base of the kiln and interior walls shall be then built inside it.

£ Classification of burnt clay bricks.

*Code of practice for preparation and use of lime mortar in buildings.

4.6.5. *Metal Bands*.—For masonry kilns metal bands shall be used around the periphery of the kiln to strengthen the shaft and to reduce the tendency to crack. The metal bands may be of mild steel, about 75 mm. width and about 3 mm. thickness. The bands shall be braced around the kiln and the ends shall be attached to shackles on a screw movement. These shall be tightened at frequent intervals. The distance between each metal band may be one metre or more.

4.6.6. *Poke Holes*.—Poke holes may be provided around the periphery of the kiln at diffrent heights to observe the progress during operation of the kiln and also to disintegrate sticking lumps in "scaffolding" or "caking" formation with pokers.

4.6.6.1. The Size of the poke hole shall be 12x8 cm. and the length shall correspond to the thickness of the kiln wall including the lining.

4.6.6.2. The poke holes when not in use may be plugged tightly to prevent side drafts. Those in the burning zone may be covered with fireclay plugs for ready view and measurement of temperatures.

4.6.6.3. The poke holes shall be spaced at every half metre to one metre and spread around the circumference of the kiln.

4.6.6.4. Where a casing is used the doors of the poke holes shall be attached to the casing and shall be gas-tight.

4.6.7. *Chimney*.—Wherever an additional draft is needed, lime kilns shall be fitted with a chimney.

NOTE.—The diameter of the chimney stack for lime kilns may be calculated from the following formula :—

$$D = 0{\cdot}3 \sqrt{\frac{c\,(t+238)\;(r+18)}{r}}$$

Where

D—diameter of the chimney-stack in centimetres,

c—kiln capacity in t of lime/24h,

t—temperature of the escaping gases in °C, and

r—weight of the lime burnt for every kg. of fuel used.

Example.—If the output of a kiln is 10 t of lime/24h, the temperature of the escaping gases is 300° C, and the weight of the lime is 4 kg for every kg. of fuel burnt (4:1), the diameter of the Chimney-stack. is :—

$$D = 0{\cdot}3 \sqrt{\frac{10\,(300+238)\;(4+18)}{4}}$$

$= 50$ cm. (nearly).

4.6.7.1. The height of the chimney depends largely on the location of the kiln. If the kiln is situated at the bottom of a quarry or surrounded on all sides, a high chimney is necessary to create the necessary draft. However, if it is in open with a fair velocity of wind, a much shorter chimney may be quite satisfactory. A chimney height of 2 to 6 m. would generally be found sufficient.

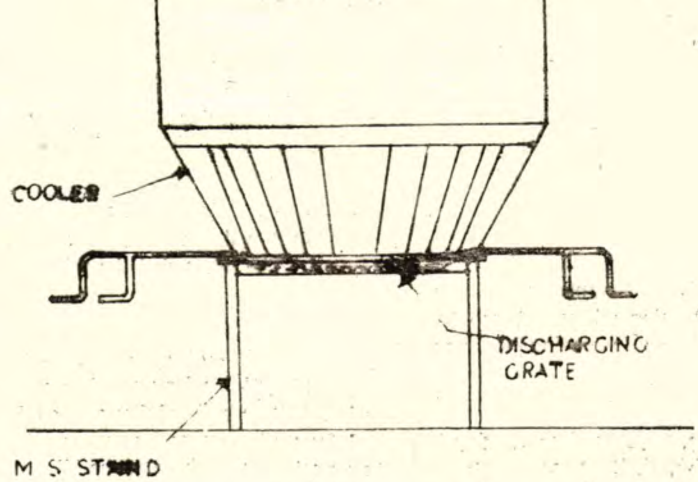


FIG 4 FIXED OVER DISCHARGING GRATE MOUNTED ON STAND

4.6.7.2. Two types of chimneys are commonly employed. In the first type the chimney may be of galvanized iron sheet or cast iron. The bottom of the chimney piece is welded to a circular disc whose diameter is slightly more than the internal diameter of the kiln, so that it may rest securely over it. A soft plaster or clay packing between the kiln and the disc renders the joint almost gas-tight (see Fig. 5). The chimney may be raised or lowered for loading the kiln, by counterpoised ropes attached to it.

4.6.7.3. The second type of chimney is known as submerged chimney. This consists of a metal pipe 4 to 6 m. high and of suitable diameter. The pipe is thicker and tapered at the base and is submerged or dipped one metre below the top of, the stone in the kiln. A tight cover may be lowered on to the top of the kiln through the chimney. This device may be found very efficient for high shaft kilns.

4.6.8. *Roof.*—For protection of kiln against rains and to enable workers to operate efficiently in all types of weather, a roof shall be provided over the kiln. It shall be of steel girder framework supported on horizontal girders. It shall consist of "housing" at the top of the kiln and suitable platforms with strong railings at different heights of kiln.

4.6.8.1. Enough space shall be provided in the "housing" at the top for strong successive batches of stone and fuel. The platforms at different heights should have space of about 1·5 m. from the kiln walls. For short kilns, sheds shall be provided.

4.6.8.2. *Stairways.*—Strong stairways with rails shall be provided to reach the "housing" at the top and platforms.

EXTRACT FROM I. R. C. (1973).

Specification for road and bridge works

403.2.7. Grading requirements of coarse aggregates: The coarse aggregates shall conform to one of the gradings given in Table 400—4 as specified.

TABLE 400. 4—GRADING REQUIREMENTS OF COARSE AGGREGATE.

Grading number.	*Size range,*	*Sieve designation.*	*Percentage by weight passing the sieve.*
(1)	(2)	(3)	(4)
1	90 mm. to 40 mm.	100 mm.	100
		80 mm.	65—85
		63 mm.	25—60
		40 mm.	0—15
		20 mm.	0—5
2	63 mm. to 40 mm.	80 mm.	100
		63 mm.	90—100
		50 mm.	35—70
		40 mm.	0—15
		20 mm.	0—5
3	50 mm. to 20 mm.	63 mm.	100
		50 mm.	95—100
		40 mm.	35—70
		20 mm.	0—10
		10 mm.	0—5

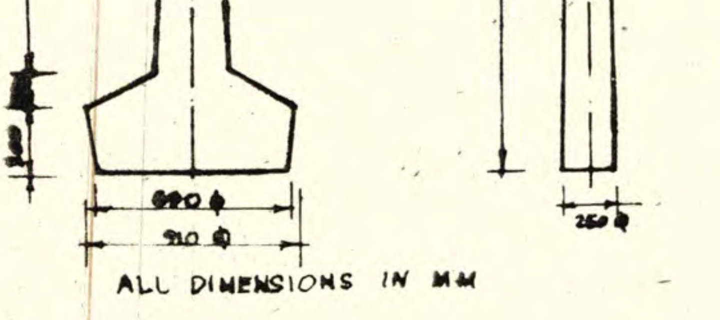


FIG 5 TYPICAL CHIMNEY

SECTION II

CLEARING SITE, DISMANTLING, QUARRYING AND BLASTING

SECTION II.

CLEARING SITE, DISMANTLING, QUARRYING AND BLASTING

CONTENTS.

466-3—6

SECTION II.

CLEARING SITE, DISMANTLING QUARRYING AND BLASTING,

INDIAN STANDARDS EXTRACTS.

SECTION II

CLEARING SITE, DISMANTLING, QUARRYING AND BLASTING

SPECIFICATION No. 16.

REMOVAL OF BUSHES, TREES, PRICKLY PEAR ETC.

1. The prickly pear shrubs, weeds and grass shall be cleared and the roots shall be throughly grubbed up. These shall be disposed of in one of the ways specified below, as directed by the Executive Engineer.

1.1. They may be removed to a convenient spot and shall be completely burnt :—

OR

1.2. They may be buried in pits with at least 30 cm. depth of earth on the prickly pear at ground level. These pits may be dug in the bed of tank or at any place shown to him by the Officer deputed by the Executive Engineer.

2. Under no circumstances shall cleared stuff be thrown by the side of or heaped on existing vegetation, without one of the aforesaid steps being taken for its destruction.

SPECIFICATION No. 17.

CLEARING AND LEVELLING SITE.

1. The area described or shown on the relevant site plan shall be cleared of all obstructions, loose stones, non-required materials and rubbish of all kinds. All brushwood shall be cleared and the roots entirely grubbed up. No trees are to be cut down and removed without the instructions of the Executive Engineer. Those which are cut down shall be grubbed up. The same remarks apply to jungle clearance. Trees to be preserved will be defined in an addendum specification.

2. The products of the clearing are to be stacked in such place and manner as may be ordered by the Executive Engineer and the ground shall be left in a perfectly clean condition ; all products of the clearing shall be the property of Government and shall be disposed of as the Executive Engineer may direct.

3. All holes or hollows, whether originally existing or produced by digging up roots shall be carefully filled up with earth, well rammed and levelled off, as may be directed.

4. In the case of buildings, in order to clear cut white-ants, the whole area proposed to be occupied by the buildings, together with an extra width of 3 m. all round shall be excavated to a depth of 15 cm. and soaked with water. Spreading wet straw over the area bring the ants to the surface. If a white-ant's nest exists on the site, its presence will become evident in a few days, whereupon the nest should be completely dug out, the queen ant destoryed, and the nest flooded with boiling water containing a solution of arsenic. The area wherefrom the top loose soil has been removed shall be refilled with earth from a source approved by the Executive Engineer and properly levelled. It should be observed that no earth filling is to be done in cases where the holes dug to remove the white-ant's nest go below the bottom of foundation level. Concrete filling will in such cases be done under the orders of the Executive Engineer and the contractor will be paid for the extra quantity of concrete at his agreement rate for the same.

5. The contract rate for this item of work shall be for complete compliance with this specification. If any extra work is necessary under this heading, a separate arrangement will be made with the contractor, in writing, before the work begins.

466—3—6A

SPECIFICATION No. 18.

DISMANTLING BUILDINGS.

1. The buildings or other structures defined in the schedule and handed over shall be dismantled down to ground level or to bottom of foundations or the posts, iron works, etc., which are specified shall be dug up to or below ground level,as may be specified in the sche duleitem wording.

2. Special care shall be taken thatthe materials are as little damaged as possible, in the process of dismantling. The value of materials broken or damaged through carelessness shall be recovered from the Contractor.

3. All serviceable materials shall be removed and stacked or disposed off as specified.

4. All mere rubbish shall be collected in heaps for disposal in the manner specified in the tender notice.

5. Method of payment will be defined in the tender notice and further supplementary specification regarding re-usage of useful material given for each case of such work.

SPECIFICATION No. 19.

INSTRUCTIONS TO CONTRACTORS ON BLASTING OPERATIONS.

1. All contractors who execute blasting operations in connection with Public Works Department Works for purpose of quarrying stones, road construction, excavating foundations, well sinking or for any other purpose, shall observe the rules and precautions set forth below and any further additional instructions which may be given by the Public Works Department Officer in immediate charge of the work, and shall be responsible for any accident which may occur to workmen or the public due to such blasting operations. The sub-Divisional Officer should frequently check the Contractor's compliance with the precautions.

NOTE : In cases where blasting is done departmentally without the services of a contractor (or piece-worker) the Sub-Divisional Officer shall himself see that all the precautions are observed.

2. *Blasting with Powder.*

2.1. Blasting operations must be in charge of competent persons appointed by the contractor and be carried out during fixed hours of the day, preferably during the mid-day lunch on hour or at the close of the work. No ignition of blasts shall be permitted by the Contractor except in the presence and under the personal supervision of such competent person. The Sub-Divisional Officer should fix the hours in written orders.

2.2. The contractor shall be responsible for the safe custody and storage of powder, dynamite or other explosives brought for use on the work, and shall keep such explosives separate from the fuses and detonators until being actually placed in the blast holes.

2.3. Instructions contained in I.S 4701—1968 shall also apply.

3. *Blasting with dynamite and other high explosives* :

3.1. Paragraphs 2.1, 2.2 and 2·3 of the instructions for Blasting with powder shall apply.

3.1.1. The competent person appointed by the contractor to be responsible for directing blasting operations will be referred to as Contractor's Supervisor in these rules.

3.2. The position of all holes to be drilled must be marked out .h white paint and the contractor's supervisor must take partiular note of these positions.

3.3. The drilling operations being finished, the contractor's supervisor must take a second inspection, and satisfy himself that the bore holes marked out by him have been drilled.

3.4. The Contractor's supervisor himself must prepare all charges necessary for the bore holes.

3.5. The contractor shall instruct his supervisor regarding the number of holes to be loaded and fired at one time. The number shall in no case be more than ten. The charges should be fired as far as practicable successively and not simultaneously.

3.5.1. The loading is to be done by the contractor's supervisor himself, and the position of the charge holes carefully noted.

3.6. Immediately before firing a blast, due warning must be given and the contractor's supervisor must see that all the coolies have retired to safety.

3.7. The safety fuses of the charged holes are to be lighted in the presence of the contractor's supervisor who must see that the fuses of all the holes charged have properly lignited.

3.8. Careful count must be kept by the contractor's supervisor and others, of each blast as it explodes.

3.9. After the blast, the contractor's supervisor must carefully inspect the work and satisfy himself that the full number of charged holes have exploded.

3.10 In case of misfired holes the contractor's supervisor must first examine the same and at once mark a red-cross over the holes.

3.11. The contractor's supervisor should also at once report to the contractor and sub-divisional officer in charge of the work all cases of misfire, the cause of the same and what steps were taken in connection therewith.

4. *Precautions against misfire* :

4.1. If a misfire has been found to be due to defective fuse detonators or dynamite, the whole quantity or box from which the defective article was taken must be returned to the office for inspection.

4.2. Instructions contained in I.S. 4081-1967 shall also apply.

5. *Notes on dynamite* :

5.1. Blasting with Dynamite covered by I.S. 4701-1968 shall also apply.

5.2. *Tamping* : Water, sand and clay are the best materials for tamping the first two being the easiest to use. Soft muram is also suitable. If water is used, the junction of the fuse with detonator must be made water-tight. This can be done by means of coal-tar thickened with quicklime. A piece of cloth can then be wrapped round the joint and kept in position with a few turns of yarn. In case of a misfire with clay tamping, the old charge must not be removed but a fresh hole should be bored not less than 15 cm from the old one, loaded and fired in the usual way. The explosion of the charge in the new hole will almost always explode the first charge. Should the first hole be of considerable depth, it will only be necessary to make the new hole 15 cm. lower than the top of dynamite in the old hole.

6. *Blasting operations* :

6.1. Hard rock requiring blasting shall comprise of:

(i) any rock or cement concrete for the excavation of which the use of mechanical plant or blasting is required ;

(ii) reinforced cement concrete (reinforcement cut through but not separated from the concrete) below ground level, and

(iii) boulders requiring blasting.

6.2. The classification of hard rock requiring blasting shall be decided by the Executive Engineer and his decision shall be final and binding on the contractor. Merely the use of explosives in excavation will not be considered as a reason for higher classification unless blasting is clearly necessary in the opinion of the Executive Engineer.

6.3. All the excavated materials quarried, from the P.W.D. or other Government quarries shall be the property of Government. Where the excavated material is directed to be used in the construction of embankment, etc., it shall be directly deposited at the required location.

6.4. All other materials quarried, which are not intended for use in the work shall be stacked neatly for future use on Governmen land as directed by the Executive Engineer. Unsuitable and surplus materials not intended for use in any part of the work shall be disposed of as directed by the Executive Engineer.

7. *Measurement* :

7.1. For rock excavation, the over burden shall be removed first so that necessary cross sections could be taken for measurement.

7.2. Where excavation is in trenches or from borrow pits in fairly uniform ground, the measurements of cutting in trenches or borrow pits shall be made.

7.3. Where the ground is not uniform, levels shall be taken before the start, after site clearance and after the completion of the work and the quantity of excavation in cutting is computed from these levels.

7.4. Where cross sectional measurements could not be taken due to irregular configuration, payments may be made for rock excavating on stack measurements after deducting 40 per cent for the quantity of voids.

7.5. The rate shall be per cu. m. of rock blasted and computed on the basis described above.

Extract From N. B. O.

Blasting and storage of explosives.

APPENDIX A

General.

1.1. The manufacture, storage, transport and use of explosives shall be covered by a licence as required by the current rules and legislature in regard to storage and handling of explosives, Instructions given hereunder wherever they are repugnant to the requirements laid down by the Central and the State Governments, shall be deemed to have been superseded by these rules. All departments officials and the contractors in charge of the use and storage of explosives, shall acquaint themselves with the current rules and legislation issued by the Government, and ensure that they are strictly complied with.

1.2. No child under 16 years of age and no person who is in a state of intoxication, shall be employed on the loading, unloading or transport of explosives, or be employed in, or allowed to enter in premises where explosives are handled and/or stored.

1.3. For issue of instructions on use of explosives, refer paragraph 3601 of the Indian Railways and Works Manual.

Carriage of explosive.

2.1. For detailed instructions about carriage of explosives, reference should be made to the I.R.C.A. Red Tariff No. 18 for "Conveyance by rail, of explosive and other dangerous goods". Special attention is invited to the following sections in the Red Tariff :—

Section number.	*Subject.*
104.2	Powers to return to consignor.
105.1	Pass required to accompany—Consignments.
106.1	Notice of despatch compulsory.
107.1	Documents required.
110.1 to 110.6 ..	Packing.
111.1 to 111.4. ..	Marking and levelling.
115	Handling.
115	Precautions
116	Storage.
119 to 124	Trains by which despatch is permissible.
124	Types of wagons and quantities permitted.
125 and 126	Carriage in brake vans, passenger compartments, etc.

2.2. The transport of explosives by rail, ship or other public conveyance, is regulated by the rules framed by Government on the subject. The civil authorities should be contacted to obtain the rules in force.

2.3. Every consignment to or from a "storage Magazine" must be accompanied by a guard and a responsible person experienced in the handling of explosives.

2.4. Detonators and explosives are not to be conveyed in the same consignment. Inflammable materials such as matches, kerosene etc., are, not to be carried in the same consignment with either explosives or detonators.

2.5. Before explosives are removed each case, barrel or package is to be carefully examined to ascertain that it is properly closed and shows no sign of leakage.

2.6. Should any case, barrel or package, appear to be damaged or in a dangerous condition it is to be removed separately and with special care.

2.7. Cases containing dynamite should not be exposed to the sun, or allowed to get damp.

2.8. Where the weight of the explosives transported in any vehicle exceeds 900 kgs. they shall be placed in the interior of the vehicles which shall be enclosed on all sides with wood or metal, so as to effectually protect the explosives from communication of fire and the vehicle shall be locked. When the weight of explosives does not exceed 900 kg. and unless they are carried in the manner laid down above, they must be completely covered with fire proofed cloth, tarpaulins or any other suitable material. So as to effectually protect explosives from communication of fire.

2.9. Explosives should not be moved during the thunder storm or dust storm.

2.10. No person except the driver should be allowed to travel on a vehicle conveying explosives, He shall not drive, conduct or manoeuvre the vehicle in a dangerous or negligent manner.

2.11. No carriage of vessel shall be used for transporting explosives unless all iron or steel therein with which a package containing any explosives is likely to come in contact, is effectually covered with lead, leather, wood, cloth or other suitable material. No lights should be carried on the vehicle carrying the explosives.

2,12. No person is to be allowed to smoke or even to carry matches when accompanying a consignment of explosives.

2.13. No operation connected with loading, unloading and handling of explosives shall be conducted between sunset and sunrise.

2.14. No explosives shall be brought to any place of loading until the carriage or vessel into which it is to be loaded, is at the place in readiness to receive it. A consignment of explosives should be conveyed direct without delay or unnecessary stoppage on the way.

2.15. In moving explosives, the cases should be carried or passed from hand to hand, not thrown, dragged or dropped. Barrels are to be carried, not rolled.

2.16. When explosives are being put into or taken out from a storage magazine the men should be divided into two gangs, one working inside the magazine and the other outside; no persons from either gang being allowed to cross the threshold while the work is going on.

2.17. The maximum quantity of explosives permitted to be carried by each consignment is fixed by the "Explosives Rules, 1940" as under—

(i) 4500 kg. in any one Railway wagon.

(ii) 2700 Kg. in any one carriage other than a railway wagon.

(iii) 22,500 Kg. in any one boat.

Custody and storage of explosives.

3.1. The explosives shall not be stored anywhere but in a special magazine to be built for the purpose. The site of the magazine shall be fixed by the Engineer-in-charge in consultation with civil authorities according to the rules in force. Explosives must not be exposed to the sun but must always be kept under cover.

3.2. Magazines may be considered as of two kinds viz., "Storage Magazines" and "expense Magazines". The former may be in any convenient position but the latter should be near the site of the work on which the explosives are to be used.

3.3. A service supply shall be storaged by the Supervisor in charge in an "expense magazine" to be built at site according to the Government rules in force on the subject, and should if practicable, be erected in such a position that in the event of an explosion neither the work nor the men employed on the same are likely to be affected, it must in no case be placed inside a tunnel mine or quarry.

3.4. For the site of a mag zine, an isolated position should be selected a a considerable distance from any town, railway station, or place of public resort, complying with the table of distance to be kept clear around explosive magazines, as per rules in force.

3.5. Under no circumstances should magazine be erected with 400 m of any working kiln or furnace, and similarly after a magazine has been constructed such operations as lime or charcoal burning should not be allowed within 400 m of the magazine.

3.6 The site for a magazine should, if practicable, be so arranged that in the event of explosion, any neighbouring town, station or other place of public resort, would be sheltered by intervening high ground. Where the natural surface of the ground is not shifted to this arrangement, a thick belt of trees may sometimes be utilised as a screen. An artificial shelter may also be made by surrounding the magazine, by a bank of earth as high as the eaves of the magazine. When this arrangement is adopted care must be taken that proper provision is made for drainage, and the slopes of the bank towards the magazine should be as easy as practicable.

3·7. The space surrounding the magazine should be fenced **in.** The ground inside this fence should be kept clear and free from trees, bushes, etc. The admission to this fenced space should be by one gate only, and no person should be allowed inside this fence, without permission of the officer in-charge. In the case of "Storage Magazine" the clear space between the fence and the Magazine should nowhere be less than 100m.

3·8. The door of magazine should be sheltered by a screen wall or other erection so arranged as to protect the doorway from direct bullet fire. The door and its fastenings should be strong enough to resist forcible entry, and should preferably be a thick wooden one, faced on the outside with plate iron about 6 mm. thick and opening outwards. The window should be of the same construction. All fittings and keys should be of brass or gun metal (not iron). The door should be fastened with two separate locks, the key of one being kept by the guard and the key of the other by the Officer-in-charge.

3·9. The roof of the magazine should be arched, and where considered desirable, may be made bomb proof by a thick covering of earth above the arch. Timber should not be used in the construction of either the walls or the roof.

3·10. Two thoroughly efficient lightning conductors should be provided to the magazine, one at each end. The lightning conductors shall be tested at least once every year.

3·11. Ventilators should be provided, and so designed as to secure good ventilation, but not admit of the insertion of a man's arm or any article being passed through them from outside. They should be protected by a grating on the outside and be fitted inside with copper wire gauze.

3·12. Every magazine should be perfectly well-drained.

3·13. No iron or steel is to be used in a magazine for nails, fastenngs, fittings or any other purpose.

3·14. The interior of the magazine, that is, the floor and walls, should be plastered smooth with cement. This is preferable to lining them with wood, which is attacked by insects and creates dust.

The magazine should at all times be kept scrupulously clean High explosives like dynamite should be stored in a dry, clean well-ventilated, bullet-proof and fire proof building, on an isolated site.

3·15. No one shall enter a magazine except in the presence of the Officer-in-charge, with his permission. The person in charge of the magazine is to take care that the magazine is well and securely locked

3·16. Magazine shoes without nails should be kept at all time in the magazine, and a wood tub or cement torough about 30 cm. high and 45 cm. in diameter, filled with water should be fixed near the door of the magazine.

Persons entering the magazine must put on the magazine shoes provided for the purpose and be careful.

(*a*) Not to put their feet on the clean floor unless they have the magazine shoes on ;

(*b*) Not to allow the magazine shoes to touch the ground outside the clean floor ;

(*c*) Not to allow any dirt or grit to fall on the clean floor.

Persons with bare foot will, before entering the magazine, dip their feet in water, and then step direct from the tub over the barrier (if there is one) on to the clean floor.

3·17. A brush or broom should be kept in the lobby of the magazine for cleaning on each occasion it is opened, for the receipt, delivery on inspection of explosives.

3·18. No matches or inflammable materials should be allowed in a magazine.

3.19. No person having articles of steel or iron on him is to be allowed to enter the magazine. Workmen or any other persons any admitted into the magazine should not have on their person any articles mentioned in paragraphs 3-18, 3-19 and 3-20.

3.20. Oily cotton rags, waste, and articles liable to spontaneous ignition, should not be taken into the magazine.

3·21. No tools or implements other than those of copper, brass gunmetal or wood should be allowed inside the magazine. Tools should only be used with great gentleness and care.

3·22. A guard should be provided to every magazine for its safe custody. The strength of the guard should be settled by the Engineer in consultation with the civil authotrities.

3·23. Detonators, for signals, fuses, etc., are not to be kept in the same magazine with gun-powder, dynamite or other explosives, Detonators can however be kept in an annexe adjoining the magazine provided that their number does not exceed 25,000, and that the annexe is so constructed that not less than 60 cm. of masonry and 100 cm. of air space shall intervene between any detonators in such annexe and the interior of the main magazine.

3·24. Barrels or cases containing explosives are not to be opened in a magazine. Explosives in open cases are not to be received into a magazine.

3·25. Explosives which appear to be in a damaged or dangerous condition are not to be kept in any magazine, but must be removed without delay to a safe distance and destroyed. Any necessary destruction of explosives such as might be required owing to deterioration of the explosives or exudation of nitroglycerine, should be carried out in accordance with the instructions given by the Engineer in-charge.

3.26. Artificial light is not to be allowed in any magazine. Electric storage battery torches may however be allowed.

3·27. No smoking shall be allowed within 100m of a magazine.

3·28. In "Expense Magazines" the mallets, levers, wedges, etc., for opening barrels or cases are to be of wood. Tools should only be used with great gentleness and care.

3·29. Packing or unpacking, or any operation involving the moving of explosives among one another in an opened case, is not to be permitted in a magazine.

3·30. Barrels or cases to be moved in a magazine are to be carried by hand, not rolled, dragged, or turned over and over on the floor.

3·31. No person is to be allowed to sleep, to take food, or to loiter in a magazine.

3·32. Should repairs or alterations be necessary in a magazine every precaution should be taken, and, if practicable, the officer-in-charge should be present while the work is in progress.

3.33. Account should kept in every magazine of all explosives received and issued.

3.34. Barrels and cases are to be properly labelled to indicate the nature of the contents, quantity, date of receipt, from whom received, and other particulars, so that their history can be traced.

3.35. Explosives which have been issued and returned to the magazine are to be issued first ; otherwise those which have been longest in store are to be first issued.

3·36. The quantity of explosives allowed to be kept in an "Expense magazine" should be limited, and a notification defining that limit should be posted up in a conspicuous position, both inside and outside the magazine.

3·37. Barrels and cases must be kept clear of the walls and floors so as to allow the air to circulate freely on all sides. It is recommended that where practicable, they should be stacked in the middle with a clear space all round.

3·38. Neatness and order in arrangements of a magazine are to be strictly enforced. No dirt or rubbish is to be allowed, and special care is to be taken to keep the floor free from grains of powder or portions of explosive matter fall on the floors due to leakage of cases, etc.

3·39. A brush or broom should be kept in the magazine or in the lobby if there is one, for cleaning out the magazine on each occasions it is opened for the receipt, delivery or inspection of the explosives.

3·40. Magazine should be opened occasionally in dry weather, so as to keep them well aired. When open they are to be carefully guarded.

3.41. The ventilaters of a magazine are to be closed during a dust storm or thunder strom, and the magazine is not to be opened during the prevalence of an atmospheric disturbance of this nature, nor should any person be allowed in the vicinity of the magazine.

3·42. Should there be a difficulty in keeping the magazines free from damp, freshly burnt quick lime, exposed in wooden trays recommended to be kept in the magazines.

3·43. In every "storage magazine" a maxima and minima thermometer should be put up in a suitable position, and a note of the temperature recorded by each instrument should be made at regular intervals not exceeding a week. It is recommended that this be also done in an "expense magazine".

3·44. A record should be kept of all occasions on which a "storage magazine" is opened, with such particulars as may appear desirable.

3·45. All magazines are to be officially inspected at definite intervals and a record kept of the results of such inspections.

3·46. At each inspection, the conditions of the lightning conductors should be carefully examined. The lightning conductors have to be got tested at least once every year by an Inspector of Explosives in the manner prescribed by the Chief Inspector of Explosives, and a certificate showing the result and the date of test obtained from him on payment of requisite fee, shall be hung up in the magazine in a conspicuous place.

3.47. The rules in force in each magazine should be printed in clear type and hung up in a conspicuous position both in and outside the building. The officer-in-charge of the magazine should be responsible to ensure that the rules are strictly observed.

3·48. When high explosives are stored, a sample should be taken at least once a year and forwarded to the nearest chemical examiner for test. High explosives are those which are habitually fixed by detonation, and used where a destructive rather than a propellant effect is aimed at, and include such explosives as :—

Blasting gelatine, carbonite, celtite, dynamite, gelignite, monobel powder, phoenix powder, negro powder, reburite, tenite ammonal, gun cotton slab, picric acid, tri-nitro-to-vol (TNT), etc.

An adequate slot must be cut on the side of the plug to hold the fuse, and prevent it from damage when the plug is being tapped down. The top of the plug should be painted red.

Use of Explosives

4.1. The explosive shall not be used on the works or on the site by the contractors without the written permission of the Engineer-in-charge.

4.2. Blasting shall only be carried out at certain specified times to be jointly agreed to by the contractor and the Engineer-in-charge within the hours of day specified by the licensing authorities, and an area of 200 m radious from the firing point is to be specially flagged out, and all workmen excluded therefrom at least 10 minutes before the hour for firing, a warning bell being sounded for the purpose.

4.3. Explosives shall not be brought on to the works in quantities exceeding the amount enough for the particular amount of firing to be done and any surplus explosive left, when all the holes have been charged, must be carefully removed at least 300 m away from the firing point.

4.4. A properly appointed agent on behalf of the contractor shall personally superintend the firing, and not more than eight holes at a time shall be sent off (fired successively and not simultaneously). Account shall be kept of the blasts : if these do not tally with the number fired, the difference indicates misfires, in which case no person shall be allowed to return to the site of the firing for at least half an hour after firing, when the misfire shall be carefully looked for by the authority's agent. In the event of misfire, a portion of the tamping may be sludged out with compressed air or water under pressure, but no kind of tool shall be used for this purpose. The hole shall thereafter be reprimed and fixed. If a relieving hole is to be drilled, it shall not be placed within 30 cm. from the misfired hole. The relieving hole shall run parallel to the misfired hole. If a misfired is detected during working hours and it is necessary to leave it charged till firing time, a slodge of red paint must be cut around the drill hole.

4·5. If misfire has been found to be due to defective fuse, detonators or explosives, special notice should be sent to the officer-in-charge of the works, and to the persons in charge of the storage and "expense magazines", so that steps may be taken to inspect the whole quantity or box from which the defective article was taken. No more of the defective stock is to be used without permission of the Engineer-in charge.

4·6. As each hole is drilled and loaded, a small wooden plug (not more than 8 cm. in length). is to be driven in at the top, confining the fuse and also helping to indicate the position of the hole if it misfires. An adequate slot must be cut on the side of the plug to hold the fuse, and prevent it from damage when the plug is being tapped down. The top of the plug should be painted red.

4·7. Dynamite should be kept dry until used. If exposed to damp, the nitroglycerine exudes and becomes most dangerous. It shall not be exposed to direct rays of the sun, also it becomes highly dangerous if placed near fires, stoves, steampipes or heated metal.

4·8. Frozen dynamite is a most dangerous substance, as simple friction of the crystals of nitro-glycerine due to rough or careless handling, dropping a cartridge or any sudden jolt or jar is liable to cause detonation. None but the most experienced men should therefore handle it in a frozen state. It should be thawed by placing the cartridges in a pan floating in warm water.

4·9. (i) A wooden tamping rod should be used to push the cartridge home. No metal rod or rammer shall be used in tamping or brough to the site of blasting work.

(ii) The charge should not be rammed or pounded but pressed firmly into place.

(iii) Dr earth should be used for tamping. If water is used, great care should be taken to press the cartridges into contact with each other, as water coming in between two cartridges will prevent the explosion of the lower one, and lead to a hole being onlypartially blown out and remaining charged with the balance of the dynamite.

4·10. The dynamite is exploded by means of a detonator pinched en to a fuse by means of special nippers, and put into the primer or cartridge. Instructoins accompany each box and these should be carefully adhered to.

4·11. All fuses must be out to the lengths required before being inserted into the holes.

4.12. Any slackness, carelessness or the infringement of the rule will render all responsible parties liable to prosecution.

4.13. Further detailed instructions for blasting operations are given in standard specifications.

Rules for opening and clossing boxes of dynamite and blasting gelatine.

5·1. Wooden wedges, about 15 cm. long, 3 cm. thick at the head and 8 cm. wide, also a small wooden mallet, weighing about 0.70 kg. and a wooden lever 60 cm. long × 5 cm. wide × 2.5 cm. thick should be provided as the tools for opening boxes.

5·2. The boxes should be opened on a wooden table or palnk, free from grit or metal nails.

5·3. To open the box, the lid should be forced up by inserting two wooden wedges in the end, and driving them in by the wooden mallet. When raised sufficiently, the wooden lever should be inserted and the lid prized off. After removing the lid, the water proof lining at the joint should be rent open, when the packets containing the cartridges will be accessible for taking out.

5·4. To re-close the box, all the brass nails should be first with drawn from the lid, the lid replaced in its proper position, and nailed with a wooden mallet.

5.5. *Metal tools shall not under any circumstances be used for opening or re-closing :—*

Accountal of explosives.

6.1. To prevent explosives being disposed off unlawfully, following orders must be strictly enforced :—

(i) The supervisor in charge of the work shall be presonally responsible for all explosives, and shall personally attend to the charging, tamping and firing of all holes.

(ii) The supervisor in charge shall maintain a register in which the explosives used each day will be entered regularly the same evening, and copy of the entry shall be forwarded to the Engineer-in-Charge and IN ADDITION, A STATEMENT AT THE END OF EACH MONTH SHOULD BE PREPARED AND SENT TO THE ENGINEER-IN-CHARGE.

(iii) The Engineer-in-Charge shall personally check the balance once a quarter.

6.2. The Engineer-in-Charge shall be responsible for implicit compliance with the instructions herein given and with such as may emanate from Government from time to time, with regard to the storage and use of such explosives on the work.

6.3. All losses, shortage of stock and thefts of explosives, shall be reported without delay to the nearest Police Station.

EXTRACTS FROM I. S. 4701—1968

Code of practice for earth work on canals.

APPENDIX—B.

TYPICAL METHODS OF DRILLING AND BLASTING ROCK IN EXCAVATION.

B-3. *Blasting with powder.*

B-3.1. In case of blasting with powder bore holes will be jumped or drilled into the rock face. The direction and spacing of the holes are very important for efficiency and economy. The line of least resistance (that is the distance of the bulk of the powder from the nearest rock face) must never be in the direction of the hole bored. The depth of the bore hole should be about the same as the line of the least resistance.

B-3.2. The bore holes shall be dried before being charged. The powder shall be enclosed in a waterproof cartridge and introduced into each bore hole by a funnel or a copper tube. Safety fuses shall then be passed into the powder and taken outside to the required distance.

B-3.3. A wadding of hay or dry turf shall be placed on the powder and around the fuse. An inch or two of the wadding shall be pressed down on the powder and the remainder of the hole shall be filled in with tamping materials, that is, dry clay. The filling material shall be rammed or tamped with a copper or brass rod until it becomes compact. Care shall be taken to avoid any possibility of an air hole around the fuse.

B-3.4. The charge shall be fired by lighting the fuse. Fuses shall be cut to the required length before being inserted into the bore holes. Joints in fuses shall be avoided. Where they are necessary a semi-circular niche shall be out in each fuse about one inch from the end and the two pieces shall be superimposed and bound together with the string. All joints exposed to damp shall be wrapped with a rubber tape.

B-3.5. The number of blasts to be fired and the actual number of shots heard shall be compared and person responsible shall satisfy himself by examination that all the blasts have exploded before workers are permitted to approach the same. The withdrawal of the charge which has not exploded is under no circumstances to be permitted. The charge shall be flooded with water and the hole marked in a distinguishing manner. Another hole shall be jumped at a distance of about 50 cm. of the old hole and fired in the usual way. The results shall be carefully examined by the persons in charge of blasting and the operations continued untill the original blast is exploded.

B-4. *Blasting with dynamite.*

B-4.1. Dynamite is procurable, made up in cartridges of two kinds, one 22·2 mm. diameter, 88·9 mm. long, weighing 56·7 g, the other 25·4 mm. diatmeter, 88·9 mm. long, weighing 66·1 g.

B-4.2. Dynamite is exploded by means of detonators. These are procurable in tin boxes and are laid in saw dust which should be blown out with a dry blow of the mouth before using. One end (cut square) of a Bickford's fuse is pushed into the detonator, till it touches the white fulminate within it. The open end of the cap is then pinched in with pincers to attach it to the fuse, care being taken not to break the powder cone of the fuse by pinching too tightly. If the detonator is to be used to damp or wet places the junction should be made watertight with grease, white lead or tar. A primer is then opened and the cap gently pushed up to its head into the dynamite, care being taken not to bury the detonator entirely. The paper of the primer is then closed up and securely bound with wire or twine to prevent displacement of the cap.

B-4.3. One cartridge is first placed in the bore hole and pressed and not rammed down with a wooden hammer, never with an iron or metal rod, so as to form a proper contact with the sides of a rock, other cartridges are then added as may be required to make up the necessary charge. The primer is then gently pushed, not rammed down on the top of the charge. The space for about 20 cm. above the charge is then gently filled with dry clay pressed home and the rest of the tamping is formed of any convenient material gently packed with a wooden rammer.

B-4.4. Following general principles should be followed in case of blasting rock with dynamite. The mode of proceeding is very much the same as for powder, but the holes of similar depth should be further apart but will have smaller diameter. Continuity of circuit shall be checked with galvanometers so that all the detonators are correctly connected before blasting.

B-4.5. The following are the diameters of drills used for different depths of bore holes :—

Depth. m.	*Drill Diameter.* mm.
1 to 2	25·4.
2 to 3	38·1 to 50·8
3 to 4. 5	50·8 to 63·5

B-4.6. The depth of bore hole should be about the same as the line of least resistance and if possible the bottom of the hole should never descend below the face of the rock. The bore holes should generally be not more than 1·5 m. deep and their distance apart should be from one and half to two times their depth.

B-4.6.1. If the required charge is so great that it cannot be held in a hole 1·5 m. deep, two or more holes should be made close together, the total charge being slightly increased and exploded simultaneously. By using delay detonators overcutting and undercutting can be minimised.

B-4.7. Cracks and fissures in the rock to be blasted should be carefully studied to ascertain the best position for bore holes. The charge should always be placed in a sound piece of rock and if possible not nearer to a crack than 30 cm. If it is desired to shatter rock, close connections between the dynamite and the rock is essential and the points of contact shouldbe multiplied as much as possible. For this reason several bore holes of moderate diameters are preferable to one hole of a larger diameter. Sometimes by having sloping holes excavation can be controlled in a particular direction.

B-4.8. In case of gently sloping rock with no face, dynamite should be used as powder is to be used, only with fewer and shallower bore holes. As the line of least resistance is not so important in dynamite as in powder the necessity for sloping the holes is not so great. But if a face is required on an almost level rock sloping holes should be used.

EXTRACT FROM I.S. 4081—1967.

Safety code for blasting and related drilling operations.

2. *Terminology—*

2.0. For the purpose of this standard, the following definitions shall apply.

2.1. *Blasting cap.*—A shell closed at one end and containing a charge of detonating compound, which is ignited from a spark, it is used for detonating explosives.

2.2. *Detonator.*—The term shell include igniters, blasting caps, electric blasting caps, or other similar devices used to explode commercial explosives.

2.3. *Electric blasting cap.*—A shall containing a charge of detonating compound which is ignited by an electric current from two projecting insulated leg wires.

2.4. *Explosive.*—Any mixture or chemical compound which is capable of producing an explosion by its own energy. This includes black powder, dynamite, nitroglycerine compounds, fulminate, or explosive substance having explosive powder equal to or greater than black powder.

2.5. *Magazine.*—Any building or other structure used for the storage of explosives.

2.6. *Missed hole.*—A drilled hole containing an explosive charge that failed to explode.

2.7. *Permanent blasting wires.*—Those wires between the firing switches ; for use in blasting where the power source is an electric circuit.

2.8. *Primer.*—An explosive cartridge with a detonator or igniting agent inserted therein.

2.9. *Safety fuse.*—A medium manufactured especially for firing explosive charges, that conveys a flame at uniform rate rather than one that is in itself a detonator or one that operates on some other principle.

2.10. *Stemming.*—Means material used for confiring a charge of explosives in a hole or to cover explosives in mud capping.

3. *Transportation of explosives—*

3.1. All the relevant central state and local laws and rules and regulations if any, framed thereunder shall be complied with. Loading, unloading and handling of explosives will be supervised by qualified personnel.

3.2. Where the magazine is located near the construction site and blasting operations continue daily, actual requirements of explosives shall be drawn from the magazine and transported to the site. Any left overs should be returned back to the magazine each time after the blast. In case of work at scattered places and for a small duration, portable magazines shall be used and kept within a fence in a safe place and properly guarded.

3.3. For carrying small quantity (approximately 5 kg. of explosives) specially designed insulated containers may be used. These containers shall be constructed of finished wood not less than 5 cm. thick or plastic not less than 6 mm. thick or pressed fibre not less than 10 mm. thick. There shall be no metal parts (not even nails bolts, screws, etc.) and the container shall be water proof and provided with a lid. The containers shall be provided with suitable non-conductive carrying device, such as rubber, leather or canvas handle or strap.

3.4. Vehicles to be used for transporting explosives shall be in good working condition and shall have a tight wooden or non-sparking metal (copper, brass and the like) floor with sides and ends high enough to prevent the explosives from falling off the vehicle. In open-bodied vehicles, the explosives shall be covered with a water proof and fire-resistant tarpauline.

3.5 Electrical wiring in vehicle shall be fully insulated so as to prevent the danger of short circuiting and atleast two fire extinguishers of carbon tetrachloride type shall be carried. The vehicle shall be properly marked so as to give adequate warning to the public in regard to the nature of cargo.

3.6. No metals except approved metal truck bodies shall be allowed to come in contact with cases of explosives. Metal, flammable or corrosive substances shall not be transported with explosives. As far as possible, transportation of any other material along with explosives shall be prohibited.

3.7. Smoking shall be prohibited in the vehicle carrying explosives.

3.8. No unauthorised person shall be allowed in the vehicle carrying explosives.

3.9. Loading and unloading of explosives shall be done carefully.

3.10. Explosives and detonators or blasting caps should not be permitted to be transported in the same vehicles.

3.11. Detonators and other explosives for blasting shall be transported to the site of work in the original containers or in securely locked separate non-metallic container and shall not be carried loose or mixed with other materials.

4. *Storage of explosives*—

4.1. Storage of explosives is registered by the Indian Explosives Act and provision thereunder should be strictly observed.

4.2. Explosives shall be stored only in a magazine which is clean dry, well ventilated, reasonably cool, correctly located, substantially constructed, bullet and fire resistant and securley locked.

4.3. Blasting caps, electric blasting caps or primers shall not be stored in the same box, container or room with other explosives.

4.4. Explosives, fuse or fuse lighters shall not be stored in a damp or wet place or near oil, gasoline, cleaning solutions or solvents or near radiators, steam pipes, or other sources of heat.

4.5. Smoking shall not be permitted within the fencing around the explosive magazine, nor matches, open lights, or other fire or flame shall be allowed near the magazine. Warning notice to this effect should be pasted at conspicuous places.

4.6. No leaves, grass, brush or debris of any kind shall be allowed to accumulate within 8 m. of an explosive magazine.

4.7. No sparking metal or sparking metal tools shall be stored in an explosives magazine. Persons entering the magazine shall not have shoes with iron nails or other sparking metal.

4.8. If nitroglycerine from deteriorated explosives has leaked down on to the floor of the explosive magazine, the floor shall be desensitized by washing thoroughly with an agent obtained before hand from the supplier of the explosives. For this purpose, desensitizing agents and the instructions for using them shall always be obtained along with the supply of nitroglycerine.

5. *Use of explosives*—

5.1. Precautions against lightning shall be provided in accordance with Indian Electricity Act and Indian Explosives Act and Rules and regulations framed thereunder.

5.2. Any package containing explosives shall not be dragged, dropped or handled roughly. The explosives packages shall be opened only at a safe distance and properly shielded from the packages of explosives in bulk storage.

5.3. Sparking metal tools shall not be used to open, legs or wooden or fibre board cases of explosives.

5.4. Smoking shall not be permitted nor matches, open lights fire, flame, or any other device capable of producing sparks or flame shall be carried while handling or using explosives.

5.5. Explosives shall not be placed where they may be exposed to flame excessive heat, sparks or impact.

5.6. The covers of the explosive cases or packages shall be replaced every time soon after taking out part of the contents as long as any explosives are left in them.

5.7. Explosives shall not be carried in the pockets of any clothing or elsewhere on any person.

5.8. Primers shall not be made up in a magazine, or near excessive quantity of explosives, or in excess of immediate needs.

5.9. Nothing shall be inserted in the open end of a blasting cap except fuses.

5·10. No person shall strike, tamper with, or attempt to remove or investigate the contents of a blasting cap or an electric blasting cap or attempt to pull out the crimped safety fuse cut of a blasting cap.

5·11. Children, unauthorised or unnecessary persons shall not be present where explosives are being handled or used.

5·12. No person shall handle, use or be near explosives during the approach or progress of any electrical storm. All persons shall retire to a place of safety.

5·13. Deteriorated or damaged explosive or blasting equipment shall not be used, but shall be disposed of as stated in 11.

5·14. No attempt shall be made to reclaim or use fuses, blasting caps, electric blasting caps or any other explosives which have been water soaked, even if they have been dried out. The manufacturers shall be consulted.

5·15. No. attempt shall be made to soften hard set explosives by heating over a fire or by rolling the explosive on the ground.

6. *Drilling and loading*—

6·1. Before planning out the drilling operations for blasting purposes, nature of stratum and the over burden should necessarily be examined to avoid possibilities of land slides after blasting.

6·2. The face of rock shall be carefully examined before drilling to determine the possible presence of unfired explosive. No attempt shall be made to drill at a site if undetonated explosives are suspected and action shall be taken according to 10·4.

6·3. The bore hole shall be carefully checked for length, presence of water, dust, etc., with a wooden tamping pole or a measuring tape before loading.

6·4. Surplus explosives shall not be stacked near working area during loading.

6·5. The line of detonating fuse extending into a bore hole shall be cut from the spool before loading the remainder of the charge

6.6. A bore hole shall not be loaded with explosives after springing (enlarging the hole with explosives) or upon completion of drilling without making sure that it is cool and that it does not contain any hot metal, burning or smoldering material. Temperatures in excess of 65° C. are dangerous.

6·7. A bore o near another hole loaded with explosives shall not be sprung

6·8. No force, hallbe used for inserting cartridges or any explosive into a bore hole or pass any obstruction in a bore hole.

6·9. No force shall be used for inserting a blasting cap or an electric blasting cap into explosive. The cap shall be inserted into a hole made with a pricker designed for the purpose. A hitch of the electric blasting cap leading wire shall be made on the primer cartridge so as to prevent pulling out of the electric blasting cap from the explosive charge. In case of fuse, the fuse shall be tied to the explosive cartridge so that the blasting cap is not pulled out. Care shall be taken so that the electric blasting cap, leading wire or the length of the fuse does not get damaged during loading of the charge.

6.10 No attempt shall be made to slit, drop, deform or abuse, the primer.

6·11. Blasting caps or electric blasting caps shall not be connected to detonating fuse except by methods recommended by the manufacturers of caps.

6·12. Explosive cartridge shall not be cut, nor explosive removed from the cartridge for use.

6·13. Metallic devices of any kind shall not be used in tamping. Wooden tamping tools with the no exposed metal parts except non-sparking metal connectors for jointed poles shall be used. Violent tamping shall be avoided. Primer shall not be tamped.

6·14. Care shall be taken to confine the explosives in the bore hole with sand, earth clay or other suitable combustible steaming material.

6·15. Kinking or injuring or fuse or electric blasting cap wires shall be avoided when tamping.

7. *Electrical short firing circuit*

7·1. In deciding the sizes of wires, fuses, circuits, blasting, switches, etc., instructions issued by the manufacturers of these articles should be consulted.

7·2. No person shall attempt to uncoil the wires and open out the short circuited bare leading wires of the electric blasting cap during approach of dust storm or near any source of large charge of static electricity or near a radio transmitter. The manufacturer of the cap or the Inspectorate of Explosives shall be consulted regarding the distance from the transmitter, beyond which electric short firing shall be conducted.

7·3. Firing circuit shall be kept completely insulated from the ground or other conductors, such as bare wires, rails, pipes, or other paths or stray current.

7·4. There shall not be any electric live wires or cables of any kind near electric blasting caps or other explosives except at the time and for the purpose of firing the blast.

7·5. All electric blasting caps shall be tested singly and also when connected in a circuit in series using only an approved type of circuit continuity tester or ohm meter.

7·6. No attempt shall be made to use in the same circuit either electrical blasting caps made by more than one manufacturer or electric blasting caps of different design of function even if made by the same manufacturers unless such use is approved by the manufacturers.

7·7. No attempt shall be made to fire a circuit of electric blastin caps with less than the minimum cu rent specified by the manufacturer of that electric blasting cap.

7·8. Care shall be taken to ensure that all wire ends to be connected are bright and clean.

7·9. The electric cap wires or leading wires shall be kept short circuited until ready to fire.

7·10. When energy for blasting is taken from power circuits, the voltage shall not exceed 220 V. The wiring and controlling arrangements shall conform to the following :—

(*a*) The blasting switch shall be strictly according to the specifications, externally operated double-pole double throw switch, which when locked in the open position will short circuit and ground the leading wires. The switch shall be installed at the location where the firing is to be controlled.

(*b*) A 'Safety' switch of the same type as the blasting switch shall be installed between the blasting switch and the firing circuit and lead lines, at a distance not to exceed 180 cm., from the blasting switch.

(*c*) Both the safety switch and the blasting switch shall be locked in the open position immediately after firing the short and before any person is permitted to return to the blasting area. Key to the switches shall remain in the possession of the blaster at all times.

7·11. Rubber covered or other adequately insulated copper wires in good condition shall be used for firing lines and shall have solid cores of appropriate gauge. Sufficient firing line shall be provided to permit the blaster to be located at a safe distance from the blast. Single conductor lead lines shall be used.

7·12. Blasting operations in the proximity of overhead power lines, communication lines, utility lines, or other structures shall not be carried on until the operator or the owner, or both of such lines has been notified and precautionary measures deemed necessary have been taken.

7·13. All holes loaded on a shift shall be fired on the same shift.

7·14. As far as possible blasting shall be carried out using suitable exploder with 25 per cent excess capacity. Electric power from the mains shall be used only when it is absolutely necessary.

8. *Short firing with safety fuse* :

8·1. The fuse shall be carefully handled to avoid damaging the covering. In very cold weather the fuse shall be slightly warmed before using so as to avoid cracking the waterproofing.

8·2. Short fuse shall not be used. The length of a fuse shall be not less than 120 cm. The rate of burning of the fuse shall be known and it would be necessary to make sure that it will take sufficient time in burning so as to enable all persons to reach a place of safety. The burning rate of the fuse shall not be more than 60 cm/min.

8·3. The fuse shall not be cut until the operation to insert the fuse into a blasting cap is ready. The fuse shall be cut off about 2·5 to 5 cm. to ensure a dry end. It shall be cut squarely across with a clean and sharp blade. The fuse shall be seated lightly against the cap charge and care shall be taken to avoid twisting after it has been placed in position.

8·4. Blasting caps shall not be crimped by any means except by a cap crimper designed for the purpose. It shall be necessary to make sure that the cap is squarely crimped to the face.

8·5. The fuse shall be lighted with a fuse lighter designed for the purpose. If a match is used, the fuse shall be slit at the end and the match head held in the slit against the powder core and then the match head rubbed against an abrasive surface to light the fuse.

8·6. The fuse shall not be lighted until sufficient stemming has been placed over the explosives to prevent sparks of live match heads from coming into contact with the explosives.

8·7. The explosives shall not be held in hands when lighting the fuse.

9. *Underground work* :

9·1. Only permissible explosives and in the manner as specified by the appropriate authority shall be used.

9·2. Excessive quantities of explosives shall not be taken underground at any time. Black blasting powder or pellot powder shall not be used with any other explosives in the same bore hole.

9·3. For blasting in tunnels and shafts precautions detailed in relevant Indian standard shall be followed. The poisonous gases shall be promptly removed by using exhaust fans in shafts and reversible axial flow fans in tunnels. The air duct shall be of such size as not to allow too much pressure drop so that the velocity of air at the delivery end is not less than 0·2 m/s.

10. *Before and after firing* :

10·1. Before firing, sufficient warning shall be given to enable the people working in the blasting area to get off the danger zone. The danger zone shall be suitably cordoned off and flag men posted at important points.

10·2. No loose materials, such as tools, drilling implements, etc., shall be left on the rock surfaces to be blasted.

10·3. Blasting in the open shall be carried out during the fixed hours every day or on fixed days in the week. This information shall be amply publicized and the following precautions observed :—

(*a*) On the projects sites, where regular blasting operations are carried out, daily blasting hours should be clearly printed on the sign-boards on all the roads approaching that area.

(*b*) Road closing barriers should be provided to elose the traffic on these roads, at least 400 metres away when the firing is to take place.

(*c*) The beginning of the firing should follow loud sirens and similarly the completion of the firing should be succeeded by loud sirens.

10·4. The bore holes shall be thoroughly cleaned before a cartridge is inserted. Wooden tamping rods (not pointed, but cylindrical throughout) shall be used in charging the holes. The cartridges should be gently placed and not rammed. The primer cartridge will be on the top.

10·5. The shot firer shall not return to the blasting site after firing, until at least 5 min. have elapsed. In case of electric shot firing, the shot holes shall be examined after firing and in case of misfire no person shall be allowed to approach the blasting site for at least 5 min. In case of shot firing with safety fuse, utmost care shall be taken to count the number of loud reports to ensure that all the shots have fired and in the event of misfire, no person shall be allowed to approach the blasting site for at least 30 minutes. In any case, a careful inspection for remainings of undetonated explosives shall be made after firing the shots. All misfired shot holes shall be cross marked. No other person than these duly authorized shall approach the holes until one of the following operations has been performed in respect of each of the misfired holes ;

(*a*) If the misfire is due to a faulty cable or faulty electrical connection the defect shall be remedied and the shot fired.

(*b*) The stemming shall be floated out oy use of water or air jet from hose until the hole has been opened to within 60 cm. of the charge, whereupon water will be siphoned or pumped out, then a fresh new charge placed and duly detonated.

OR

(*c*) A new hole shall be drilled 60 cm. away from the old bore and parallel to it and about 30 cm. less in depth and the new hole charged and duly fired.

10·6. A careful search shall be made of an exploded material in the debris of the second charge.

NOTE : If a shift change is unavoidable, the person incharge of one shift before leaving the work shall inform the person relieving him for the next shift of any cases misfired and shall point out their positions duly cross marked and also state clearly what action has to be taken in the matter.

11. *Explosives disposal* :

11·1. No explosive shall be abandoned. They shall be disposed off or destroyed strictly in accordance with the approved methods and in doing so the manufacturers or the appropriate authority shall be consulted.

11·2. Explosives, caps, boxes lines or material used in packing of explosives shall not be left lying around in places to which children or unauthorised persons or livestock can have access.

11·3. No paper or fibre material employed in packing explosives shall be put to any subsequent use. Such material shall be destroyed by burning in the presence of a responsible person.

APPENDIX XXV.

FORM OF AGREEMENT FOR THE REMOVAL OF BUSHES, TREES, PRICKLY PEAR, ETC., ON THE DUTCH AUCTION SYSTEM.

(*Vide* relevant remarks in paragraph 210 of the Tamil Nadu Public Works, Highways and Rural Works Department Code).

DUTCH AUCTION SYSTEM.

FORM OF AGREEMENT.

Articles of Agreement made this day of 19 between His Excellency the Governor of Tamil Nadu (hereinafter called the Governor which expression shall where the context so admits include his successors in Office and assigns) of the one part and of (hereinafter called "the contractor" which expression shall where the context so admits include his heirs, executors, administrators and legal representatives) of the other part.

Whereas it has been agreed by and between the parties here to that the contractor shall effect the clearance of prickly-pear bushes trees, etc., over the area in accordance with the measurements set forth in Schedule A hereto in the manner set forth in the Standard specification in National Building Code and Tamil Nadu Building Practice such work to be carried out and completed in accordance with the conditions set forth in Schedule B hereto and to be paid for as

therein provided the terms and provisions contained in the said schedule hereto being read with and forming part of this contract and whereas the contractor has deposited with,
the sum of Rs. equivalent to 5 per cent of the amount specified in the clauses below as security for the due fulfilment of the contract to the satisfaction of the Executive Engineer, ... Division.

Now it is hereby agreed that in consideration of the payment of the sum of Rs.

The contractor, will, upon and subject to the condition set forth in Schedule B hereto, execute and complete the works entered in Schedule A.

In witness whereo the contractor and the officer in-charge of Division, Public Works Department, acting on behalf of and by the order and division of His Excellency the Governor of Tamil Nadu have hereunto set their hands the day and year first above written.

Witness to the signature of the Contractor.

Signature of the Contractor

Signature of the Officer-in-charge of Division.

Witness to the signature of the Officer-in-charge of Division, P.W.D.

SCHEDULE A.

Measurement of work to be done (to be signed by the Contractor as well as the Officer entering into the contract).

Description of the locality.	Measurement.		Area.	Total Area.
	Length.	Breadth.		
(1)	(2)	(3)	(4)	(5)

Supplemental List.

Description of the locality.	Measurement.		Area.	Total Area.	Date on which the work was ordered.
	Length.	Breadth.			
(6)	(7)	(8)	(9)	(10)	(11)

SCHEDULE B.

SCHEDULE OF CONDITIONS OF CONTRACT.

1. Works referred to :—The measurement entered in detail in Schedule A show the area over which the clearance of prickly pear bushes, trees, etc., has to be done and they shall be carefully followed :

2. Works and specifications :—The work shall be carried out to the satisfaction of the Executive Engineer, Division (hereinafter called the Executive Engineer) in accordance with his directions and in compliance with the said measurements, specification and written instruction in explanation of the same as may from time to time be given by the Executive Engineer or his authorised representative at the spot.

3. Power of Executive Engineer to order removal of improper work :—In case of default on the part of the contractor to carry out the work in accordance with the specifications, the Executive Engineer shall have power to employ and pay other persons to carry out the same at the contractor's risk and all expenses consequent thereon or incidental thereto shall be borne by the contractor and shall be recoverable from him by the Government of Tamil Nadu (hereinafter called the Government) or may be deducted by the Government from the security deposits mentioned in clause 8 below or from any moneys due or that may become due to the contractor.

4. Defects after completion :—Any defects or other faults which may appear within one month after completion of the work shall upon the directions in writing of the Executive Engineer, be amended and made good by the contractor at his own cost, failing which the Executive Engineer shall pay him such reduced amount as he thinks fit or deal with him as provided for under clause 8. The final payment for the work shall therefore be deferred for such period as herein mentioned after the date of completion.

5. Date of commencement and completion :—The contractor shall forthwith commence work and complete the same within a period of calender month after the date of commencement subject nevertheless to the provision or extension of time hereinafter be considered as of essence of this agreement.

6. Extension of time:—If in the opinion of the Executive Engineer the works shall have been delayed on account of any reasonable cause, the Executive Engineer may grant in writing a fair extension of time for completion.

7. Payment and Certificates :—The Executive Engineer will cause only one final payment to be made to the contractor if the total amount of the contract is Rs. 300 and less. but if the contract amount exceeds Rs. 300 he may cause intermediate payments to be made upon certificates to be issued at reasonable frequent intervals, either by himself or by an Officer of rank not less than that of an Assistant Executive Engineer to the extent of 75 per cent of the value of work executed by the contractor. The balance of 25 per cent will be dealt with as provided below. The contractor when applying for a certificate shall furnish to the Executive Engineer a statement of measure ments of the work executed based on the original detailed estimate of quantities included in Schedule A together with a bill.

In calculating the amount of each item due to the contractor in every bill submitted for payment under the contract, sums of less than 2½ percent shall be omitted and sums of 2½ percent and more but not exceeding 5per cent shall be reckoned as 5per cent. The amount shall be rounded to the nearest rupee, sums of less than 50 Paise being omitted and sums of 50 Paise and more being reckoned as One rupee.

8. Security Deposits :—In cases where the contract amount exceeds Rs. 300 the 25 per cent of the value of the executed work withhold from intermediate bills under clause 7 above,will be treated as further security in addition to the security deposit mentioned in the agreement. These security deposits or so much thereof as may be returnable will be refunded after the expiration of the period fixed in clause 4 above. If the contractor fails to start work forthwith or to execute the work within the period fixed in clause 5 or within such extended time as may be allowed under Clause 6 or if the contractor shall be guilty of a breach or non-observance of any of the conditions herein contained and to be performed or observed by him it shall be lawful for the Executive Engineer, in addition and without prejudice to the other rights and remedies of the Government, to determine the contract and such determination shall carry with it the forefeiture of the security deposits mentioned above together with the value of a such work as may have been executed and not paid for or such portion of such sums as may be decided by the Executive Engineer.

SECTION III

EARTH WORK

CONTENTS.

SECTION III.

EARTH WORK.

INDIAN STANDARDS EXTRACTS.

SECTION III.
EARTHWORK.

SPECIFICATION No.20-A.

EARTHWORK.

Repairing or raising Tank-Bunds and River Flood Banks.

Forming or Reforming Tank-Bund- or Closing Breaches.

Forming Channel Banks.

Silt Clearance—Channels and Drains, where sectioned spoil Bank is required.

1. *Preparation of bed.*—Ant hills are to be completely dug out and queen ants destroyed before earth work is started. In the absence of any separate contract schedule provision for such works as removal of shrubs, loose stones, digging of any hills, etc., involved in the preparation of bed, the contract rate for earth work shall include all the work to be done in accordance with this clause. In cases where the work of preparation of bed is rather extensive, the Executive Engineer will usually provide a separate schedule item for such preparation, but in the absence of such schedule provision, the contractor shall understand that his tender rate is inclusive of all such work without extra charge. The contractor should therefore examine the site always before tendering and provide for all items to be done under his earth work tender rate. Old bunds will be benched before addition of earth, the benches being 500 mm x 500 mm unless other sizes are specified, Benching will usually be paid as a separate schedule item, per 100 running metre of trench and where such is required, but not mentioned in the tender notice, a rate sball be agreed on, prior to commencement of work. The benches shall be inspected by the PublicWorksDepartment subordinate in charge of the work and approved before new earthwork is keyed into them. Mode of removal of prickly pear and its disposal will be as per specification no. 16 under section II. The Sub Divisional Officer should check compliance with the specifications for preparation of bed, before work is startsd in laying the bank.

2. *Ordinary embankment earth and placing.*—(*a*) Earth for embankments shall be free from roots and vegetable mould. Earth containing admixture of large stones is not to be used, unless otherwise instructed by the Executive Engineer. All clods and lumps shall be broken up as the work proceeds to ensure close consolidation and in no case shall the size of lumps after breaking exceed 25 mm cube at each layer. Each layer shall be 150 mm in thickness or such other thickness as may be otherwise specified and each layer shall be well rammed with iron rammers, unless consolidation by rollers or other method is specified or ordered by the Executive Engineer. The layer of earth shall have a slight slope towards the centre of the bund, the earth being thrown down from the sides towards the centre of the bund and not vice versa. For channel banks the top shall be dresses off, so that drainage does not flow off on the channel side to erode the berms or channel banks. In case thin earth strips are added, the layers should be deposited normal to the outer slope.

2.1. On resuming work each day or after an intetval of a few days the old surface of the bund shall be moistened with water to ensure a better joint between the old earth and new. If the interval has been of longer duration than a month, or if the old surface has in any way become hardened, than it should be picked up and moistened before any new earth is laid on it. If there is water available within 100 meters of the portion to be moistened then no extra payment will be made for this work and the contract rate for earth work shall include the same. If there is no water available within this distance, then the Executive Engineer will decide if watering is to be done and decide the extra payment that will be made before the work is started.

3. *Borrow pits.*—

3.1. *Porous strata.*—In digging borrow pits, no porous strata should be uncovered on the inner side of the bank or bund.

3.2. *Private land.*—The contractor shall not enter on patta or private lands to excavate pits until formal arrangements have besn made with the patta-holder or owner either directly by the Public Works Department or through the Revenue Department as may be required. Where land is being required for borrow areas, entry can be permitted only after the consent statement is obtained from the Revenue Department. In these cases. the contractor will be instructed regarding the maximum depth of pits to be formed (the rate to be paid for such spoil earth being settled in writing with the owner, at the usual sanctioned revenue seigniorage rates and in the absence of other modifying specification, the cost of such borrow earth will be paid for by Government and shall not be included by the contractor in his earth work unit rate). Contractors shall be personally responsible for all damage that they may caused to private property in the execution of thier work.

3.3. *Location.*—The location of borrow pits will in some cases be shown on the plans. In other cases, the contractor shall conform to the restrictions of this standard specification, obtaining, in every case, prior orders from the Executive Engineer, where he finds it necessary to locate pits else where.

3.4. *For tank-bunds and river banks.*—No excavation shall be made outside of the tank-bund unless otherwise ordered by the Executive Engineer. No excavation shall be made on the inside of the tank-bund nearer the toe of the slope than twice the height of the bund at the point-nor on the outside of the tank-bund, than three times the height of the bund. For river banks the pits shall be on the river side not less than 10 metres from the toe of the flood bank If there are old pits at that site and only the same site is to be used the new pits, should exhibit berm allround and shall have a cross thandu. This should be restricted to only where fresh area is not available.

3.5. *For channel banks.*—The location of the borrow pits will usually be shown on the plans. For earth required for banking on excess of the amount available from the channel section, pits will be formed. Ordinarily outside the bank, and at such a distance from the toe of the slope that the 4:1 hydraulic gradient does not enter the pit.

3.6. Borrow pits should not be deeper than one metre, nor more than 50 m long or such other maximum depth and length as may be specified or ordered by the Executive Engineer and a clear space of 3 m (other width specified or ordered) should be left between pits.

3.7. *Change of classification of soil in borrow pits.*—In cases where a lump sum contract is entered into for earth work irrespective of class of soil met with, then change of type of soil as found during execution and which soil is passed by the Executive Engineer as suitable for the work will not affect the lump-sum. Change in type of soil found during pit excavation should be at once brought to the notice of the Executive Engineer, so that he may reject soil if he considers it unsuitable. Failure by the contractor so to inform the Executive Engineer will render him liable to remove the rejected soil and re-do, at his own expense, with approved soil, as may be instructed by the Executive Engineer.

3.7.1. In cases where a contract schedule rate is for earthwork of a particular classification, and a different classification of soil is found during execution, then a new or supplemental agreement rate should be taken at once for the new classification of soil, if it is approved to be used before such earthwork is done. In the absence of such an agreed rate, the contractor will be paid for the new classification earthwork at the rate for such classification of earth work entered in the schedule of rates of the division in which the work is being done or at a lower rate as the Executive Engineer may decide.

3.8. *Measurement, thandoos, etc.*—Measurement of earthwork shall be taken from pit measurements, unless in any case the Executive Engineer has reason to suspect that fraud has takes place, for instance, by deepning or widening of old pits without instructions, and forming deceptive deadmen or thandoos. In such cases the Executive Engineer shall disallow the measurements entirely or estimate the quantity at his discretion. Pits should be so far as possible, of uniform size. They should be numbered by page or in other manner readily to locate the pit referred to in the measurement book. They should be cleared level at the bottom, Measurements of a pit should be the average of length, breadth and depth taken at sides, and centre of the pit-using a streched string and rod to get depths below ground level, Deadmen or thandoos are to be left, during excavation, of full width of pit or of such shape and size as may be specified or instructed and shall in all cases be sufficiently close to determine accurately the original ground level. Deadman or thandoos are to be left, during excavation, of full width of pit or of such shape and size as may be specified or instructed and shall in all cases be sufficiently close to determine accurately the original ground level. These thandoos are to be left till final measurements are taken and then removed from the cuttings. The contractor is responsible to ensure that the thandoos are made of sufficient section and so maintained that they remain intact till final measurements and check measurements are taken. If for any reason the thandoos are washed out by the time the measurements are taken and it is difficult to estimate the correct quantity of earth work, the measuring or check measuring officer shall estimate the quantity earthwork at his descretion and such estimate shall be final. All temporary path ways, ramps, etc., are to be dressed off neatly. A liberal deduction from the pit measurements will be made in the first instance for these thandoos and slopes left in the pits and the same quantity added when the pits are cleared true and square to section and so certified by the Sub-Divisional Officer in the measurement book.

NOTE.—It is essential that the inspection and certification of removal of thandoos should be done by the Sub-Divisional Officers but in rare cases the Executive Engineers may delegate this duty to section Officers, provided that the amount withheld pending removal of thandoos does not exceed Rs. 50 and that the withheld amount is 5 per cent or more of the total cost of the earthwork. Such delegations can be made only in individual cases as and when required, and in the following cases, only, viz., (*a*) in the case of channels and drains inaccessible at the time and likely to be filled with water very soon and (*b*) in cases where theSub-Divisional Officers had inspected such places and check-measured the particular reaches where " thandoo clearance has to be certified."

3.9. *Draining.*—The borrow pits should be connected together by a drain of 0·60 m bottom width ; the width to be increased suitability in the case of soils which have attendency to well and check the drain. The earth work involved in the excavation of the connecting drains will be measured and paid for at the rates for excavation adopted in the case of borrow pits.

3.10. *Selection of earth.*—In the case of all important embankments the Executive Engineer will select the earth to be used for the embankment after examination of the soils available at the site and will instruct the contractor regarding the location of the borrow pits.

3.11. *For silt clearance channels and drains where sectioned spoil bank is required.*—Clauses 1 and 2 of the following specification S.S. 20-B on "Earthwork and rough banking" shall apply to this specification—regarding excavating and dressing bed to working sections and removal of deadmen and thandoos.

4. *Profiles and shrinkage allowance.*—The allowance for shrinkage shall be such that no addition to earth will be required after settlement to bring the bank up to its full designed dimension unless otherwise directed, the following allowance will be made for shrinkage of earth in small embankments of not more then 3 metres.

In firm compact earth : 13 cm per metre of height of new embankment.

In ordinary loose earth : 17 cm per metre of height of new embankment.

In black cotton earth : 25 cm per metre of height of new embankment.

The bank is to be constructed evenly to the full section of the profile set up. The Sub Divisional Officer should test accuracy of profiles before work is started.

5. *New tank bunds.*—The method of compaction will be specified in the tender notice or instructed by the Executive Engineer, and the contract rate for earth work will include the cost of such compacation done to the satisfaction of the Executive Engineer. No extra rate will be paid for the necessary watering to bring the earth to the moist state demanded above, unless there is a separate item provided in the contract schedule, and the contractor shall observe this when submitting his tender but an addendum specification will be issued and method of payment will be defined where water is available to moisten the bund after stages of compaction, as referred to in the preceding sub paragraph.

5.1. *Notes on design.*—The standards of typical sections of embankments for tank bunds of various depths based on C.E. (I)'s circular Memo. No. 6375/3-A1, dated 20th August 1963 reproduced below shall be adopted.

(i) *Standards of Typical Sections of Embankments for Tank Bunds of various Depths Based on Chief Engineer (Irrigation)'s Circular Memo. No. 6375/63 A 1, dated 20th August 1963.*

Serial No.	Average depth of water	Top width of bund	Free board. in m.	Side slopes. Front	Rear	Berm at	Width of berm in m.	Revetment	Remarks,
(1)	(2)	(3)	(4)	(5)		(6)	(7)	(8)	
1.	0 to 3	2	1	1:5:1	2:1	..	..	..	May be adopted invariably for small tanks with small capacity and lesser length of bund.
2.	Over 3 to 4.5	2	1.25	1:5:1 1.5:1 1.5:1	2:1	..	..	.. 0.3 m above M.W.L.	May be adopted generally for a good sized tank with a good fetch.
3.	Over 4.5 to 6.	2.75	1.5	1:5:1	2:1	6 m intervals	1.5	Do.	May be adopted for big tanks.
4.	Ove r3	3.5	2	2:1 upto 6 m. from T.B.L. and than 2:5:1.	2:1 upto 6 ms from T.B.L. and then 3:1.	Do.	1.5	To top of bund.	May be adopted invariably for major tanks.

NOTE.—(1) Filter arrangement and Zoned sections may be provided according to site condition and availability of suitable soil. For Depths over 6 metres, zoned sections must invariably be adopted.

(2) The above standards are suggested for general guidance. But here may be certain cases where the bunds will be a right angles to the wind direction which will require special attention. Our tanks are mostly full during the North East Monsoon period. Hence where thebunds face either North East or East the free board should be adopted based on the formula H—0.762—0.361$\sqrt{}$F—0.271$\sqrt{}$F, where H—height of wave in metres F—Fetch in kilometres. Generally the free board would be raised above M.W.L. to a height some what greater than (H).

(3) Average depth of water means the depth of water between the level of the average deep bed and F.T.L.

Remark 1.—The soils of which a bund may be composed of will be divided into three classes and will determine the nature of the side slopes to be given.

NATURE OF SOILS AND THEIR SLOPES.

Side slopes	*Side slopes*	*Side slopes*
1½ to 1 or 34°	2 to 1 or 26°	2½ to 1 or 22°
Red gravel	Suddha	Sowdoo
Morambu	Morsel	Sand
Light red loam	Light saady loam	Palasathi
Black loam	Clay	Muggu, etc.
White gravel	Black cotton soil	
Red earth, etc.	Soft decomposed rock, etc.	

Remark 2,—Departmental officers should clearly understand that these tables are only intended as a guide. They must always exercise their own judgement. When deviations from the tables appear necessary, the necessity should be clearly and briefly explained in the report accompanying the estimate.

Remark 3.—As a rule, newly formed section may be kept to the rear of the existing one as much as practicable so as to utilise well-formed slopes in front and to avoid the necessity of removing and repacking revetment that has become set.

Remark 4. –In the case of T.R.S. tanks or railway affecting tanks the circle or other standards applying are to be adopted.

5.2. *Gravel.*—In some cases from the flanks of tank bunds, the most suitable earth available for raising bunds, will be found, this soil can be used for coating the bund with 15 cm thickness of gravel from the top of revetment of the inner slope to the toe of bund on outer slope. In such cases, the cost of conveyance of the gravel or other selected earth will have to be considered along with the suitability of using other borrow earth closely.

5.3. In places where a rew bank is to be formed, the junction between the new earth and old will require special orders in each case depending on the character of the earth met with, but, as a general rule, after the ground surface has been prepared, trenches, parallel to one another, and to the axis of the new bank, will be excavated to a depth of 1 metre with 60 cm bottom width and sides with a reversed slope of 1 in 4 or so, to ensure proper bonding of the earth filling. These trenches will, as a rule be sited about 3 metres apart centre to centre. The earth surface between the trenches shall be broken up in each case before any new earth is laid thereon.

5.3.1. The junction between the new bank and old surface at a breach site will invariably require special treatment in each case. In all cases the breach shall be cleared of all water ; the sand, stones soft mud, slush vegetable mould and shrubs, trees, etc., if any, found in the bed of the vanka or in the valley at the vanka sides, shall be carefully removed from the whole area to be covered by the new bank, and new bund laid on foundations approved by the Executive Engineer. Where porous strata are met with in the foundations a trench shall be dug of such width and depth as may be considered necessary; such trench shall be filled in with concrete, puddle or specially selected earth as may be directed. When the bank has to be formed on smooth rock, a bond may be ensured by constructing one or more masonry dwarf walls running longitudinally with a thickness of not less than one metre with battened sides and height not less than one metre. The filling in shall be done with earth thrown in uniform layers along the entire breach length and well consolidated.

5.4. All loose soil shall be removed from the ends of the bund on either side of the breach and the earth joggled, with slip tongues inclined up the face of the slope to allow the new embankment to settle tightly on to the old one.

5.5 Where a new tank bund is laid on steep side-long sloping ground, trenches will be dug as instructed in each case, to bond the new bank with the old ground surface. Where embankments are made over the bed of a stream and puddle trench (or cut off) is specified, it shall, exceed the width of the stream but not less than 6 metres to prevent leakage at ends. The Excavation may be carried either to a stratum of relatively impervious material or to a depth that will provide the desired lengthening of the path of perculation. Usually, this depth is kept as half the hydrostatic head over the foundation. The bottom width of the cut off trench is dictated by the equipment employed for back filling and rolling. Hence the width is kept as 3 metres for accommodating back rollers.

5.6. Typical sections of earth dams in the state (see plate attached may be adopted for depth and conditions obtaining.

5.7. It may also happen that the breach filling or other part of the bund is so situated that water may accumulate and stagnate against the outer toe. Such contingency should be avoided, if possible by suitable drains ; if this is impossible, the bund at such points, will require the additional protection and support of a dry rough stone toe. Such toe will be provided for the full length of bund which will be affected by the stagnant water, and of such height as is adequate to protect the toe. The front slope of such toe will be a continuation of the outer slope of the bund, and the inner slope will be 1 to 1. This toe will be formed of the same class of stones as used for the revetment to the inner slope of the bund, and will be built with the same care, with all the interstices fully filled in with small stones and chips.

5.8. It may frequently happen especially at valley crossings that the foundations of the outer casing require drainage. In such cases a longitudinal drain shall be made at the outer foot of the hearting and another at the outer toe of the bund ; these two will be connected at such intervals as is deemed necessary, by parallel cross drains at right angles to the longitudinal drains. Further longitudinal, drains may be considered necessary between the two above mentioned. In all cases, such drainage system will be set out, so as to preserve a proper slope of bed to an outlet which takes off all accumulated drainage without stagnation. The Drains shall be made to the section designed, and shall be filled up with small size stone with a superimposed layer of smaller material or gravel to prevent the earth of the bund falling in and clogging the drains.

5·9. A separate schedule item will be provided for such stone work as herein described, or in the absence of same in the tender notice, an agreement rate is to be arrived at before the work is commenced.

6. *Sectioning*—This work shall comprise the final shaping, triming, dressing, levelling, and ramming of the top surface to bring the section exactly to the dimensions of the working plans.

6.1. No extra payment will be made for sectioning, which shall be done evenly and true to the working plans. In cases where the contractor delays sectioning beyond the specified time or beyond the time set by the Executive Engineer for completion, the Executive Engineer shall, at his discretion either get the work done by other agency and deduct, the cost plus ten per cent centage from the contractor's bill or make a suitable deduction from the contract rate.

NOTE : This specification alters the practice which has prevailed in some parts, of paying for sectioning as a separate item, and it is now to be included by the contractor in his tender unit rate for earthwork. The standard specification which follows this specification deals with cases where special sectioning is not required.

7. Extra lift and extra lead (by head-load) When carting of earth for placing on bank is cheaper or required by specification to be done, the conveyance will be paid at the contract schedule rate for same when there is such a rate, but otherwise at the rate entered in the schedule of rates of the P.W.D. Division in which the cartage is to be done. An agreement for cartage rate should always, however, be taken before such work is begun, in which case the following sub-clause on lift and lead will not apply.

8. (i) " Lead will be the horizontal distance between the vertical central lines of the pit cross section and the bank whichis formed with the excavated earth. " Extra lead " by head load will be the " lead " as above defined less an initial lead of 50 metres. For every exra lead of 50 metres or part there of payment will be made at the contract schedule rate.

(ii) " Lift " will be the vertical distance obtained by adding up

(*a*) Half the depth of pit actually excavated;

(*b*) half the maximum height of the bank formed with the excavated earth over existing ground or bank; and

(*c*) the difference between the top level of pit actually excavated and the level above which (*b*) is reckoned in respect of diagrams 1 to 5 on plate No. 3.1 and in the case of diagrams 6 to 10, the values of " C " as shown on those diagrams.

8.1. " Extra lift " by head load will be the sum of height (*a*), (*b*) and (c) as above defined less an initial lift of one and half metree See typical sketches on plate No. 3-1, illustrating the method) For every " extra lift " of one and half metre or part thereof payment will be made at the contract schedule rate.

NOTE.—I. S. 1200 Part I/1974 also regarding " lead" and " lift " shall also apply.

9. *Rate* : These remarks on " rate " are not applicable to such lumpsum contract rates as may specify that the work will be done complete to specification for a fixed sum.

9.1 Contract unit rates for earthwork per 10 m³ shall include—

(*a*) The initial rate for excavating and depositing in layers not exceeding 15 cm in thickness, inclusive of the first 50 metres lead and 1.5 metres lift.

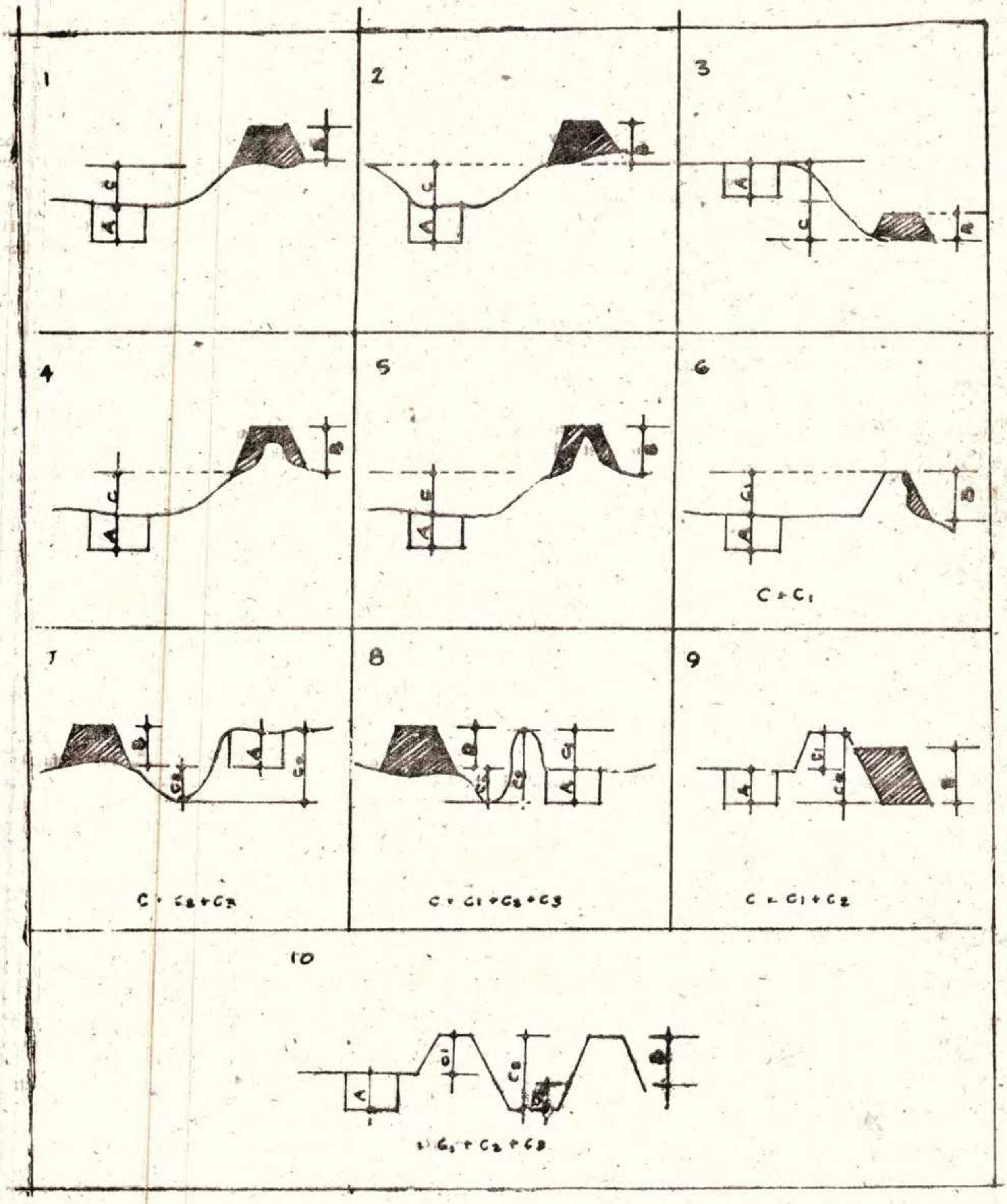
(*b*) Preparation of bed—vide Clause 1 above (Benching paid separately).

(*c*) Ramming and consolidation, breaking clods and sectioning inclusive of watering after temporary stoppage of work-*vide* Clause 2 above.

(*d*) Profiles, etc,—*Vide* paragraph 4 above.

(*e*) Watering—*Vide* Clauses 2 and 5 above. No extra payment will be made for watering to be done under this standard specification as detailed in addition in an addendum specification, unless a contract rate is approved prior to commencement of the work.

SEC 3



Legend :—

A—Depth of pit actually excavated in metres.

B—Maximum height of the bank formed with the excavated earth over existing ground or bank in metres.

C—Difference between the top level pit actually excavated and the level above which " B " is reckoned in respect of diagrams 1 to 6 and in the case of diagrams 7 to 10 the values " C " as shown therein in metres.

—Newly formed bank.

Note :—

Extra lifts involved in all the above cases equals = (A/2 + B/2 + C — 1-5) metres. Part of one and half metres to be counted as one and half metres.

SPECIFICATION No. 20-B.

EARTHWORK AND ROUGH BANKING.

NOTE.—This specification will apply to cases of excavation where breaking clods, ramming and sectioning to the spoil bank are not required—such as may occur in some drain excavation, etc.

1. *Pits in channel, drain section, Etc.*—Excavation shall be done exactly to the working plans. Since in most cases of excavation under this specification the borrow pits will be in the bed of the drain, the accuracy demanded in the previous specification for forming the bank shall in this case be applied to the section of the drain.

2. *Removal of thandoos. Etc.*—The clauses of the preceding specification regarding borrow pits shall apply to this specification. It is essential that the removal of deadmen or thandoos and final dressing of the bed to the working sections should follow immediately after the final measurement and passing of pits by the Executive Engineer or the Sub-Divisional Officer and the Contractor shall arrange accordingly. Failure so to comply shall preclude, the contractor from any rights of payment for the earthwork done under this specification, or part payment at the sole discretion of the Executive Engineer and this shall be clearly understood as an inseparable condition of the contract.

(If thandoos are left in drains or channels after admission of water thereto resilting to the original bed level will frequently occur, and the excavation rendered purposeless.)

3. *Depositing.*—Spoil from the pits shall be deposited on bank to each sections as are shown on the relevant plans, specified or ordered by the Executive Engineer. Ramming, breaking clods and smooth surface sectioning shall not be necessary, but a spoil bank with a neat straight toe, even slopes and even top surface shall be formed as the depositing proceeds.

3.1. Deduction from the earth work rate as decided by the Executive Engineer shall be made for careless deposition.

4. *Rate.*—The contract rate for earthwork per 10 cubic metres shall include the initial rate for excavating dressing bed and sides to exact section of working plans, conveyance and depositing to the requirements of this specification, inclusive of 50 metres lead and 1.5 metre lift, providing and forming such profiles log spikes strings and stakes as may be considered necessary by the Executive Engineer to guide the contractor in excavating and depositing.

4.1. Lead and lift will be paid for at the agreement rate and as defined in the preceding specification.

SPECIFICATION No. 20-C.

EARTHWORK SLOPING DOWN MARGIN—RIVER CONSERVANCY WORKS.

1. The margin shall be trimmed to the required slope and the spoil shall be thrown into the river or used up to fill hollows in the sloped margin as directed by Executive. Engineer, When filling hollows, the earth shall be laid in layers, watered and tampered very hard so as to afford a firm base for revetment or pitching to rest.

2. Thandoos shall be left at specified intervals for the full length of the sloped margin and shall be removed immediately after check measurement.

3. The rate shall be for ten cubic metre of earthwork done.

SPECIFICATION No. 21.

PUDDLE WORK.

1. *Composition.*—The puddle will consist of stiff clay with about 20 per cent of sand. If this percentage of sand does not exist in the clay, it shall, after being dug weathered and pulverised, be mixed with sand up to the required proportion.

2. *Weathering, pulverising, mixing and kneading.*—The clay will be dug and exposed to the sun and air for at least four days and when dry will be pulverised with rammers. Sand is to be uniformly mixed, if necessary, with the powdered clay and two days previous to that on which the clay is required for use, the whole shall be wetted and worked up in a pug mill, puddled under men's feet or trodden by bulls or buffaloes, into a plastic mass.

3. *Consolidation.*—When being laid, each basketful should be well trodden and incorporated with that already laid, care being taken that no stones, bricks, roots, grass, or rubbish of any kind is allowed to remain in the puddle.

4. Measurement of clay puddle will be recorded before hand by measuring the space where puddle work is to be done. After completion, the Officer in charge will certify that the work is completed in accordance with the measurements already recorded.

NOTE : I.S. 4701/1968 shall also apply.

SPECIFICATION No. 22.

TURFING.

1. I.S. 4701/1968, particularly paragraph 10 dealing with the above subject, shall also apply.

2. *Taking over.*—The turfing or planting shall be finished by the beginning of the rainy season, but should not be taken over from the contractor until it has formed a complete close grassy growth over the earth. No area which does not show a good healthy growth shall be paid for.

SPECIFICATION No. 23.

EXCAVATING FOUNDATIONS.

1. Excavated material is not to be placed nearer than 1 m from the outer edges of the excavation but shall be placed anywhere within 50 metres, as may be ordered by the Executive Engineer without extra payment. For removal beyond 50 metres, vide clause 6 below :

2. The bottom of foundation pits shall be dressed level in all directions and before any concrete is put in, shall be well watered and thoroughly rammed. The foundation trenches shall be dug out to the exact width of the lowest step of the footing and the depth shall be in accordance with the plans, or as may be otherwise ordered by the Executive Engineer. In firm soils, the sides of a trench shall be kept vertical upto a depth of 2 metres from the bottom and for a greater depth, the trench shall be widened by allowing steps of 50 cm on either side after every 2 metres depth from the bottom, so as to give a vertical side slope of $\frac{1}{4}$ to 1. The earth work excavation made shall be measured and paid for, taking into account sloping back as laid down above. The excavation made in excess of the above requirements shall not be measured and paid for.

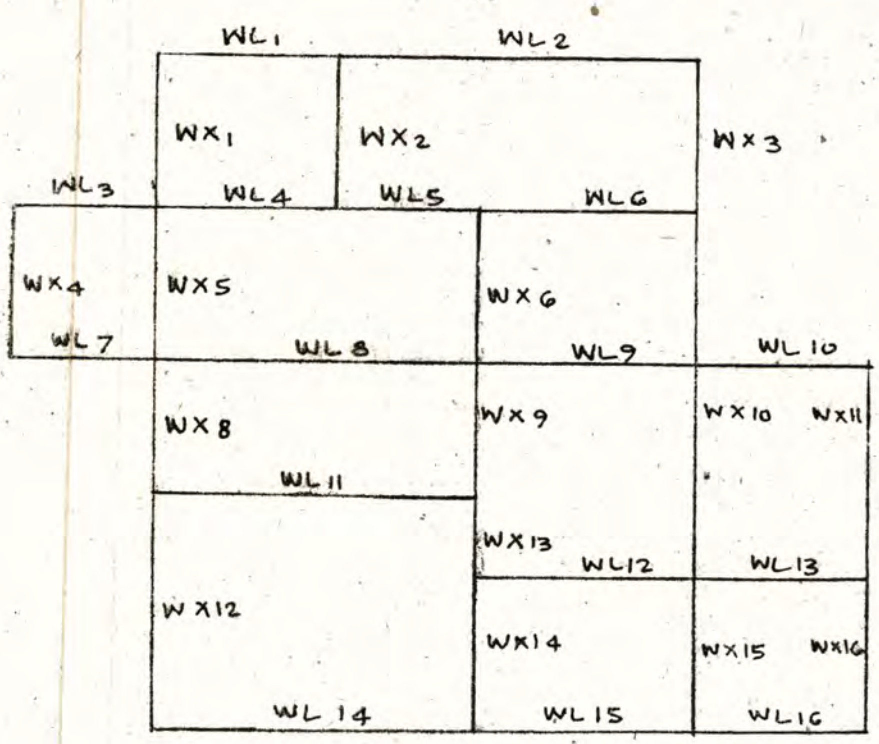


FIG. 2. TYPICAL MARKING DETAILS FOR WALLS.

2.1. For excavation in loose soil I.S. 3764/1966 shall be followed.

2.2. Where different foundation levels are necessary I.S. 1904-1966 may be followed.

2.3. If, by the contractor's mistake the excavation is made deeper or wider than shown on the plans, the extra width or depth shall be made up with concrete—and not with earth or other material —at the cost of the contractor,

3. Should rocks, or remains of old buildings, be met with, the material shall be removed with wedges and levers. Blasting will not be allowed, without the permission in writing of the Executive Engineer. In cases where the Executive Engineer considers blasting is essential, the extra rate, if any to be paid shall be fixed in writing before the work is put in hand.

4. If bad ground or loose soil be met with, the contractor, will be responsible for reporting the fact to the Executive Engineer who will issue such orders as may be necessary. For extra excavation, concrete and masonry arising from bad ground, the contractors shall be paid extra according to the schedule of rates agreed to.

5. Before concrete is laid in the trenches, they shall be passed by the Executive Engineer.

6. All excavated earth, which is unfit or surplus to requirements for filling in, shall be spread as instructed in the standard specification for "Filling in foundation" at the contractor's expense. If the excavated earth is to be removed byond 50 metres, then the rate in the agreement for extra lead will be paid or in the absence of such rate, the contractor will be paid in accordance with the schedule of rates of the Division in which in the work is being executed. If the cartage is cheaper than head loads, then cartage shall be done and all rate shall be fixed in writing by the Executive Engnieer before cartage is begun.

7. The contract rate for excavation of foundation shall include the following:—

(a) Setting out works, profiles, etc.

(b) Site clearance, preparation of bed.

(c) Forming deadmen or thandoos and their removal after measurements.

(d) Forming (or leaving) steps inside of deep excavation and their removal after measurements.

(e) Excavation for insertion of planking and strutting.

(f) Unless otherwise specified, removing slips or falls in excavation.

(g) Bailing out water on excavation from rains, sub-soil water, etc.

(h) Shifting or supporting pipes, electric cables, etc. met during excavation.

NOTE : Pumping out water caused by springs, tidal or river seepage broken water mains or drains, well point pumping and the like shall be measured in kilolitres of water and paid for separately.

8. Shoring, sheeting, planking, strutting, etc., needed for supporting sides of excavation shall be paid for separately unless otherwise specified in the description of relevant schedule items and in addendum specifications.

Extra rate for work in or under water, in or under foul conditions, under tides and in snow shall be paid for unless otherwise specified in the description of relevant schedule items and in addendum specifications. The levels of high and low water tides where occurring shall be stated in the tender schedule.

9. Classifications of soils for earth work I. S. 1200 Part I/1974 shall apply.

NOTES : 1. In all such cases, the classification as made by the Executive Engineer shall apply and the contractor shall make the excavation under the most favourable conditions, when so instructed by the Executive Engineer. No revision of classification will be made by the Executive Engineer.

1.1. When rock is to be excavated by blasting, it will always be specified before work starts. In no case is blasting to be done before a rate has been agreed on and the approval of the Executive Engineer to such action obtained.

1.2. Contract rate for any classification of soil assumes that wedges, levers, picks, mamooties and manual tools only are to be used in excavation and in no case will the contractor be allowed to obtain a revision of classification on the ground that blasting is necessary unless such necessity is approved by the Executive Engineer prior to commencement of blasting. In lump sum contracts, the

466-3—9

contractor assumes the risk of meeting with hard rock, requiring removal without extra compensation unless separate provision for such contingency is specifically entered in the conditions of contract.

10. At places of foundation where existance of colonies of subterranean termites are found or where the structure is likely to be attacked frequently chemical barriers which prevent the termite from reaching the super structure of the building shall be introduced. The soil treatment for anti-termite measures in buildings i.e. in basement excavation. column pits and wall trenches shall be as per I.S. 6313 (Part II)—1971.

SPECIFICATION No. 24.

FILLING IN FOUNDATIONS.

1. All foundation shall be refilled to the original surface of the ground with approved materials, well watered and rammed.

2. The contractor shall not fill in around any work, until it has been approved by the Executive Engineer. In cases where the excavated foundation soil is to be used for refilling, it shall be brought back from the place, where it was temporarily deposited, and the trenches or other excavations shall be filled up to the height of the original surface with this earth, carefully rammed in regular layers of not more than 20 cm in thickness, and consolidated by the addition of water to each layer as and if found necessary according to the directions of the Executive Engineer.

3. After completion of the building, the ground shall be carefully dressed with a gentle outer slope for a distance of 50 metres, all round the building, unless otherwise described in the schedule item description or otherwise directed by the Executive Engineer. The contract unit rate for "Filling in Foundations" is inclusive of this work.

4. The dimensions of consolidated earth shall be measured for the purpose of payment, where returning filling and ramming of excavated earth is not described with the item of excavation. The dimensions of filling shall be measured correct to the nearest cm. and cubical contents worked out correct to two places of decimal.

SPECIFICATION No. 25.

FILLING IN BASEMENT.

1. Materials for filling in basement shall be as defined in the general specification or descriptive specification sheet ; or shall be brought from a source approved by the Executive Engineer.

2. The surface to receive the filling shall be first cleared free from all roots, vegetation or spoil and wetted.

3. Filling upto plinth level is to proceed in layers with the construction of the building so that the earth, filling may be thoroughly consolidated by the tramping of the workers. It shall have optimum moisture content and well rammed in layers of 15 cm. After thorough consolidation, a sufficient quantity of the filling is to be removed to make room for the flooring. For floors to rooms, the excavation shall be level and for verandah, the slope shall be 20 mm. per metre towards the verandah edge, unless other solpe is specified, shown on the drawings or ordered by the Executive Engineer. The depth excavated should correspond with the required thickness of the floor.

4. Where sand filling is specified, the sand shall be clean, free from admixture of foreign material and approved by the Executive Engineer before filling is commenced. Should there be a necessity to fill in a basement with sea sand prior written approval of the Executive Engineer shall be obtained. Sand filling should be saturated with water and the flooring should be laid in this condition.

5. Filling in basement shall have optimum moisture content and, well consolidated in layers of 15 cm. by ramming with iron rammers and butt ends of crowbars. When filling reaches finished level the surface shall be flooded with water for at least 24 hours, allowed to dry and then rammed and consolidated in order to avoid any settlement at a later stage."

SPECIFICATION No. 26-A.

WELL-SINKING FOR FOUNDATIONS.

1. *Excavation.*—Unless otherwise specified, open excavation shall be carried down to 30 cm. above sub-soil water level, before the well curb is laid.

1.1. I.S. 3955/1967 shall apply for formation of island to sink well foundations in water (Particularly refer Para 6.4.). The island shall be brought up at least 30 cm. above the water level before the well curb is laid and if the Executive Engineer shall so direct, the sides of the island shall be protected from erosion by means of suitable piles and shuttering. Separate agreement rates for this work being decided on before the work is done, unless the work is to be done under an all inclusive lump sum agreement.

1.2. Whether the steining be sunk, or constructed in open excavation by bailing as necessary blasting must never be resorted to without obtaining prior permission of the Executive Engineer. I.S. 3955/1967 shall also apply.

1.3. The instructions contained in the clauses 1 to 1.2. under "Notes" to Standard specification for "Excavating Foundations" shall apply also to this specification.

1.4. The instructions contained in the following clauses of the standard specification for "Excavating Foundations" shall apply also to this specification :—

Paragraphs (2) and (4) regarding precautions in bad ground.

Paragraph (3) regarding rocks or remains.

Paragraph (6) regarding removal of unfit or surplus material.

Paragraph (2), (7) and (8) regarding shoring, dewatering, etc.

2. *Curbs.*—The design for the curb will be made by the Executive Engineer and in cases where the curbs are to be supplied by the contractor, they shall be in conformity to the sanctioned plans therefor. The curb will be made 25 mm. greater in diameter than the steining; The curbs shall be assembled and passed by the Executive Engineer before the steining is commenced. If it is necessary to take the curb, apart, for the purpose of lowering to the bottom of excavation, the parts shall be numbered and re-assembled at the bottom of the excavation. Wooden curbs for wells of 2 metre diameter and under will be made of two thickness of wood, and for wells above that size of three thicknesses or more -unless other design is shown on the plans or ordered by the Executive Engineer. When the rings cannot be made of one piece across the width, the concentric rings shall break joint ; successive layers of the curb shall also break joint with the rings above and below them. The separate pieces in each layer shall be cut to the requisite curve, and each shall not be less than 1.2 m. long, 20 cm. wide and 13 cm. thick unless otherwise shown on the plan or otherwise specified. All individual segments of each ring shall be strongly dovetailed together and the successive rings, dowelled together with hardwood dowels—all to the satisfaction of the Executive Engineer. Iron bolts will also be used for jointing the several layers of the curb, as may be shown on the plans or ordered by the Executive Engineer. The curb shall be levelled up truly, and brought to exact position before the steining is commenced.

N.B.—Wooden curbs—(*See* Memorandum No. 5807—Works 92 C.P., dated 15th November 1929, for suitable wood—babul, tamarind, mango or teak being also suitable) are commonly used for moderate size wells, but reinforced concrete curbs will be frequently found cheaper. Curbs with steel cutting edge are used for large size wells.

3. *Tie-rods.*—Holes shall be drilled in the middle of the curbs to receive the tie-rods. Tie-rods shall be threaded both ends and fixed through and to the bottom of the well curb by nuts and washers and shall be carried up—forming a continuous length to the height specified or shown on the drawings. Unless otherwise specified or ordered, they shall be 20 mm. diameter and in 3 m. lengths, not more than 1.5. m. apart circumferentially measured and shall be joined together at bond rings or plates by 15 cm. long bottle nuts. The

plans will show or it will be specified, if the upper end of the tie-rods shall be threaded through iron plates or weather through a 80 mm. x 10 mm. flat iron bond ring (temporarily secured to keep the rods vertical and immovable while the steining is being built around them.) The upper nuts will be screwed down to press against the top of the steining. The object of the tie-rods is to secure the curb to the steining, and strengthen the steining while it is being sunk and they must be kept truly vertical and in the centre of the steining throughout their height.

4. *Steining*.—I.S. 3955/67 shall apply (particularly refer para 4.3.1. (c) and 5.10.3.)

4.1. It is dersiable to have specially moulded bricks for well steining but such bricks, if demanded, will be so specified.

4.2. If plastering is to be done to the outside of the well to facilitate sinking, it will be so specified under the description of the masonry.

5. *Sinking*.—Para 5.9.1 of I.S. 3955/1967 also shall apply.

5.1. Sinking must not be started till the depth of the masonry to be sunk has set and until the steining has been passed by the Executive Engineer and commencement of sinking approved.

5.2. The contractor shall arrange his own method of sinking unless otherwise specified or ordered by the Executive Engineer (*i.e.*), either by manual labour or divers, or by dredgers, weighting the top of the steining to assist sinking.

5.3. No dewatering of the wells must be done during sinking without obtaining prior permission of the Executive Engineer and any damage which may result either to the well or adjoining structures by such dewatering shall be made good at the contractor's expense.

5.4. For well sinking I.S. 3955/19/67 shall apply (Particularly refer paras 6.7. and 7.2.).

5.5. If it is necessary to sink a well deeper than the specified depth, in order to correct any tilt or error of position, such sinking must be done at the contractor's expense. If the Executive Engineer so instructs, the sinking shall be done continuously working day and night till the required depth is reached. Wells shall not be left, partially sunk during period of probable floods. Rectification of damage to partially sunk wells from any cause shall be made good by the contractor to the satisfaction of the Executive Engineer.

6. *Removal of bad work*.—If the steining splits during the sinking or within six months after completion, and in the opinion of the Executive Engineer, be unsound the contractor shall be bound to dismantle the whole or part according to circumstances and reconstruct it without charge, and if the falling in of the sides of the excavation from insufficient shoring, or any other cause due to negligence of the contractor, renders it necessary in the opinion of the Executive Engineer, the contractor shall be bound to construct and sink an entirely new well without charge.

7. *Protection during construction*.—Attention is directed to the relevant clasues of the standard general conditions of contract.

8. *Rate*.—In the case of lump-sum contracts, the work will be executed for a definite contract amount but completed according to the plans and specifications.

8.1. Tools and plant shall be supplied by the Contractor at his own expense—both for dredging and dewatering where such is required—unless other arrangements are definitely prescribed in the relevant specifications or tender notice. The contractor shall quote his tender rate accordingly. The contractor's attention is directed in this connection to the relevant clauses in the standard general conditions of contract, but it is to be understood that Executive Engineer does not bind himeslf to supply any tools and plant on hire.

8.2. If the schedule prescribes payment for separate items of the well—then

(i) Earthwork for open excavation will be paid only for th quantity actually required to be excavated taking into account sloping back as mentioned in the relevant specification for earth work in foundation. The excavation made in excess of the above requirements shall not be measured and paid for—notwithstanding that the contractor may find it more convenient to take out the excavations at slopes other than those shown in the plan to avoid shoring. In every case the contractor shall make excavations perfectly safe at all stages, for the workmen, for whose safety he shall be wholly responsible.

(ii) Curbs will be paid for per curb or per 0·01 cubic metre as indicated in the relevant schedule item.

(iii) Masonry shall be paid for on the quantities as shwon in the schedule or deduced form the plan.

(iv) Sinking shall be measured per meter run, for different depth as specified in the contract. The depth of sinking shall be measured to the bottom of well curb from the actual level at which the cutting edge was laid and in no case 30 cm. above sub-soil water level. The rate for sinking will be inclusive of all dredging and dewatering as necessary and inclusive of all tools and plant.

SPECIFICATION No. 26-B.

WELL-SINKING FOR WATER SUPPLY.

1. The work shall be executed to the standard specification for "well-sinking for foundations".

2. If dry stone masonry is to be laid, it shall be executed to the relevant standard specification, either coursed or random rubble as specified, without mortar, and with width of vertical open joints as specified, to the true shape of the well as per plan; and if of dry brick masonry, width of open joints, bond and type of bricks to be used will be specified.

3. Platform, parapet, pulley arrangement, ladder or rungs in well-steining drain etc., shall be executed as shown in the relevant plan, standard specification materials being used in all parts of the work.

NOTE.—(i) Thickness of steining—The following dimensions are suitable :—

Depth of well from ground level.	*Brick work.*	*Stone masonry.*
(1)	(2)	(3)
Wells—3 metres and under	40 cm.	30 cm.
Wells—Above 3 metres and upto 10 metres	50 cm.	40 cm.
For every additional 3 metre depth	Increase the thickness by 10 cm.	

(ii) Where wells are excavated in hard ground and no puddle or other lining is required, steining should be provided for a depth of at least 2 metres to prevent pollution from surface washings.

EXTRACT FROM I.S. 4701/1968.

Code of practice for earthwork on canals.

4. *Clearing*.—

4.1. The land over which embankments are to be formed and other excavation is to be carried out shall be cleared of all trees, bushes, rubbish, ant hills and other objectionable matter.

4.3. It is desirable to protect the trees outside the outer edge of the canal embankments. However, the presence of trees in the vicinity of a canal can accentuate variation of moisture content in the sub-stratum. In the case of expansive soils such excessive moisture variation can result in damage to the lining. Such influence is believed to extend to distances equal to twice the height of the tree.

6. *Embankment construction*—

6.1. Before commencing the work, the toe of the slope on each side of the banks shall be lock-spitted (Dag-Belled) and marked by pegs, firmly driven into the ground at intervals of about 20 m. Profiles made by bamboos, earth or other convenient materials and strings shall be set up for the guidance of the workmen at about 50 m. aprat over straight reaches and about 25 m. apart at curves. In setting up the profile for an embankment a suitable allowance shall be made for settlement (*see* 6.2.2.1.).

6.1.1. Masonry blocks shall be constructed at each profile to indicate the centre line as also the bed level of the canal before starting the entire earthwork.

6.2. *General requirements*.—Embankments shall be built to the height and slope as shown on the drawings. All the edges of the embankment shall be neatly aligned symmetrical to the centre line of the channel. They shall be absolutely straight in straight reaches and smoothly curved at bends.

6.2.1. The top of each embankment shall be levelled finished and so as to be suitable for road way and given a cross outward slope to drain away rain waters. The bank carrying inspection road shall be given a suitable cross slope.

6.2.2. For embankment in which controlled compaction has not to be carried out (*see* 6.6.1.) suitable allowance shall be made for settlement.

6.2.2.1. An allowance of about 10 per cent, for settlement is recommended for embankments in which controlled compaction has not been carried out (*see* 6.6.1.).

6.3. ***Methods of Construction.***—**Embankments may be built by manual labour or by machinery depositing the materials directly, from excavation.**

6·3·1. *General drainage*.—Under ordinary circumstances no special drainage works are necessary in embankments but when required ditches may be dug at a distance not less than 3 m. from the toe of the slope. The necessity for any drain so provided will depend on the topography of the ground on which the embankment is constructed, having regard to the desirability of preventing an accumulation of water at the base of the embankment.

6·4. *Requirements for material*.—Where the embankment constructed by taking material from borrow pits care shall be exercised that all large clods are broken and no clods bigger than human fist, say 8 to 10cm.roots,grass and other rubbish are burried in the Banks. Before procuring materials from borrow pit all perishable material shall be stripped off from the top surface as specified in 6.5.1. Unless otherwise directed by the Engineer-in-charge all materials shall be deposited in embankments so that cobbles, gravel and boulders are well distributed through other material and not rested in any position within or under the embankment.

6·5. *Preparation of ground surface for embankments*.—Before beginning the construction of embankments the surface area of ground to be occupied shall be cleared of all roots and vegetable matter of any kind and stripped to a suitable depth. The stumps shall be pulled or otherwise removed and the roots grubbed. The stumps and roots removed shall be suitably disposed of. For roky surface under embankments a cut off of suitable size may be provided.

6·5·1. The depth to which top soil is removed shall be adequate to remove all perishable material and any soil which may become unstable on saturation or may interfere with development of proper bond between the foundation and embankment. It is not necessary to remove all the soil containing fine hair like roots but only the rather heavy mat. Table I may serve as a guide for fixing the depth of stripping.

TABLE I—DEPTH OF STRIPPING.

Type of Vegetable cover on the soil.	*Depth of Stripping.*
Soil containing light grass cover ..	5·0 to 7·5 cm.
Agricultural land	To the bottom of ploughed zone usually 15·0 to 22·5 cm.

6·5·2. The ground surface under all canal embankments excepting rock surface, where it is below the maximum water level in the canal, shall be scored making open furrows not less than 20 cm. deep below natural ground surface at intervals if not more than 1 m. However where the ground surface is below the bed level of the canal the entire surface of the foundations for embankments shall be stripped to a depth of not less than 15 cm.

6·6. *Compaction requirements*.—Embankment shall be compacted, as shown on the drawings, to achieve the requirements laid down in 6·6·1· and 6·6·2· General methods of compaction of embankment are given in 7.

6·6·1. *Embankments without controlled compaction*.—Where the natural ground surface is above the maximum water level in the canal but below the top of the embankment, the embankment shall be built in layers not exceeding 30 cm. in thickness and to the full width of the embankment. Each layer shall be commenced from the edge farthest from the excavation. Top of each layer shall be kept slightly depressed in the centre. The excavating and hauling equipment shall travel over the embankment to evenly distribute the material and compacting effort over whole surface. If the embankment is to carry a highway it shall be constructed in accordance with 6.6.2., 6.6.3.1., 6.6.4., 6.6.4.1. and 6·6·5.

6·6·2. *Embankments with controlled compaction*.—Where the natural ground is below the maximum water level in the canal the portion of the embankment up to the maximum water level or where rigid lining is to be laid, the portion of embankment up to the upper level of the lining, shall be built according to the requirements given in 6.6.3.1., 6.6.4. and 6.6.5.

6.6.2.1. Embankment shall be built in layers generally not exceeding 25 cm. in thickness (loose layer) and to full width of the embankment. Each layer shall be commenced from the edge farthest from excavation. Top of each layer shall be kept slightly depressed in the centre.

6.6.3. *Impervious zone*.—The impervious zone wherever shown on the drawings shall be built of material having sufficient percentage of clay so that it can be compacted at optimum moisture content by suitable compacting equipment to the maximum dry density. The material shall be compacted to a density as specified in 6.6.5. The water tightness of material should be checked by carrying out permeability test. The co-efficient of permeability of impervious material should not be greater than 30 cm. per year. The impervious material should preferably be free from large size particles. If this is not possible the maximum size and percentage or gravels to be permitted is 40 mm. and 20 per cent respectively. When the above relaxation is allowed the Engineer-in-charge should ensure that relative standards set for dry density and permeability are fulfilled.

6.6.3.1. The rest of the compacted zone may consist of any suitable material adequately compacted to provide stable support for the impervious core under various conditions of saturation and draw down. If silty or sandy material is used for this portion, such a material will not be emenable to compaction by the usual compaction procedure using sheep foot rollers. For such materials proper machinery utilising the principle of vibrated compaction should be used. The minimum relative density of the compacted material shall not be less than 70 per cent. The distribution of material shall be such that the compacted material will be homogeneous and free from lenses, pockets or other imperfections. The maximum dimension of stones placed in the embankment shall be not more than 13 cm. The excavating and placing operations shall be such that the materials when compacted will be blended sufficiently to secure the best practicable degree of compaction, impermeability and stability.

6.6.4. *Moisture content.*—Prior to and during compaction operations the embankments shall have optimum moisture content required for the purpose of compaction and this moisture content shall be fairly uniform throughout the layer. In so far as practicable the moistening of the material shall be supplemented as required by sprinkling water at the site of compaction, if necessary.

6.6.4.1. If the moisture content is greater than optimum for compaction, the compaction operations shall be delayed until such time as the material has dried to the optimum moisture content.

6.6.5. *Dry bulk density after compaction.*—The dry bulk density of the soil fraction in compacted embankment material shall be not less than 95 per cent of the maximum dry bulk density at optimum moisture content obtained in accordance with I.S. 2720 (Part VII) 1965 *.

NOTE.—It has been observed that optimum moisture contents determined in the laboratory are seldom satisfactory in field. It is, therefore, essential to develop suitable moisture density relationships in the field for the type of compacting equipment being used.

7. *Compaction of earth works.*—

7·1. *Tests for compaction of earthworks.*—The following tests shall be carried out for determining compaction:—

(*a*) Density moisture relationship of the soil,

(*b*) Density of soil in field, and

(*c*) Moisture content.

7·1·1. Density moisture relationship of the soil shall be determined in accordance with I.S.: 2720 (Part VII)—1965* and I.S. 2720 (Part VIII)-1965.

7·1·2. Density of soil in field shall be determined in accordance with I.S. 2720 (Part XXVIII)-1966 or I.S. 2729 (Part XXIX)-1966.

7·1·3. Moisture content of soil shall be determined in accordance with I.S. 2720 (Part II)—1965.

7·2. For deciding methods of compaction to obtain the required amount of compaction by most economic means it is necessary to employ systematic field control for a particular job, the following items should be decided :—

(*a*) Dry density of the soil required with regard to the soil type,

(*b*) The most suitable moisture content at which to work and the effect of probable moisture content variation.

(*c*) The type or types of compaction equipment most suitable for compacting the soil having due regard to relative costs, and

(*d*) The thickness of loose layer.

7.2.2. Where the magnitude of work justifies it, the procedure described in 7.2.2.1. to 7.2.2.3. is recommended to determine the required compaction method. In deciding the method to be employed, economic considerations should be kept in view. For example, it may have to be decided light roller or thick layers with heavy rollers, again, consideration may have to be given to the number of passes required with smooth and sheepfoot rollers to produce specified density. Often it may be found that a combination of two or more types of equipment would give best results.

7·2·2·1. Standard compaction tests shall be made on available materials. The tests will indicate broadly which are the most suitable and give a rough idea of the best type of equipment to be used and the moisture content at which compaction should be undertaken. This method would help in classifying a material according to its compaction characteristics.

7.2.2.2. Having decided on the filling material to be used field compaction trials should, where possible be made with the compaction equipment expected to be used under conditions which are likely to obtain during construction to determine the effects of soil moisture content, thickness of layer, and number of passes.

7. 2.2.3. In deciding on the range of moisture contents, day-to-day variations in moisture content should be taken into consideration, particularly in the case of cohesive soils. Limitation of control of moisture content are dealt with in 6.6.4. Having decided on the thickness of layer and range of moisture contents, tests should be made with the different types of equipment available and the required number of passes should also be determined. In all this work the state of compaction should be measured in terms of dry bulk density.

7.2.3. During the actual construction of any earthwork maximum use should be made of constructional plant and deployment of the plant should be carefully controlled to obtain uniform compaction over as wide an area as possible. Care should also be taken during the compaction operation to shape the surface of the works to facilitate the shedding and to minimize the absorption of rainwater, particular attention being given to the prevention of ponding. It is advisable to do this at the end of each day's work.

7·2·4. Where, in the construction of an emban ment, it is necessary to construct a culvert over which the filling has to be placed, it is essential that the filling and subsequent compaction should be carried out in such a manner as to avoid an unbalanced thrust on the culvert which might displace or damage it.

9·1. Where canal excavation does not furnish sufficient suitable material for embankments, additional material required may be procured from the borrow pits. The location of borrow pits will depend on the material that is being sought which in turn depends on the design consideration. It may be necessary to survey the soil by means of auger borings or trial pits to determine the extent and nature of the deposits in the borrow area.

9·2. No borrow pits shall be dug within 5 m of the toe of embankments, if their depth is less than 0·5 m, and 10 m, if their depth is more than 0·5 m; or within such a distance from the toe of the bank where a 4:1. hydraulic gradient line cuts the ground surface, whichever is more. Borrow pits shall not be more than 1 m in depth and 25m in length. A clear distance of 1 m. shall be left between the pits. The bed of borrow pits shall be left reasonably smooth and even.

9·3. Borrow pits shall be drained to avoid stagnation of water. The bottom level of borrow pits should be fixed with reference to the prevailing ground slope towards the nearest natural drainage course The pits shall be connected together by a drain about 0·5 m wide. The bottom level of connecting drain should suit the bed level of the pits it connects.

10. *Turfing*—

10.1. *Principles underlying the use of grass on earth slopes.*—Surface stabilization of slopes and the prevention of soil erosion and weathering may be accomplished by the establishment of grass or other herbages. The living grass roots machanically reinforce the soil, and decaying organic matter improves soils structure. The grass leaves, living or dead, protect the surface against rain and wind. The combination of improved soil structure and protection gives stability against erosion.

Virgin clays and other sub-soils are usually deficient in those bacterial organisms which promote healthy growth. The application of top soil to any new slope is usually a pre-requisite for the successful establishment of grass.

10.2. *Top soiling.*—The depth of top soil required will vary according to the nature of the sub soil and a depth of about 15 cm. of good quality soil overlying the sub soil is usually sufficient to sustain plant growth.

10.3. *Sodding.*—The sods used shall be cut in rectangular shape 8 to 10 cm. thick and laid so that their edges are in close contact and then welded by being gently rammed till they form a level and compact mat. When old surfaces are to be turfed, they shall be picked upto a depth of about 4 cm to give a hold to the sods. For sodding any grass which forms a thick short turf shall be used.

10.4. *Turfing.*—It is difficult to generalize on the type of grass to be used since each particular soil type requires a specific grass. To ensure a satisfactory award it is desirable to consult agriculture department, who would make any necessary analysis of the soil before specifying the type of grass, It would also be a help to study the grasses growing in the neighbourhood and to include the varieties that appear to be most suitable, this of course, largely depend on ne top soil being obtained from the same vicinity.

* Method of test for soils Part VII Determination of moisture content—dry density relations using light compaction.

EXTRACT FROM I.S. 4839 (PART I) —1968

Code of practice for maintenance of canals—unlined canals.

APPENDIX A.

RECOMMENDED METHOD FOR CLOSING BREACHES IN CANALS.

A-0. *General*—

A-0·1 Methods for closing breaches in running canals are recommended for general guidance only. However, expert technical advices-ould be immediately sought as to the method to be adopted:

A-1 *Breach in a small distributory or minor*—

A-1.1 Water of the breach spreads on the adjoining lands and usually there is no place to take earth for closing the breach. The earth has to be obtained by cutting the outer slope of the existing bank. Enough earth should be collected on both sides of the breach on the existing bank The earth baskets should never be thrown in the water. The closing process should be started from both ends by slipping the earth from the heap and protecting the canal side by grassy clods usually available from the berms No grassy clod should be allowed to be washed down into the breach site. With a rush of earthwork at the end, the breach may be closed straight away progressing from the bank.

A-2. *Breach in a major distributory or small branch canal.*—

A 2.1. In this case it is necessary to reduce the flow through the breach, otherwise a lot of earth will be washed away before the breach is closed. This should be done by driving a double line of stakes as shown in Fig. 1 and then putting planks or mattresses against them, if available and if not then filling jungle in between the stackes pressing it down with bags filled with sand and by men walking over them. No earthwork should progress before the flow thorugh the breach has been arrested to some extent in this way. Meanwhile earth should be piled up on both sides. The closing should be then started from both sides by slipping earth from the heap in form of a ring bund as shown in Fig. 1. All jungle from the ring bund site should be removed before earth work progresses no earth basket should be thrown in water. It must always be slipped from a heap. The last gap of about 3 m should be closed with a rush when enough earth has been collected on both sides. Straight closure in large canals is not possible.

A-3. *Breach in a large canal*—

A-3.1. It would be desirable to get the supply reduced from headworks as soon as possible. In case of a breach in a large canal the closing of the breach in a canal follows the same method of the ring bund as described in A-2.1 but the jungle or planks would not serve the purpose of arresting the flow through the breach. The double line of stakes should be driven as before if depth permits and double line of gunny bags filled with sand should be put in it. The inter-spaces should be plugged with berm earth. A temporary bank of gunny bags should be raised in the position of stakes and bushing as shown in Fig. 1. The closing of the breach should then be done by constructing a ring bund behind.

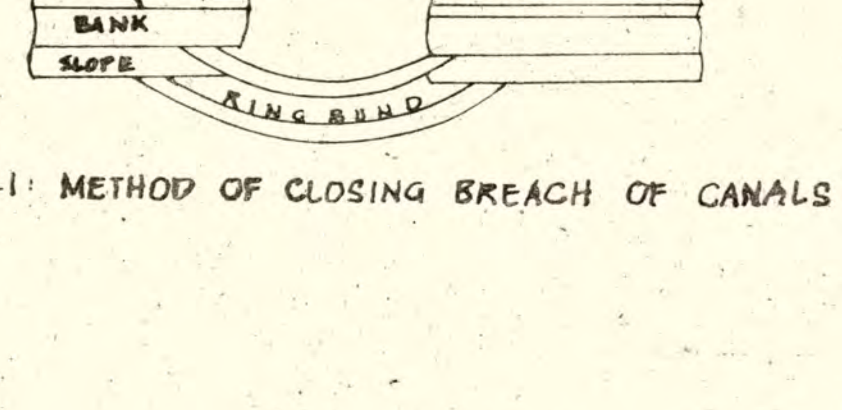


FIG-1: METHOD OF CLOSING BREACH OF CANALS

EXTRACT FROM I.S. 3955-1967.

Code of Practice for design and construction of well foundations.

4.3.1. The mixes for concrete and reinforced concrete in the various components of the well should be as follows:

(a) *Bottom plug*—Plain concrete not leaner than 1:3:6. plus 10 per cent excess cement or Grade M 100 (See I.S. 456-1964).

(b) *Curb*—Reinforced concrete of Grade M 150 or higher (mix not leaner than 1:2:4.)

(c) *Steining*—Cement concrete of Grade M 100 or higher (mix not leaner than 1:3:6) (See I.S. 456-1964) or brick masonry using first class bricks of strength not less than 70 Kg. cm^2 and cement sand mortar 1:3 to 1:4 or ashlar or rubble masonry in cement mortar 1:3 to 1:4 depending upon the depth and size of the well.

(d) *Top plug*—Plain concrete not leaner than 1:4:8.

(e) *Reinforced concrete capping*—Reinforced concerte Grade M 150 or 1:2:4 mix.

5.9. *Sinking stressess* :

5.9.1. The well shall be made sufficiently strong to withstand all stresses during sinking.

5.10.3. *Stennig* :

5.10.3.1. It should be strong enough to transmit the superimposed loads to the base.

5.10.3.2. It shall provide weight for sinking to the extent necessary.

5.10.3.3. Sufficient bond rods should be provided in the steining to bend the units of the steining built up as the well is sunk.

5.10.3.4. The steining should be reinforced horizontally to take the tension likely to come on the steining during sinking or during service (see also 5.10.3.3.).

6.4. *Laying the well curb*:

6.4.1. The cutting edge over which the well curb is built shall be placed at the correct location and shall be initially levelled.

6.4.2. For laying in water, where the depth of standing water is less than a metre, simple sand islands may be made by laying a few rings of sand bags.

6.4.3. For laying in water, where the depth is 1 to 5 metres the sand island may be made by driving sheet piling and filling inside or by driving two rings of poles with their inside filled with sand bags or other material and the central space being filled with sand.

6.4.4. The size of the island made in each case should be sufficient to allow free working space necessary for various purposes.

6.4.5. Adequate provision shall be made to protect the island from scour.

6.4.6. For deep water it may be economical to build the curb on dry ground and float it to the site. For this purpose, the curb should be built initially of sufficient height.

6.5. *Steining* :

6.5.1. The steining shall be built in one straight line from bottom to top. In no case shall it be built in plumb at an intermediate stage when the well is tilted.

6.5.2. The steining should be built in true shape both on the inner and outer edges.

6.5.3. The height of the steining built at any time shall be such that the well does not lose stability.

6.6. *Bottom plugging* :

6.6.1. The bottom of the well should be cleaned of unwanted material before plugging is started.

6.6.2. The method adopted for concreting should be such that sound concrete is obtained. In any method adopted the concrete should be placed at the bottom and should in no case be dropped from a height. The methods used may be tremie, prepakt concrete or concreting by skip boxes.

6.6.3. In case bottom plug concrete is laid by skip boxes the arrangement should be such that it discharges the concrete at the base only and the concrete should be evenly distributed at the base.

6.6.4. The concreting for plugging should be done in one continuous opertaion. If there are two or more dredge holes, plugging should preferably be done simultaneously and to equal height in all the dredge holes.

6.6.5 There should be no flow of water through the concre te till it is set.

6.7. *Sinking* :

6.7.1. All precautions shall be taken against possible damage to the foundations of structures in the vicinity of the walls prior to commencement of dredging of the material from inside of the well.

6.7.2. The sinking of the well should be done in such a way, that the well does not go out of position or out of plumb beyond the specified tolerance.

6.7.3. Dredging may be done manually or mechanically.

6.7.4. When sinking in clay, the work may be done in dry by dewatering but precautions shall be taken regarding the heaving or bursting of the base soil.

6.7.5. As sinking preceeds a record of the different kinds of soil penetrated by the well shall be kept by preserving suitable soil samples.

7.2. *Tilt* :

7.2.1. Provision shall be made in the design for a tilt in the well in any direction. The limit shall be specified by the Engineer in-charge ; generally it should be limited to 1 in 60.

7.2.2. Careful watch shall be kept during sinking and any tilts developing should be immediately attended to. Whenever the well shows tendency for tilting, adequate preventive measures shall be taken. This may be done by putting eccentric kentledge, by pulling or by pushing the well, or by any other means,

EXTRACT FROM I.S. 1904-1966.

Code of practice for structural safety of buildings—foundations.

7.7. *Foundation at different levels* :

7.7.1. Where footings are adjacent to sloping ground or where the bottoms of the footings of a structure are at different levels or at levels different from those of the footings of adjoining structures the depth of the footings shall be such that the difference in footing elevations shall be subject to the following limitations.

(*a*) When the ground surface slopes downward adjacent to a footing, the sloping surface shall not encroach upon a frustum of bearing material under the footing having sides which make an angle with the horizontal of 60° for rock and 30° for soil and the horizontal distance from the lower edge of the footing to the sloping surface shall be at least 60 cm. for rock and 90 cm for soil.

(*b*) In the case of footings in granular soil a line drawn between the lower adjacent edges of adjacent footings shall not have a steeper slope than two horizontal to one vertical (See Fig. 1).

(*c*) In clayey soils where the concrete or the masonry of the footings is deposited directly against the vertical sides of the excavation, a line drawn between the lower adjacent edge of the upper footing and the upper adjacent edge of the lower footing shall not have a steeper slope than two horizontal to one vertical (See Fig. 2)

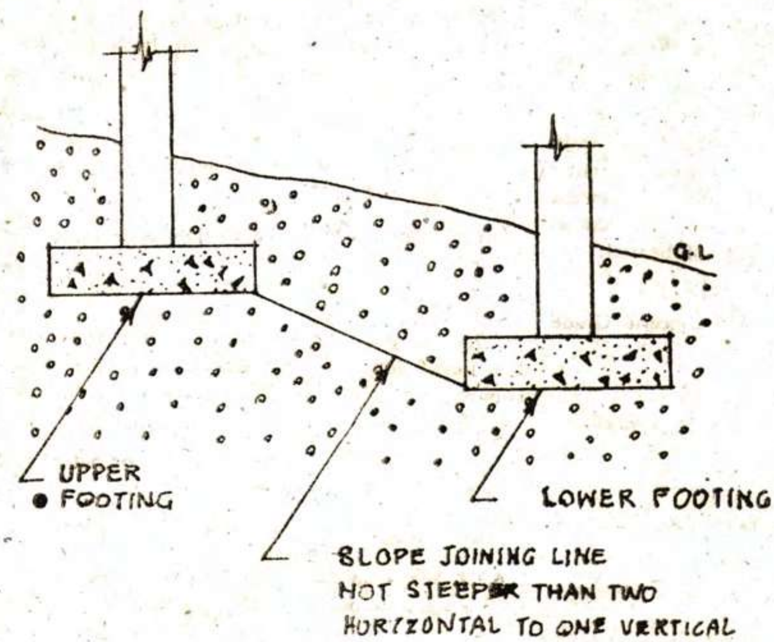


FIG. 1 FOOTINGS IN GRANULAR SOIL

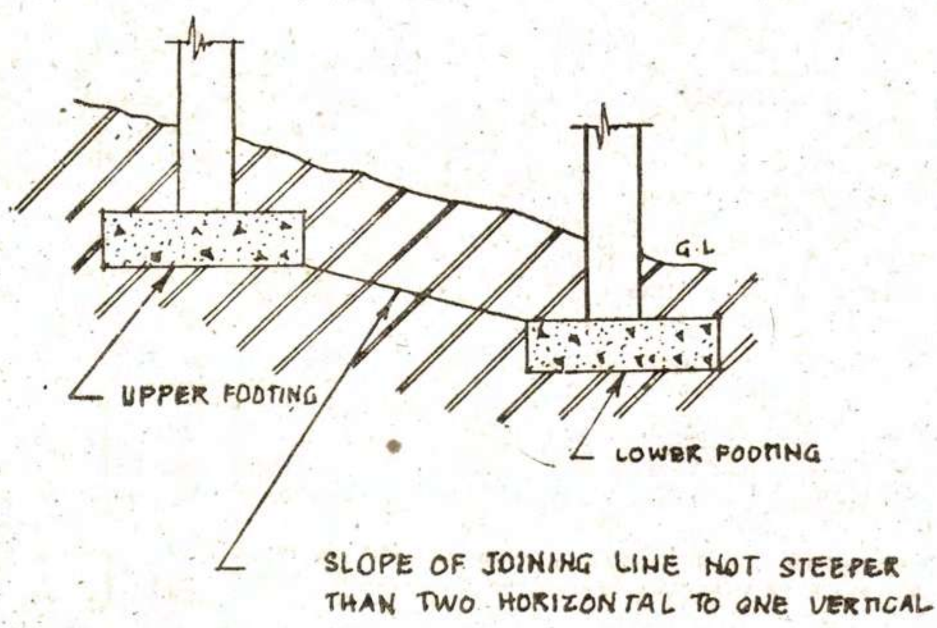


FIG. 2. FOOTINGS IN CLAYEY SOIL

7.7.2. The requirements of 7.7.1. shall not apply under the following conditions:—

(a) where adequate provision is made for the lateral support (such as with retaining walls) of the material supporting the higher footing.

(b) when the factor of safety of the foundation soil against shearing is not less than four.

7.8. Notwithstanding anything specified in the foregoing clauses the depth of the foundation shall be enough to obtain the safe bearing pressure against shear failure.

EXTRACT FROM 3764—1966.

Salary code for excavation work.

3. *General recommendations*:

3.1. Responsibilities of Foremen and Supervisors in all works on experienced and competent foreman or Supervisor shall be placed in charge of work whose authority and responsibilities have been made clear to him and his subordinates. The foreman or supervisor shall be made responsible for the strict observance of the safety rules. He shall have full authority to enforce the rules guard against these use of defective safety appliances, rigging, tools and materials, to see that no man is permitted to do work for which he is not qualified and to brief all workmen on the plan of work before work is started with special emphasis on all potential hazards and on the ways to eliminate or guard against them.

3.1.1. Excavation shall be inspected by foreman or supervision after every rain storm or other hazard increasing occurrence and pro ection against slides and cavings shall be increased if necessary.

3.1.2. Before doing the excavation work a complete knowledge of the underground structures (such as water pipe lines, sewers gas mains and electrical conduit system) is essential proper precaution shall be taken to prevent accident to the workmen engaged in excavation work and calamities for the general public.

4. *Shoring and timbering*:

4.1. *General*.

4.1.1. All trenches in soil other than rock or hard compact more than 1.5 m deep, into which men enter shall be securely shored and timbered.

4.1.2. All trenches in soil soft or assured rock or hard soil exceeding 2m in depth, into which men enter shall be securely shored and timbered.

NOTE 1.—The above requirements do not apply in cases where the sides of the trenches are sloped to within 1.5 m of the bottom. The slope that is provided for such purposes shall be inspected and certified as stable by the persons in charge of work in all cases.

NOTE 2.—Notwithstanding any hing said above, it shall be under-stood that the need for shoring is a matter which shall receive careful and frequent consideration even in trenches less than 1.5 or 2 m in depth (as the case may be) and where there is any doubt as to the safety of the work without shoting no further excavation or other work shall be continued until adequate shoring is provided.

4.1.3. Where the sides of trenches are sloped as specified in 4.1.2 but not to within 1.5 m of the bottom, the vertical sides shall be shored and the shoring shall extend at least 30 cm above the vertical sides. When open spaced sheathing is used, a toe board shall be provided to prevent material rolling down the lope and falling into the part of the trench with vertical walls.

4.1.4. Shorting and timbering shall be carried along with the opening of a trench but when conditions permit protection work such as sheet piling may be done before the excavation comences.

5. *Loose side material*:

5.1. All loose stone projecting clumps of earth, pockets of unsuitable material which might come down on the workers in the trench or any condition which is a hazard, shall be either removed or the excavated sides adequately braced and the trench suitably guarded. On steep slopes workmen shall not be permitted to work one above the other.

6. *Minimum berm*:

6.1. Excavated material shall be kept back from the edge of the trench to provide a clear berm of a width of not less than one-third the final depth of excavation.

6.1.1 In special cases, where the disposal area is limited or where the application of this requirement is impracticable, the person in charge may adopt a berm of reduced width in any case not less han 1 m provided the material being excavated is sufficiently stable and the shoring is designed to carry the additional load. In all such cases there shall be provided substantial toe boards to prevent "roll backs" in the trench.

EXTRACT FROM I.S. 1,200 (PART I)—1974.

Method of measurement of building and civil engineering works.

PART I—EARTHWORK.

3. *Classification* :

3.1. The materials to be excavated shall be classified as follows unless otherwise specified :—

(a) *Soft|Loose Soil*—Generally any soil which yields to the ordinary application of pick and shovel, or to PHAWRA, rake of other ordinary digging implement; such as vegetable or organic soil, turf, gravel, sand silt, loam, clay, peat, etc.

(b) *Hard|Dense Soil*—Generally any soil which requires the close application of picks, or jumpers or scarifiers to loosen; such as stiff clay, gravel and cobblestone.

NOTE.—Cobblestone is the rock fragment usually rounded or semi-rounded having maximum diameter in any one direction between 80 and 300 mm.

(c) *Mud*—A mixture of soil and water in fluid or weak solid state.

(d) *Soft Disintegrated Rock* (*Not Requiring Blasting*)—Rock or boulders which may be quarried or split with crowbars. This will also include laterite and hard conglomerate.

(e) Hard Rock (Requiring Blasting)—Any rock or boulder for the excavation of which blasting is required.

NOTE.—Boulder is a rock fragment usually rounded by weathering disintegration and exfoliation or abrasion by water or ice, having maximum diameter in any direction of more than 300 mm., found lying loose on the surface or embedded in river bed, soil, talus, slope wash and terrace material of dissimilar origin.

(*f*) ***Hard Rock*** (*Blasting Prohibited*).—Hard rock requiring blasting as described under (*e*)] but where blasting is prohibited or any reason and excavation has to be carried out by chiselling, wedging or any other agreed method.

NOTE.—A broad classification of soil and rock for earthwork suitable for conditions generally occurring in practice has been provided where necessary, further sub-classification may be done to suit individual cases depending on the properties of the substrata.

5. *Lead and lift* :

5.1. *Lead*—The distance for removal shall be measured over the shortest practicable route and not necessarily the route actually taken. Distances not exceeding 250 m. shall be measured in units of 50 m. Distance exceeding 250 m. and not exceeding 500 m. shall be measured as a separate item. Leads beyond 500 m. shall be measured in units of 500 m. that is there will be one item for lead exceeding 500 m. and not exceeding 1,000 m., another item for lead exceeding 1,000 m. and not exceeding 1,500 m. and so on upto 5 k.m. Where the lead exceeds 5 k.m., it will be measured in units of 1 k.m., half k.m. and above be reckoned as one and less than half kilometre shall be ignored.

5.1.1. The description of items shall include loading and unloading.

5.1.2. If soil heaps requiring re-handling have become consolidated due to passage of time or any other reason, it shall be so stated and such heaps shall be measured separately.

5.1.3. For the purpose of measurements of lead the area excavated shall be divided into suitable blocks and for each block the distance from the centre of the block to centre of placed earth pertaining to this block shall be taken as lead.

5.2. *Lift*—Lift shall be measured from ground level. Excavation upto 1.5 m. depth below ground level and depositing excavated material on the ground shall be included in the item of earthwork for various kinds of soil. Extra lift s[illegible] be measured in unit of 1.5 m. or part thereof. Obvious l[illegible] shall only be measured ; that is lifts inherent in the lead [illegible] to ground slope shall not be measured except for lead up[illegible] 250 m.

When earth has to be carried over a bank|obstruction anc dumped beyond it, the lift shall be the difference in level between the centre of gravity of the excavated earth and the top of bank construction.

6. *Planking and strutting* :

6.1. The planking and strutting required to uphold the face of excavated earth, etc., shall be measured in square metres of face supported and grouped ; separately in stages of 1.5 m.

6.1.1. The description shall include use and waste of all necessary timber work, including wales, struts and open o[illegible] close poling boards their fixing and subsequent removal.

6.1.2. *Planking*—Planking and strutting to the following shall be measured separately :

(*a*)] Trenches ;

(*b*)] Areas (The description shall include use and wa[illegible] or raking shores)] ; and

(*c*)] Shafts, wells, cesspits, manholes and the like.

6.1.3. Where tightly driven close but jointed sheeting [illegible] necessary in the case of running sand, the item shall be m[illegible] sured separately and the packing of cavities behind sheet[illegible] with suitable material shall be included in description of [illegible] item.

6.1.4. Planking and strutting required to be left perma[illegible] in position shall be measured separately.

SECTION IV.

CONCRETE.

(Lime and Surki Concrete, Cement Concrete, Repair Grouting, Reinforced Concrete and Notes on Reinforced Concreta.)

SPECIFICATION No. 27.

Lime Mortar Concrete and Surki Mortar Concrete.

1. I.S. 2541/1965 for preparation, properties and use of lime concrete shall be followed. In cases where the importance of the work demands, special experiments regarding the best size for the locally available broken stone and regarding the amounts of voids therein, the schedule description and relevant specification will define the size of the aggregate and proportion of materials. Similarly, this will be done for any work where the size of aggregate or proportion of materials is to vary from the standard specifications. In all other cases the standard specification shall be followed.

2. The proportion by volume of aggregate (stack measurement, inclusive of voids) to the volume of prepared mortar, for items of concrete, shall be as defined in the standard data for the relevant item.

3. While mixing the concrete measuring boxes must be used for both the stone and the mortar one over the other so that there may be no variation in the proportion due to improper stacking.

4. Regarding laying and curing of concrete I.S. 2545 : 1965 shall applly.

5. The contract rates are to include the cost of mixing, conveying placing, ramming, watering, barrows, tools and all appliances required to complete the concrete in position but excluding necessary form work which will be paid for separately. They shall also include the cost of baling and pumping for keeping the excavation free of water unless otherwise specified.

6. When concrete is laid against a boxing of bricks or wood, the joints of the boxing shall be close to prevent escape of mortar and the boxing must be removed before refilling is done against the concrete.

SPECIFICATION No. 28.

Cement Concrete.

1. I.S. 456/1964 I.S 383/1963, and I.S. 269/1967 shall also apply.

2. *Mixing Concrete.*—Cement and sand shall be measured in accurate proportions, and well mixed in a dry state, thrice over, on a clean dry platform of wood or slabs with tight and even joints, so that there may be no wastage of mortar, or difficulty in mixing. As much quantity of the aggregate, washed and cleaned of dirt and allowed to dry, as can be mixed and laid within 15 to 20 minutes after water is added to the mixture, shall then be laid on the dry platform and on it shall be spread the dry mixture of cement and sand in correct proportions. The cement is to be weighed 50 kg. being taken as 35 litres and measuring boxes are to be used to maintain the correct proportions of sand and broken stone. A convenient size of measuring box would be inside dismensions of 40 cm long, 35 cm wide and 25 cm deep. The mixing platform should be large enough to enable the continuous procedure of two batches being mixed, to avoid partial sets of the concrete between laying of successive batches. The whole mass shall then be thoroughly mixed with a shovel, turning over atleast three times and adding sufficient quantity of water with a sprinkling can, until the colour of the cement uniformly distributed throughout the whole mass.

The whole operation shall be so arranged as to take the minimum time possible, so that the mixed concrete shall be placed in position before initial setting begins. Concrete which had begun to set, or which has been condemned by the Executive Engineer, shall be rejected and removed from the work spot.

3. For water for mixing, setting time, laying and machine mixing of concrete, I.S. 456 : 1964 and I.S. 269 : 1969 shall apply.

4. *Rate.*—The contract rates are to include the cost of mixing, conveying, placing, ramming, watering, barrows tools and all appliances required complete the concrete in position. They shall also include the cost of baling and pumping for keeping the excavation free of water unless otherwise specified. Centering shall be measured and paid separately.

Quantities.—The standard data for the division is to be followed for the quantities of material and labour required for the various items of work. The relevant schedule item will define the proportion of cement to sand i.e., whether 1 : 2 or 1 : 3 etc.

SPECIFICATION No. 29.

Repair grouting to aprons and revetments with Surki concrete and pointing with surki mortar.

1. The surface of the apron or revetment shall be thoroughly cleaned and the joints raked out to 230 mm depth. The whole surface shall be swept clear.

2. The joints shall then be filled in with surki mortar concrete prepared in accordance with the standard specification for same. 1 lime, 1/2 surki, 1-1/2 sand and with stone or brick jelly as specified broken to 6 mm to 20 mm cubes. If the interestices are large, a larger size aggregate will be specified by the Executive Engineer. The concrete shall be rammed with flat bars, trowels of flat ends of small thin crowbars to ensure close compaction.

3. The surface shall then be pointed flush with standard specification surki mortar, covering the joints of the newly laid concrete filling by 5 mm. The pointing must be done before the concrete before has set, in order that it may bend well with it. The joints be finished off neatly.

4. Special attention is necessary to keep the concrete and pointing continuously wet at all stages of the work and for three weeks after completion (by covering with sand or mats and keeping same watered is otherwise the effect of the sun on the exposed face of an apron or revetment will cause the concrete and pointing to perish before they have set.

NOTE.—If 230 mm raking of joints is unsuitable for any particular work, the alteration to the standard specification should be stated in the tender notice.

(*f*) *Hard Rock* (*Blasting Prohibited*).—Hard rock requir-

Reinforced Concrete Work.

Specifications contained in I.S. 456 : 1964, *I.S.* 269 : 1967, I.S. 432:1966, *I.S.* 1139 : 1968, *I.S.* 1786 : 1966, *I.S.* 2502 : 1963, *I.S.* 5525 : 1969, *I.S.* 2759 : 1966, *I.S.* 1199 : 1959, *shall also apply.*

1. For aggregate, sand and cement specifications given in section I Materials of this shall apply.

2. *Water* (a) I.S. 456 : 1964 shall apply.

3. *Steel reinforcement.*—Specification of reinforcement is covered by I.S. 456 : 1954, 432 : 1956, 1139 : 1966, 1786 : 1966 and 2502 : 1963.

(*a*) In the case of rods supplied by contractor test certificate may be called for, or the rods tested in a laboratory as may be approved by the Executive Engineer.

(*b*) All protruding bars from piers, columns, beany and slabs to which other bars are to be spliced, and which may be left exposed to the action of the weather for an indefinite period shall be protected from rusting by encasing the same in lean cement. Brick jelly concrete mix 1 : 5 : 10 (one cement, five sand and ten brick jelly), and the surface plastered over with cement mortar 1 : 5.

(*c*) After all the steel has been placed in position, it should be passed by the Executive Engineer or by his representative, before any concrete is laid.

(*d*) No part of the reinforcing metal in a building shall have such contact as to enable the same to transmit any electrical current.

4. *Splices or overlaps of reinforcement.*—I.S. 456 : 1964, I.S. 5525 : 1969, 2502 : 1963 shall apply. 456 : 1964 and 2751 : 1966 shall apply for welding.

The following shall be observed to safeguard against failure of structural members :

4.1. (i) For all R.C.C. works, the Executive Engineer shall prepare detailed section with dimensions and bar-bending schedules and furnish the same to the contractor after affixing his approval. The fact of furnishing such approved bar-bending schedule and working sketches should be recorded in the concerned file.

(ii) When all the reinforcement have been placed in position, the Executive Engineer or his representative, not below the rank of Assistant Executive Engineer should inspect and pass the same before any concrete is laid.

(iii) The Executive Engineer shall personally satisfy himself about the adequacy and soundness of the scaffolding and entering before concreting is started.

5. *Mixing concrete.*—(i) (*a*) All arrangements shall be made, before mixing is started, to ensure that there will be no stoppage of work at a stage of the mixing, handling, placing and tamping, as such toppage may lead to exceeding of the permissible time-limit laid down for finally placing the concrete in the forms up to a pre-determined stopping point. Concrete which is not placed in position within the permissible time-limit shall be rejected.

(*b*) In all cases, the mixing and laying of concrete shall be done only in the presence of the officer in immediate charge of the work ; the contractor or his agent shall give due notice to the Executive Engineer or his representative when mixing is to be proceeded with. The Executive Engineer or his deputy may reject any concrete mixed, when such notice is not given.

(ii) *Hand Mixing.*—(*a*) If the concrete is mixed by hand, the mixing platform shall be large enough to provide space for the partially simultaneous mixing of batches of about 0.25 m3 each or any other quantity fixed by the Executive Engineer; Paragraph 20.1.2.2. of I.S. 456 : 1964, shall also apply.

(*b*) Cement shall be superimposed over the sand, and the sand and cement thoroughly and evenly mixed, until a uniform colour is attained. It shall be turned at least three times. The sand and cement mixture and the aggregate shall then be placed in superimposed layers, the former on top and should then be added, using a hose, to produce the required consistency and then turned together, at least three times, exclusive of the shovelling or handling from platform to place of deposit or into the vehicle of transport. The number of turnings shall be sufficient to produce a concrete thoroughly mixed and of a consistency, uniform throughout, the use of a rake or hoe can be permitted for mixing sand and cement, but not when stone comes into the mix.

(iii) *Machine mixing.*—For large works, machine mixing will be necessary to ensure sufficient outturn to enable each unit of the system to be laid continuous by eliminating or minimising the number of construction joints. The contractor shall arrange the size of machine mixer and operating plant accordingly. I.S. 456:1964 and 1791 : 1968 shall also apply.

6. *Consistency.*—(i) Paragraph 53 of I.S. 456 : 1964 shall apply.

(ii) *Slump test.*—The slump, is the amount of settlement in cms. obtained after filling with concrete a standard metal cone form, or 10 cm. top diameter, 20 cm. bottom diameter, and 30 cm. high and then removing the form. The filling should be done in layers approximately 7.5 cm. high, each layer being punned 25 times with a 16 mm in diameter rod, bullet pointed at one end. The less the slump and consequently the stier the mixer provided that it is workable, the stronger will be the concrete, other conditions being equal. The smallest slump that will give a consistency suitable for, the work in hand should be used. The recommended values for the slumps are :—

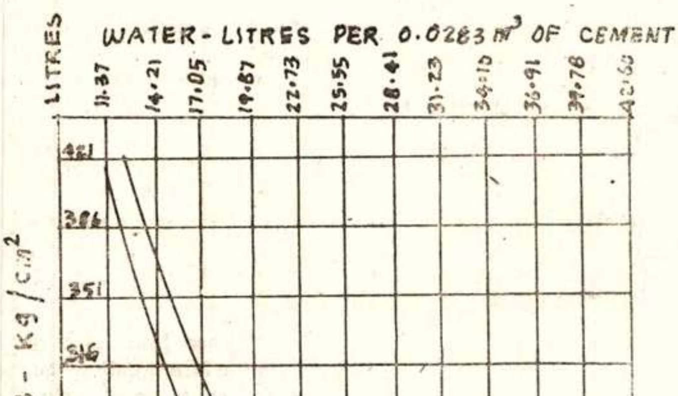
Serial number and Type of Work.	*Slump.* *When vibrators are used.*	*Slump.* *When vibrators are not used.*
(1)	(2)	(3)
1. Mass concrete in foundations footings, retaining walls and pavements.	10 mm to 25 mm.	30 mm to 75 mm.
2. Thin flooring of less than 75 mm thickness.	25 mm to 40 mm.	75 mm to 100 mm.
3. Mass concrete in R.C.C. foundations footings and retaining walls.	10 mm to 25 mm.	80 mm.
4. Beams slabs and columns simply reinforced.	25 mm to 40 mm.	100 mm to 125 mm.
5. Thin R.C.C. section or Section with congested steel.	40 mm to 50 mm.	125 mm to 150 mm.

(iii) In the case of pipes or similar articles where the space to be filled is narrow and confined, a concrete that will flow readily has to be used, but case must be taken to eliminate the entrapped air bubbles.

(iv) Some experiments indicate that every ½ kg. weight of excess water used has the same effect on strength, as to the omission (two kilograms or more) of cement.

(v) Excess of water not only causes loss of strength, but also involves increased shrinkage, and liability to cracking.

RELATION BETWEEN WATER-CEMENT RATIO AND STRENGTH OF CONCRETE



NOTE :- CURVE A - RESULTS WITH ALL OPERATIONS UNDER STRICT SUPERVISION AND CONTROL
CURVE B - RESULTS WITH LESS CLOSE SUPERVISION.

(vi) A working mean to get best strength and workability has to be adopted to enable the use of the direst possible concretcthat can be worked successfully around and between the steel bars so as to thoroughly envelop all of them, and leave no voids and hollows. With insufficient water, the chemical action in setting will be adversely affected.

(vii) The diagram appended is illustrative of the effect of water on the strength of concrete.

7. *Mix design.*—The procedure for concrete mix design, has been given in the end of this section. This shall be followed while designing the concrete mix.

(*a*) For works in which water tightness is required the specifications laid in I. S: 3370—1965 Parts I to III shall apply.

8. *Forms and centering.*—(*a*) A constructional load of 400 Kg/m^2 in addition to the dead weight of the concrete may be assumed in designing the centering. The forms shall be carefully designed and the design shall be subject to the approval of the Executive Engineer, who may require the contractor to alter the designs in accordance with instructions, or adopt designs prepared by him without extra cost. If wooden centerings are adopted only well seasoned timber should be used in their construction. It is better to use too thick, than too thin timber as it is false econony to use light forms, which will not lend itself for frequent removal and reerection. Under no circumsfrances should green timber be used, as it is liable to shrink after erection.

(*b*) If the forms are held together by bolts or wires they shall be so fixed that no iron will be left exposed on the face of the finished work.

(*c*) All centering and supports shall be properly braced and cross-braced in two directions and well stayed or strutted on all sides rigidly enough to resist storm or high winds during execution. The forms should be strong enough to withstand the weight or pressure when a considerable height of wet concrete is being poured, as in walls or columns. Many authorities suggest that pressure may be taken as caused by a liquid of half the weight of concrete, namely 1,200 kg/m^3.

(*d*) For joints and gaps, paragraph 20·2·1 of I. S: 456-1964 shall apply.

(*e*) To ensure that all faces of concrete which will be expossd to view on completion of the work have smooth finish, bevelled edge timber (tongued and grooved, if so specified or ordered) shall be used, giving smooth tight joints.

(*f*) In special cases, the surfaces that are to come in contact with the concrete should be planed flat and smooth and be free from knot holes and other imperfections. Oiling or greasing of forms shall not be done if the concrete is to receive a coat of plaster after removal of the forms. I. S: 456-1964 shall also apply.

(*g*) Old forms, or forms left long exposed to weather should be examined carefully before re-use.

(*h*) The centering should be so designed and arranged that the sides of columns can be first removed, then the sides of beams, then boarding under the floor slabs and lastly the soffits of beams.

(*i*) Where the centering posts rest on soft ground, the load should be got distributed by means of sleepers or short piles; otherwise the supports may punch into the ground, causing a sag and settlement and possibly, cracks in beams and floor slabs. All uprights should be provided with a double set of wedges or sand boxes, so that they may be gently removed. The section of the scantling from which the wedges are cut should be at least 10 cm. by 10 cm.

(*j*) When the concrete is placed in layers' no calculation necessary as it has been found in practice that for beams, the bottom boards should be 5 cm. to 6 cm. thick with sides 4 cm. to 5 cm. thick for columns sides should be 4 cm. to 5 cm. thick and for walls 4 cm. boards are generally used. The thickness can be varied according to the spacing of the clamps or braces but on this account the material should not be made too thin. For slab panels, 2·5 cm. board is generally used which require staying every 60 cm. 4 cm. boarding will require staying every 90 cm. and 5 cm. boarding every 1·2 m to 1·5 m. The studs, i.e. the vertical pieces on which the sheathing or planking is nailed, should be of such a size and be so spaced as to prevent the boards between them from springing.

(*k*) For square columns three sides of the form should be bolted or clamped together and the fourth side left open and braced at intervals sufficient to keep the box or casing in shape. This open side should be gradually built up a little in advance of the concrete laying. For this purpose, strong timbers fixed with wedges behind vertical runners should be used.

(*l*) Other shapes of columns must all be filled from an open side in the form to allow the steel to be kept in its proper position, the structure to be gradually built up and the concrete properly and thoroughly consolidated.

(*m*) A completely enclosed form should not be used as it will necessitate filling in of concrete from a considerable height and prevent the casting of concrete from being properly inspected or compacted.

9. *Laying concrete.*—(A) *General*: (i) Paragraph 20·2·1 of I.S. 456-1964 shall apply.

(ii) Usually it will be found preferable to completely fix the reinforcement for the whole floor, before begining to place concrete.

(iii) Suitable wooden plugs may be placed in the centering for electric fittings. Similarly, clamps for hanging ceiling fans or sewing planks should also be fixed in their correct positions. In all such cases where fixed blocks are embedded, care should be taken to see that the strength or effective cover of any part of the structure is not reduced below the standard required by this specification.

(iv) *Electrical Conduits to be placed in Concrete Beams and Slabs.*—Where conduits are to be cast in concrete slabs, the boxes and conduits are installed and held in position by blocks and iron wire fastened to the reinforcing bars. The concrete is then poured and tamped. For structural reasons these runs of conduit are usually close to the bottom surface or near the central portion of a floorslab. If a great number of conduits must be embedded it may be necessary to increase the slab thickness. This refers of course, to conduits being installed in a structural slab. In many instances, the structural slab is covered with a concrete topping or fill in which the conduit may be installed without affecting the integrity of the slab. In all cases, local buildings codes should be consulted for limitations or imbedded conduits. In any event the top of any conduit shall be at least 18mm below the finished floor surface in order to prevent cracking. When heavy trucking is expected, this allowance should be increased to 1½ minimum.

In general the following rules should be observed and included in all specifications for conduit work in concrete slabs.

(1) Conduits shall have an OD not greater than 1/3rd of the slab thickness as measured at its thinnest point.

(2) conduits running parallel to each other shall be spaced not less than 3 times the OD of the largest conduit centre to centre.

(3) Conduits running parallel to beam axis, shall not run above beams.

(4) Conduit crossings shall be as near to a right angle as possible.

(5) Minimum cover over conduits shall be 18mm.

(B) *Handling*.—Para 20·1·3 and 20·1·4 of I. S: 456-1964 shall apply.

(C) *Placing and vibration of concrete*.—I. S: 456-1964 shall apply.

(*a*) Where the sections of concrete members are thin and very heavily reinforced, carefully executed vibration, either alone combined with tamping, causes the concrete to flow uniformly round the bars. Moreover, the increased fluidity due to vibration occurs even with mixes which would otherwise be regarded as too dry for reinforced concrete work. In consequance, in work where a low water cement ratio would be necessary, with hand tamping, higher strength may be obtained by vibration due to the drier concrete, that can be used and compacted with these machines.

(*b*) All beams and slabs shall be filled to the top surface in one continuous operation, that is from the bottom of beam to top of floor.

(*c*) *For vertical joints in long buildings*.—Para 19 of I.S. 456-1964 shall apply.

(*d*) In cases where the outer faces of buildings are plastered the reinforced concrete roofs should be as a rule, be carried through to the outside of walls and a small parapet built over them. In cases where the outer faces of buildings are pointed, the reinforced concrete roofs may be stopped short of the face by half a brick or a full briek and the face so left on the wall built up with bricks to suit the pointing over the rest of outer face. If leakage through the joint between the end of roof slab and masonry is anticipated the joint at weep holes shall be filled with an asphaltic composition and covered with flat tiles before building on the parapets.

(D) *Treatment at bearings of reinforced concrete slabs and beams* :

(*a*) The principle underlying the treatment at bearings of R.C.C. slabs and beams, is to effectively insulate the R.C.C. structures from the masonry or other supports on which they bear.

(*b*) The vertical face of the masonry rebate at bearings should also be plastered smooth with cement mortar 1 : 3. A gap 12 mm wide should be left between the vertical face of the masonry and the R.C. work and thin gap should be filled with a mastic. Composition of bitumen for caulking purposes given in the I.S. 1580/1969 shall apply. Composition specification for mastic given in I.S. 3037/1945 and for bitumen felt in I.S. 1322/1970 shall apply. The object of filling is to minimise chances of stone chips or other hard materials inadvertantly falling into the gap and getting wedged between the R.C.C. and masonry, thus obstructing free movement. Where the spaces will not be easily accessible for mastic filling after the concrete is laid, as for example, at sides of a tee-beam with slab extending to full length of the beam at the bearing, precate pads of the mastic 12 mm. thick could be inserted before laying the concrete. The mastic filling of pad should not exten to full depth of the gap but a space of say 25 mm to 40 mm should be left vacant at top in order to admit of the mastic being squeezed when the slab or beam moved against it. Similarly, the mastic should be stopped about 40 mm away from the vertical face of walls to ensure the walls being finished with plaster.

(E) (*a*) *Finishing the concrete surface*.—Best results at least cost are obtained when the finishing is undertaken while the concrete is still green. The fins and any rough projections can then be rubbed down and the whole surface brought to an even finish by rubbing with a wooden float using a mortar of one part cement by two parts of coarse sand as an abrasive, the mortar at the same time filling the voids. A neat cement work shall then be applied to give a smooth surface. If the concrete has set hard, the fins and rough projections, if any, shall be removed by using corborandum brick or a paved grinding machine by chipping, before finishing off with the smoothing wash. If the work of chipping is not done with care or if the surface exposed after removal of the forms can not be satisfactorily dealt with in this manner due to bad form work or for other reasons, a coat of cement plaster of 1:2 of thickness as ordered by the Executive Engineer shall be applied. No extra payment will be given for finishing concrete surfaces as instructed above in this clause. However, for a work where the finishing of R.C.C. surface with a plaster coat is found necessary for aesthetic beauty, the authority calling for tenders should furnish a supplemental specification indicating the thickness and proportion of mortar to be used for the plaster coat over the R.C.C. concrete surface and also the method of payment in the schedule of tender notice.

(*b*) *Weathering course over the R.C. Slab*.—In the case of buildings, where there is no storey over it, the R.C. slab is to be protected against alternative shinkage and expansion. For this a weathering course of brick jelly concrete is laid over the slab. After fifteen days of the laying of R.C. slab, for every 1 m^3 of weathering course a layer of brick concrete 100 mm thick with 0.96 m^3 broken brick 20 mm gauge and 0.375 m^3 slaked lime (no sand) shall be laid over and well beaten to 75 mm thickness with wooden hand beaters. Necessary slope to drain the rain water shall also be given in the weathering course itself. The beating shall continue until the conerete is well consolidated and the beater makes no impression and readily rebounds from the surface when struck on it, the whole shall be constantly wetted by sprinkling lime water. Should this surface, during the process of beating become so uneven that water lodges, it shall be picked up and fresh concrete added as may be necessary.

[After six days or after the concrete laid has hardened, one course of pressed tiles of size 20 cm. x 20 cm x 20 mm. shall be laid in oiled mortar in C.M. 1 : 3 and rubbed smooth.

(*c*) Payment for treatment at bearings of reinforced concrete slabs and beams should be made separately and not included in the rate for R.C. Work.

(*d*) *Joints in buildings* :— The various types of joints that may have to be installed in buildings are as follows :—

1. *Expansion joints.*— Joints provided to accommodate the expansion of adjacent parts and relieve compressive stresses that may otherwise develop.

2. *Construction Joint.*— Joint installed at location whose construction stops for any reason.

3. *Contraction Joints.*— These are separation or plans of weakness introduced in concrete structure to localise shrinkage movements.

4. *Sliding joint or vertical joints.*— When variation in temperature, moisture content, or loading results in unequal settlement or movement in different parts of the building vertical joints are formed so as to provide as slip plane.

5. *Spacing of expansion joint.*— (1) Roof R.C.C. 20 mm. interval and at changes in direction.

6. Vertical joints may be located at 30 m. intervals in long uniform structures and at junction of L. H. and T shaped structures.

7. Joints may be provided at every 10 m. for parapets compound wall, chajja and balconies.

8. *Expansion joint in R.C.C. roof slab or floor slab with or without R.C. beams.*— The expansion joint should span in the same direction as that of the main reinforcement. In case the site conditions require the joints to be spanned across the main reinforcement, necessary beams should be introduced at the joints to support the slab. A typical sketch of the expansion joint in R.C.C. roof slab is enclosed. The same can be adopted for floor slabs by omitting the raised portion above the R.C.C. slab. The avoid cracks in the supporting masonry below and in cases where it is not possible to provide a vertical joint in the masonry, it is preferable to provide cement concrete bed block on the bearing, In the case of joints in floor slab over R.C.C. column the copper sheet can be perforated with slotted holes or groves and inserged over the reinforcement and the joint finished as usual.

9. " *Method of formation* " *Type* ' A '.— While laying the slab, the water bar is placed in its position and tied with the slab reinforcement grill. While concreting the ends of the slab the joints are given increased thinkness by giving a slope of 1 in 12 for 60 cm width, on both sides and raised to 30 cm· as shown. The top and sides are finished smoothly. (It is not advisable to raise this portion by masonry, as masnory will separate from R.C. slab during expansion and there is likelihood of rain water leaking through the separated crack).

The weathering courses are then laid and furnished as shown in the raised portion. At the tope of one side of the raised portion an asphalt pad or tar felt is placed. The joint is then covered at top with two courses of precast cement concrete slabs of mix. 1:2:4 and 2·5 cm· thick in a staggered manner. The top course of slabs is given a slope of 1cm· (in 50 cm· width) by adjusting the thicknes of mortar between the two courses of cover slabs as shown in the sketch.

A.C. Sheet is fixed at the bottom of the joint with suitable screws and plugs. The ends of the joint are also finished smoothly.

Type ' *B* '.— While concreting, the ends of slab at the joint are given increased thickness, by giving a slope 1 in 12 for 60 cm width, on both sides, from the edge of the joint and raised to 30 cm. as shown. The top and sides are finished smoothly. (It is note advisable to raised this portion by masonry, as masonry will separate from R.C. slab during expansion and there is likelihood of rain water laking through the separated crack).

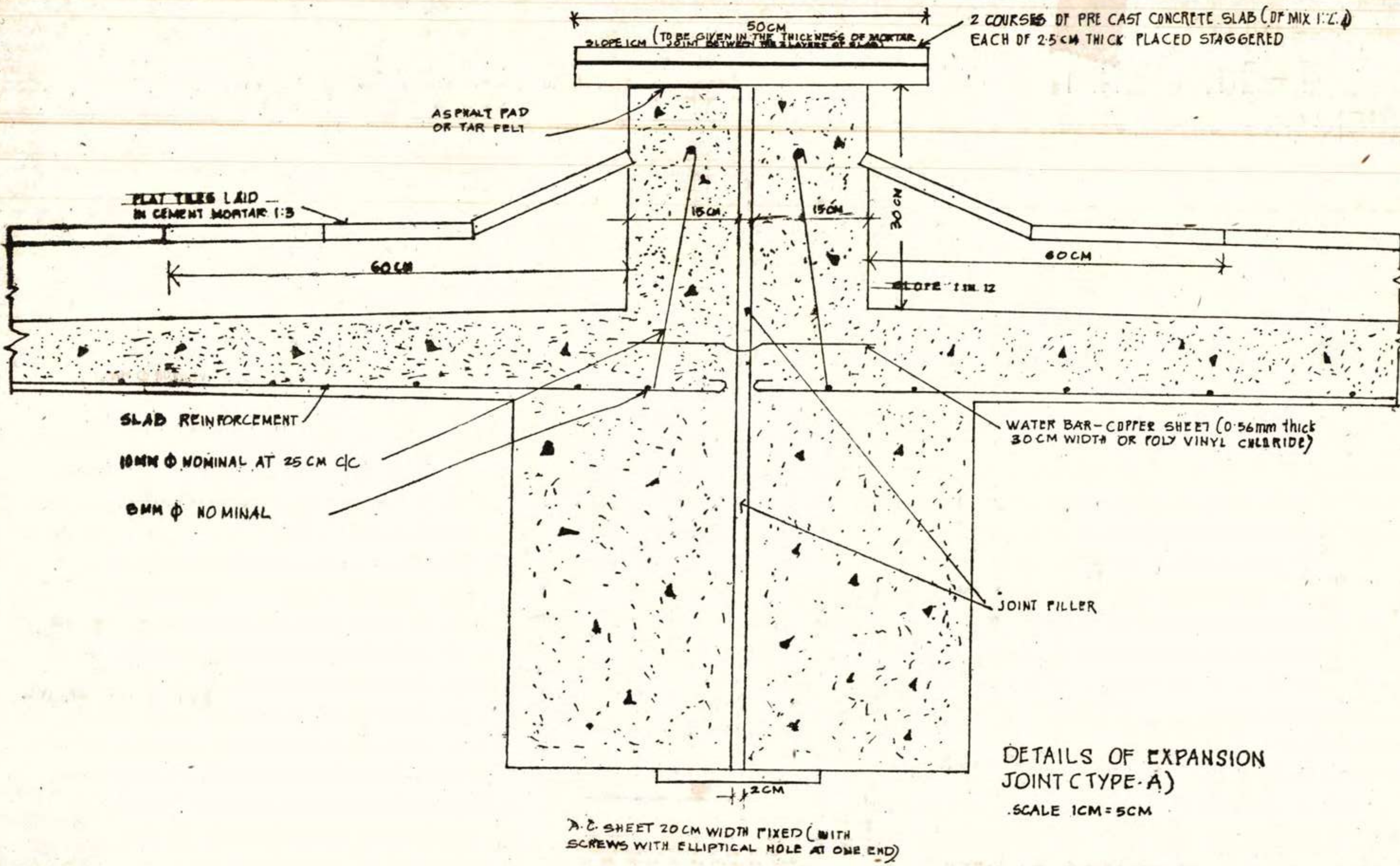
Weathering course (viz.) brick jelly lime concrete and flat tile or pressed tiles as the case may be, are then laid and pointed ass shown in the sketch.

A.C. Sheet is then fixed at the bottom of the joint with suitable screws and plugs. The joint is then filled up with suitable backup materials like, plastics, cork strips, granulated cork, board, Dehy drated cork, Fibre Board, flexible foam, or rope, etc. as shown in the sketch, up to 1 cm below the top of the raised portion of the joint. A bond breaker such as polythylene strip should be use in case the sealant has adhesive tendency to the bottom of the joint or to the back-up material. The sides of the joint should be absolutely free from moisture, oil, dust, loose particles, etc., Damp joints may be dried by the use of gas torch, or hot air blower. Dust may be removed by wire brush. The sides of the joint are then treated with primer. The primer is a two component system with a base and a hardener, mixed at a suitable proportion mentioned by the manufacturer. Adequate time as stipulated by the manufacturer may be allowed for the primer to set.

The space at the top over the backup material and between the dried primer sides is then filled up with the Sealant. Sealing compound application should be completed within the potlife period stipulated by the manufacturer.

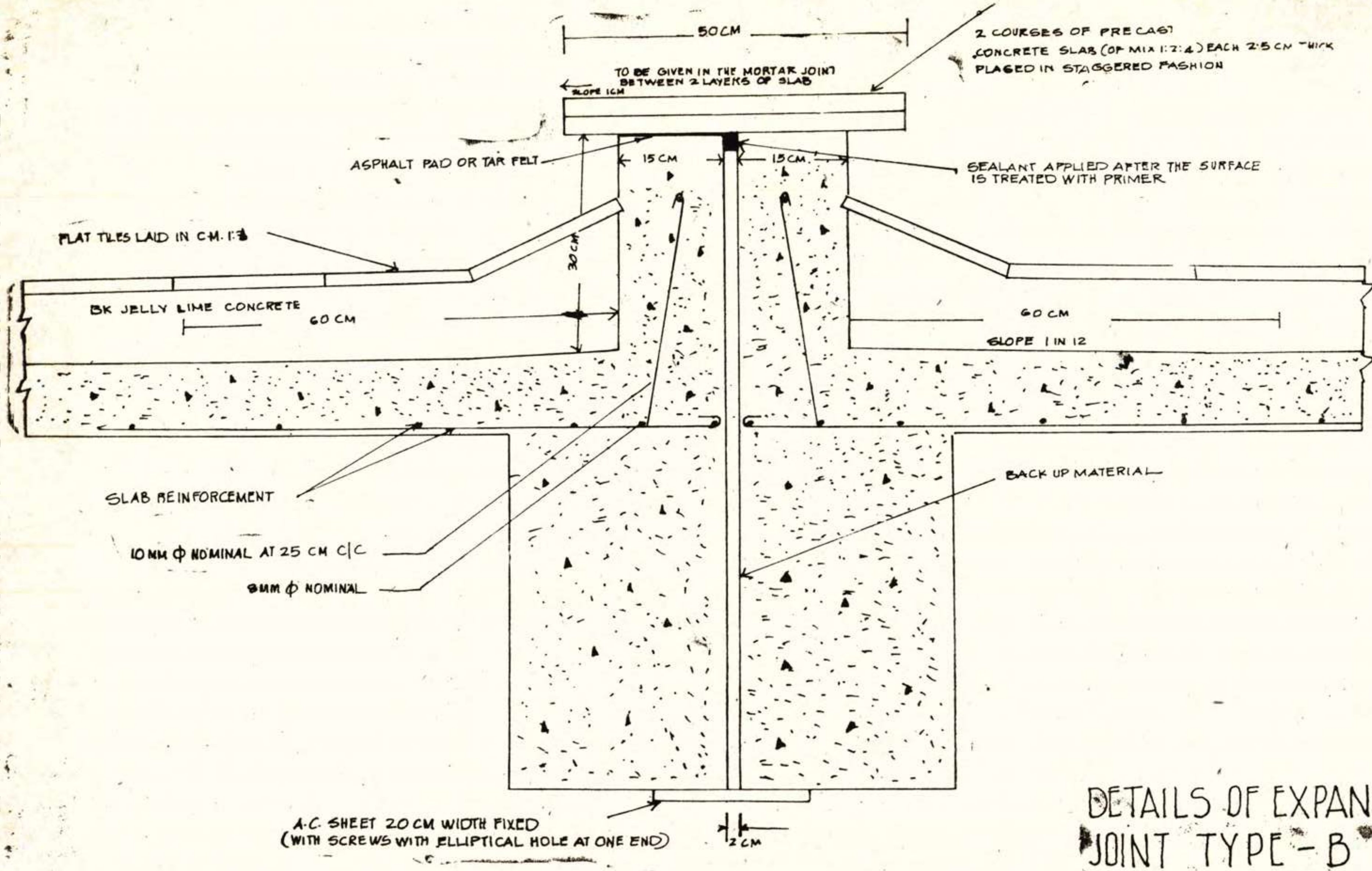
At the top of one side of the raised portion an asphalt pad or felt is placed. The joint is then covered at the tope with two courses of precast cement concrete slabs of mix. 1: 2: 4 and 2·5 cm thick in a staggered manner.

The top course of slab is given a slope of 1 cm (in 50 cm) witdh by adjusting the thickness of mortar between the two courses of cover a slabs as shown in the sketch".



DETAILS OF EXPANSION JOINT (TYPE-A)

SCALE 1CM = 5CM



DETAILS OF EXPANSION JOINT TYPE - B

SCALE 1CM= 5CM

SPECIFICATION No. 30-A.

PILE FOUNDATION.

1. *Materials.*—Specifications contained in specification No. 30 shall apply regarding cement, sand, water, aggregate steel, etc.

1.1. *Equipment and accessories.*—The machinery to be used for the type of pile shall be as approved by the Executive Engineer.

2. *Choice of pile.*—The type of pile, shape and cross section of pile shall be as per the design approved.

3. Bearing capacity of the pile foundation shall be determined as per the standard test furnished in Appendix of I.S. 2911 (Part-I)—1964.

4. For reinforced concrete piles, pile caping, spring of piles and other details the specifications laid down in I.S. 2911 (Part I)—1964 shall apply.

5. For the design and construction of Under-reamed pile foundation I.S. 2911 (Part III)-1973 shall apply.

SPECIFICATION No. 30-B.

CHANNEL UNIT FOR FLOOR/ROOF

1.1 The precast R.C.C. unit shall be constructed complying with standard specification No. 30.

1.2. The shape and size, structural design, mould for casting, curing of units. assembly of floor/roof, balcony projections shall be as per the extracts of C.B.R.I. Data sheet 5 furnished.

1.3. Procedures for fixing various fixtures like hooks, electric conduits, etc., shall be as furnished in the C.B.R.I. Data sheet.

Necessary precautions mentioned therein shall be followed during construction.

1.4. The data furnished by the C.B.R.I. shall be followed for guidance only.

SPECIFICATION No. 30-C.

CORED UNIT FOR ROOF/FLOOR.

1.1. The precast R.C.C. unit shall be constructed complying with the standard specification No. 30.

1.2. The shape and size, mould for casting, the method of casting and curing, assembling of floor/roof, construction of balcony projection, etc., shall be as laid down in the Data sheet No. 3 of C.B.R.I. Roorkee (Extract furnished).

1.3. *Structural Design.*—The unit and reinforcement required shall be rationally designed as per standard practice. The principle of design for the two stages furnished in the Data sheet shall be followed. In case of residential buildings the Tables I and II shall apply regarding reinforcements for the spans considered.

1.4. The data furnished by the C.B.R.I. shall be followed for guidance only.

SPECIFICATION No. 30-D.

PRECAST R.C. PLANK FLOORING/ROOFING.

1.1. The precast R.C. plank and partially precast R.C. Joist shall be constructed complying with specification No. 30.

1.2. The details of precast plank and partially precast joists details of mould, method of casting and curing the sequence of assembling and erection laying of weathering course shall be as laid down in Data Sheet No. 7 of C.B.R.I. Roorkee.

1.3. The structural design shall be as per the Data Sheet No. 7 of C.B.R.I. in accordance with I.S. 456-1964. The roof/floor shall be adopted for residential buildings.

1.4. Procedures for fixing fan hooks, provision of balcony projections, construction of bathroom, water closet, shall be as specified in the data sheet mentioned above.

1.5. Necessary precautions enumerated in the data sheet shall be adhered to during construction.

1.6. The data furnished by the C.B.R.I. Roorkee shall be followed for guidance only.

SPECIFICATION No. 30-E.

CELLULAR UNIT FLOOR/ROOF.

1.1. The cellular unit, supporting joists and deck concrete shall be constructed complying with specification No. 30.

1.2. The shape and size of units, design of supporting precast or cast-in-situ joists, the deck concrete shall be constructed as laid down in Data sheet No. 4 of C.B.R.I., Roorkee. The moulds for casting and method of casting and curing, assembling of floor/roof shall be done as specified in the Data sheet and observing necessary precautions as laid down therein.

1.3. The data furnished by the C.B.R.I., Roorkee shall be followed for guidance only.

SPECIFICATION No. 30-F.

PRECAST WAFFLE UNIT FLOOR/ROOF.

1.1. The waffle unit and the grid beams shall be constructed complying with the specification No. 30. It shall be adopted for floors spanning in two directions having a span of 9m and above.

1.2. The shape and size of units, form work for precasting, placing of concrete and compaction, curing errection and assembly of floor/roof shall be as laid down in Data Sheet No. 6 of C.B.R.I., Roorkee.

1.3. The structural design of the waffle unit floor/roof shall be based on the analysis of two way slabs given in I.S. 456-1964.

1.4. Electric conduits, junction box, wooden plugs, fan hooks, etc., shall be provided as specified in the Data sheet.

The precautions detailed therein shall be followed during construction of the floor/roof.

1.5. The data furnished by the C.B.R.I., Roorkee shall be followed for guidance only.

SPECIFICATION No. 30-G.

CELCRETE COMPOSITE FLOOR/ROOF SLAB.

1. *Celcrete block.*

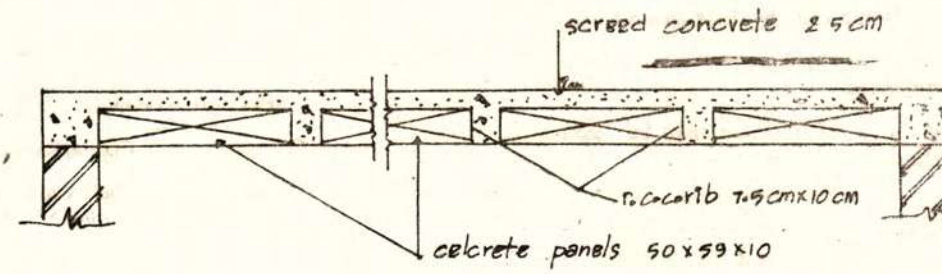
1·1. *Material.*—The composition and properties of the celcrete block for roof and floor shall be as in the specifications No. 35-K for celcrete block masonry.

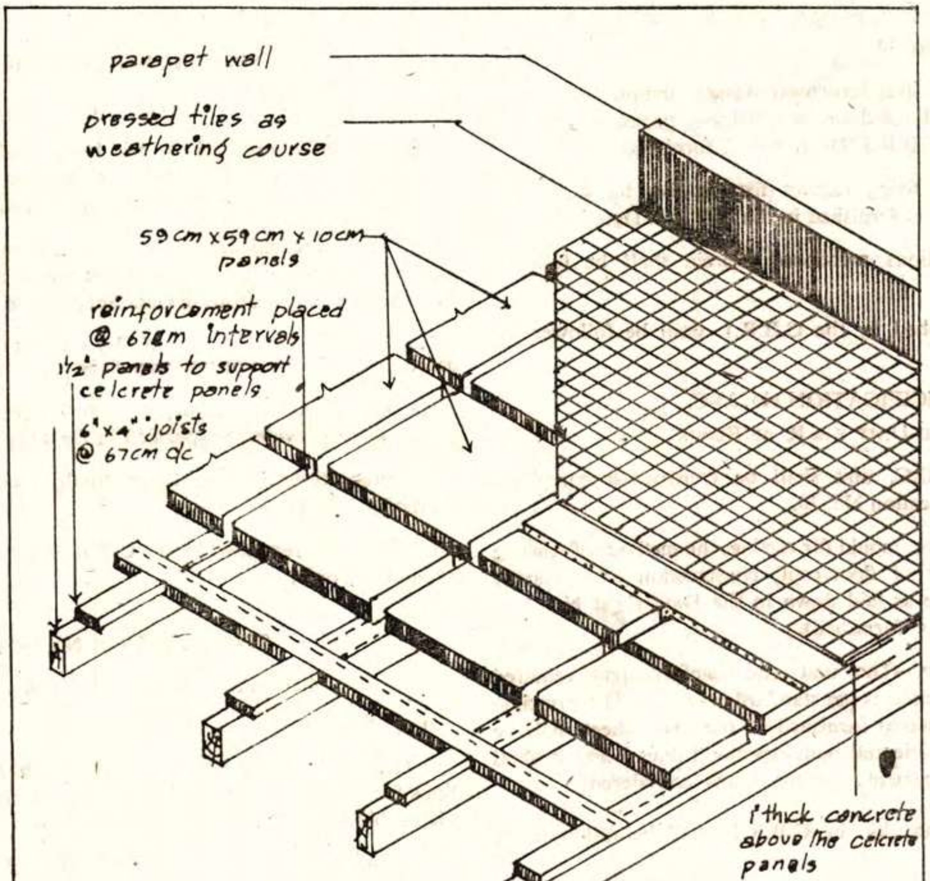
1·2. The celcrete panels of size 59 cm × 59cm × 10 cm shall be used in between the reinforced concrete ribs.

1·3. The reinforced concrete ribs shall be either precast or cast-in-situ. Specification No. 30 shall apply for the reinforced concrete used.

2·0. *Structural design.*—In the celcrete roof/floor slab, the rib together with screed is designed as a "T" beam. The co-efficient of two way slab furnished in IS: 456-64 shall be adopted for designing the slab. The rib at support shall be designed as a rectangular beam and checked for shear also.

Minimum 2·5 cm. screed shall be provided over the slab. The screed thickness shall be increased to suit the design condition while designing the rib as a "T" beam.





DETAILS FOR COMPOSITE CELCRETE ROOF SLAB.

3·00. The assembly and erection shall be in steps as shown in the sketch.—

(i) The supporting form work shall be levelled and checked.

(ii) Celcrete blocks shall be lifted and placed in the shuttering in grid pattern leaving required gap for the designed width of rib.

(iii) The reinforcement cage shall be fixed in position with necessary cover.

(iv) Where so shown in the drawing, various features like fan hooks, electric conduits, etc., shall be fixed in the manner as shown in Data Sheet No. 6 of C.B.R.I. for waffle unit floor/slab in Specification No. 6.

(v) Fresh concrete mix of 1 : 2 : 4 (one cement, two sand and four aggregate) shall be poured in the joints and over the celcrete panel to the required thickness and vibrated thoroughly with plate vibrator.

4. *Curing.*—The concrete so laid shall be cured for 14 days.

5. Shuttering shall be struck off after 14 days of casting.

6. *Finishing.*—The roof slab shall be finished with weathering course and pressed tiles as in Section 8.

7. Ceiling plastering shall be done as per specification for plastering and shall be paid for.

8. Form work shall be measured for rib beam only with maximum allowance of 5 cm. on either side and shall be paid for.

NOTES ON R.C.C. DESIGN AS PER I.S. 456—1964—HAND BOOK FOR BUILDING ENGINEERS IN METRIC SYSTEM BY N-B-O.

Unless otherwise stated these Standard Design Notations mean the following :—

A. Cross-sectional area of concrete excluding any finishing material or reinforcing steel.

A_1 Loaded area at column base.

A_b Equivalent area of helical reinforcement (volume of helical reinforcement per unit length of column.)

A_t Cross-sectional area of steel in tension.

A_k Cross-sectional area of concrete in column core, excluding area of longitudinal reinforcement.

A_s Cross sectional area of steel or cast iron core.

466—3—12

A_s Total cross-sectional area of the bent bar or bars crossing a section of a reinforced concrete member.

A_{sc} or A_e Cross-sectional area of steel in compression.

A_w Cross-sectional area of stirrup.

a Depth of the concrete stress block.

a_1 Lever arm ratio, a/d.

B Overall breadth of compression flange of a beam.

b Breadth of a rectangular beam or breadth of flange of T or L-beam.

be Effective width of the slab.

br Breadth of the rib of a T-beam or L-beam.

C_1 Permissible stress in compression in column bars.

C Total compression at a section.

Cr Stress reduction co-efficient for long columns.

D Overall concrete depth or least lateral dimension of a column.

D_1 Diameter of column.

d Effective depth.

d_c Depth of compressive reinforcement.

d_s Total depth of slab.

dsd Total depth of drop.

E_c Modulus of elasticity of concrete.

Es Modulus of elasticity of steel.

EL Earthquake load.

F^1_c Ultimate cylinder strength of concrete in compression.

K_b Stiff ness of beam.

jd Lever arm of the resisting moment.

K_{b_1} Stiffness of beam on one side of a column.

K_{b_2} Stiffness of beam on the other side of a column.

K_1 Stiffness of lower column.

K_m Least radius of gyration of column.

K_u Stiffness of upper column.

k $= \frac{dc}{d}$

L Length of a column or beam between adequate lateral restraints, (In the case of flat slabs, L is the average of L_1 and L_2)

L_1 (In the case of flat slabs) Length of panel in the direction of span, measured from centre line to centre line of columns.

L_2 (In the case of flat slabs) Width of panel at right angles to the direction of span, measured from centre line to centre line of columns.

LL Live load.

l Effecive span of beam or slab, or effective length of column.

lx Length of shorter span of slab spanning in two directions.

ly Length of longer span of slab spanning in two directions.

M Bending moment.

M_e Bending moment at the end of beam framing into a column assuming fixity at connection.

M_{es} The maximum difference between the moments at the ends of two beams framing into opposite sides of column, each calculated on the assumption that the ends of the beam fixed and that one of the beams is not loaded.

M_r Resisting moment.

M_t Torsional moment

M_x Maximum bending moments for span 1x on strips of unit width in slabs spanning in two directions.

M_y Maximum bending moments, for span 1y on strips of unit width in slabs spanning in two directions.

m Modular ratio $\frac{E_s}{E_c}$

n Depth of neutral axis below compression edge.

n^1 Neutral axis ratio, $\frac{n}{d}$

nl Depth of neutral axis in critical or balanced section.

ΣO Sum of perimeters of the bars in the tensile reinforcement.

P Axial load permissible on a short column.

Pt $= \frac{At}{bd}$

P^1_t $= \frac{At}{bd} \times 100$

$P_c = \frac{Ac}{bd}$

P^1_c $= \frac{Ac}{bd} \times 100$

Q Total shear across a section or $\frac{Mr.}{bd^2}$

Q' Resistance to shear at a section of beam of varying depth.

q Shear stress at a section of a beam or slab.

R Modulus of rupture.

s Pitch or spacing of stirrups.

T Total tension at a section.

t Tensile stress in reinforcement.

c Stress in compression reinforcement.

W Total load on a beam or slab.

Wd Total dead load per span.

Ws Total superimposed load per span.

w Total load per unit area of slab or unit length of beam.

X_1 Distance of the concentrated load from the face of the cantilever support.

X_1, Y_1 Sides rectangular, stirrup or sides of rectangle representing mean of the areas enclosed by the unit.

X Distance of concentrated load from the nearer support.

Z Bending moment co-efficient.

Z_x Bending moment co-efficient for the short span for slabs spanning in two directions and simply supported on four-sides.

Z_y Bending moment co-efficient for the long span for slabs spanning in two directions and simply supported on four sides.

Z^1_x Bending moment co-efficient for the short span for rectangular panels supported on four sides and with provision for torsion at corners.

Z^1_y Bending moment co-efficient for the long span for rectangular panels supported on four sides with provision for torsion at corners.

σ_b Bond stress in concrete at a section.

σ_{ba} Permissible average bond stress in concrete.

σ_{bl} Permissible local bond stress in concrete.

σ_c Permissible stress in concrete in direct compression.

$\sigma_{c'}$ Actual maximum compressive stress in concrete.

σ_{cb} Permissible compressive stress in concrete due to bending.

σ^1_{ct} Actual maximum compressive stress in concrete due to bending.

σ_{ct} Permissible tensile stress in concrete.

σ_{cu} Ultimate cube strength of concrete in compression.

σ_m Allowable unit stress on metal core not to exceed 1,250kg./cm.^{2} for steel core or 700 kg/cm.^{2} for cast iron core.

σ_{sc} Permissible compressive stress in reinforcement.

σ_{sh} Permissible tensile stress in helical reinforcement.

σ_{ss} Permissible tensile stress in the shear reinforcement.

σ_{st} Permissible tensile stress in reinforcement.

σ_{sy} Yield strength of the reinforcement.

α the angle between the inclined bar and axis of the beam.

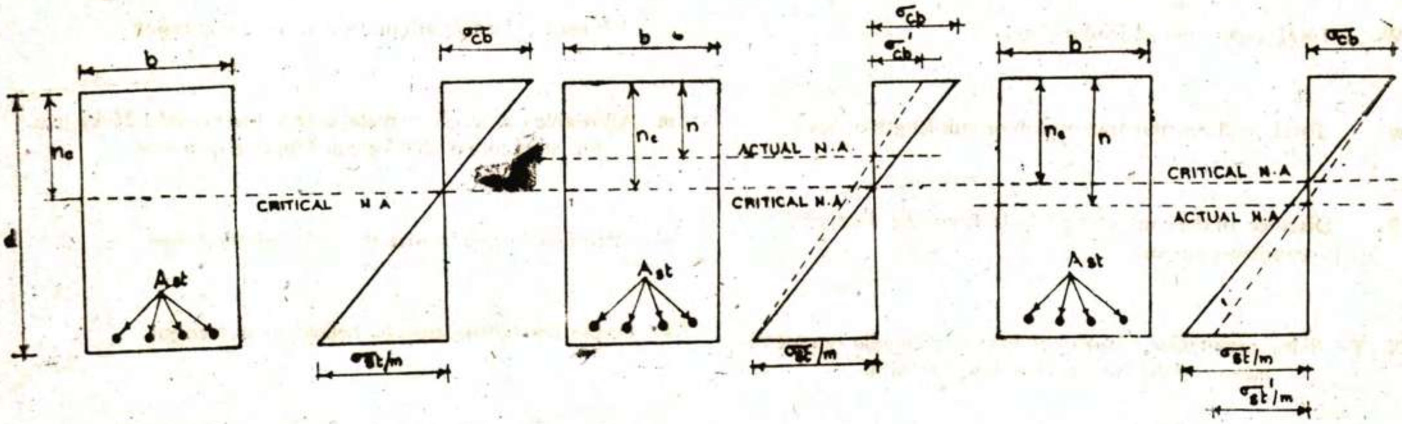
DESIGN CONSTANTS FOR BALANCED SECTION

Grade of concrete.	*Permissible stress in concrete in bending.* σ_{cb}	*Permissible stress in steel in tension.* σ_{st}	*Modular ratio.* m	*Neutral axis factor.* $n_{c/d}$	*Lever arm factor.*	*Q.*	*Per cent of steel.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
M 150 (1:2:4)	50	1400	19	0·4	0·867	8·75	0·71
M 200 (1:1½:3)	70	1400	13	0·4	0·867	12·00	1·00
M 250 (1:1:2)	85	1400	11	0·4	0·867	14·75	1·14

R.C.C. DESIGN FORMULAE IN METRIC SYSTEM.

ELASTIC THEORY : SIMPLE BENDING.

I. Singly reinforced sections balanced section.



(i) $n_c = kd$

$$k = \frac{n_c}{d} = \frac{m\,\sigma_{cb}}{m\,\sigma_{cb} + \sigma_{st}}$$

or

$$\tfrac{1}{2}\,bn^2 = m\,A_{st}\,(d-n)$$

(ii) Moment of resistance of balanced section.

$M_b = \sigma_{st}\,A_{st}\,jd$ where $jd = (d - n/3)$

$= \tfrac{1}{2}\,bn_c\,\sigma_{cb}\,jd = (\tfrac{1}{2}\,\sigma_{cb}\,kj)\,bd^2 = Q\,bd^2$

where $Q = (\tfrac{1}{2}\,\sigma_{cb}\,kj)$.

(iii) $$A_{st} = \frac{M}{\sigma_{st}\;jd}$$

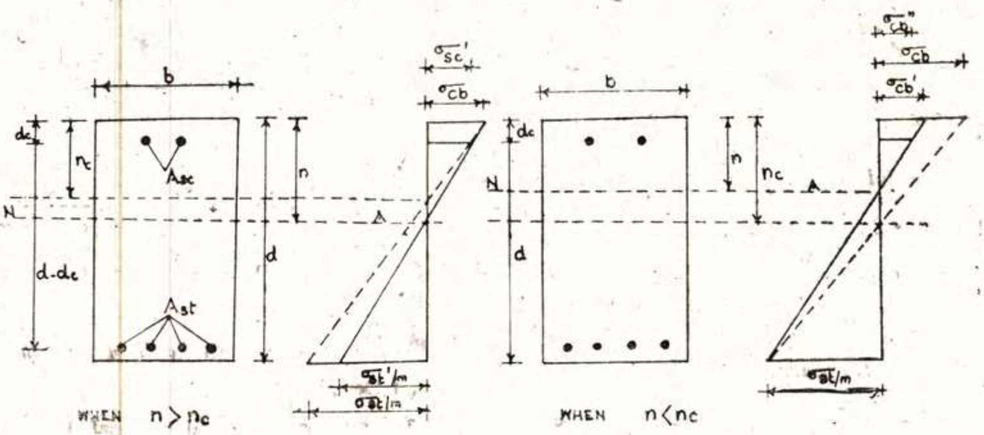
(iv) Moment of resistance of under reinforced section

$$M.R. = \sigma_{st}\,A_{st}\left\{d - \frac{n}{3}\right\} \text{when } n < n_c$$

(v) Moment of resistance of over reinforced section

$$M.R. = \tfrac{1}{2}\,bn\,\sigma_{cb}\left\{d - \frac{n}{3}\right\} \text{when } n > n_c.$$

II. SIMPLE BENDING, DOUBLY REINFORCED SECTION.



$$nc = \left(\frac{m \ \sigma cb}{m \ \sigma cb + \sigma st}\right) d$$

When the cross section and area of reinforcements are known to find "*n*" from

$$\frac{bn^2}{n} + (m-1) \ Asc \ (n-d_c) = m \ Ast \ (d-n)$$

(ii) When '*n*' is greater than n_c, Moment of resistance of a doubly reinforced beam

$$MR = bn \frac{\sigma cb}{2}\left(d - \frac{n}{3}\right) + (m-1) \ Asc \ \sigma sc(d-d_c)$$

Where σsc is the compressive stress in concrete at centre of gravity of compressive steel $= \sigma cb \ \dfrac{(n-d_c)}{n}$

(iii) When '*n*' is less than n_c

$$MR = \frac{bn \ \sigma cb}{2}\left(d - \frac{n}{3}\right) + (m-1) Asc \ \sigma cb \ \frac{(n-dc)}{n} \ (d-d_c)$$

$$\text{Where } \sigma cb = \frac{\sigma st}{m} \ \frac{(n)}{(d-n)}$$

(iv) $Ast = Ast_1 + Ast_2$

$$Ast_1 = \text{area of steel for balanced section} = \frac{M_b}{\sigma st \quad jd}$$

$$\text{and } Ast_2 = Asc = \frac{M - M_b}{(d-d_c) \quad \sigma sc}$$

III. T. beam and L. Section.

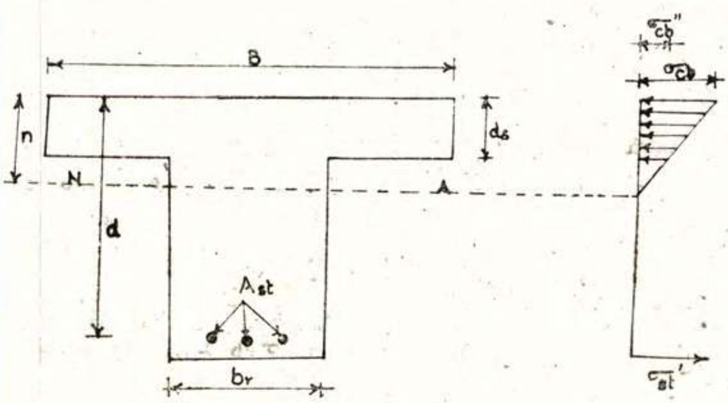
(i) To find the depth of Neutral Axis

$$\frac{Bn^2}{2} = m \ Ast \ (d-n)$$

When the neutral axis lies within the flange

$$Bd_s\left(n - \frac{d}{2}\right) = m \ Ast \ (d-n)$$

When the neutral axis lies below the flange



(ii) Lever arm when N.A. is below the flange

$$jt = d \frac{ds}{3} \left(\frac{3n - 2ds}{2n - ds}\right)$$

(iii) Moment of resistance

$$MR = Bds \frac{(\sigma cb + \sigma cb'')}{2} jd$$

$$\text{Where} \quad \sigma cb'' = \sigma cb \frac{(n - ds)}{n}$$

IV. Doubly reinforced T or L section.

(i) Moment of resistance of doubly reinforced T — beam

$$MR = M_b + (M - M_b)$$

$$MR = \frac{Bds\, \sigma cb'}{2} \left(1 + \frac{n - ds}{n}\right) jd$$

$$+ (m - 1)\, Asc\, \sigma cb' \left(\frac{n - dc}{n}\right) (d - d_c)$$

(ii) Area of total tensile steel $= Ast_1 + Ast_2 = \frac{MB}{\sigma st \quad jd} +$

$$\frac{M - M_B}{\sigma st\, (d - dc)}$$

and

$$Asc = \frac{M - M_B}{(d - dc)\ \sigma sc}$$

V. *Column under Direct Compression:*
Refer para 10.4 of I.S. 456-64 (Appended)

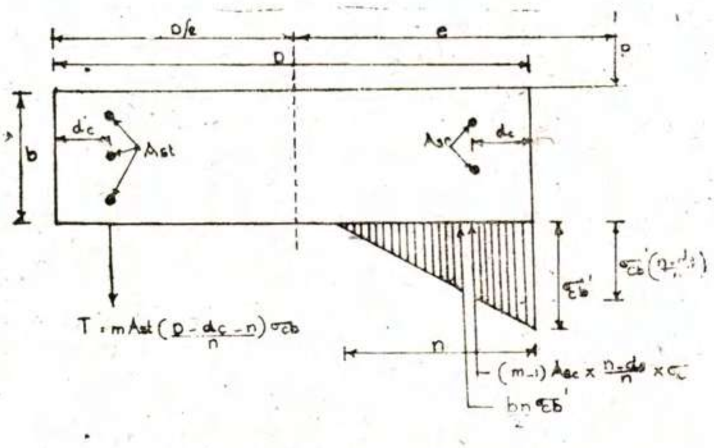
VI. *Eccentrically Loaded Rectangular Columns:*

(i) Design based on uncracked sections.

The member subjected to axial load and bending should satisfy the condition.

(a) $\frac{\sigma c'}{\sigma c} + \frac{\sigma cb'}{\sigma cb} \leq 1$

(b) The resultant tension in concrete is not greater than 35% and 25% of the resultant compression for biaxial and uniaxial bending respectively, or does not exceed ⅔ of the 7 day modulus of rupture of concrete.



COLUMN WITH LARGE ECCENTRICITY

(ii) Columns with large eccentricity so that tension is developed.

$$e + \frac{D}{2} - d'c = \frac{\frac{bn}{2}\left(D - d'c - \frac{n}{3}\right) + (m-1)\, Asc \times \frac{(n - dc)}{n} (D - dc - d'c)}{\frac{bn}{2} + (m-1)\, Asc \frac{(n - dc)}{n} - m\, Ast \frac{(D - d'c - n)}{n}}$$

where

d'c is the cover to steel on the tension side

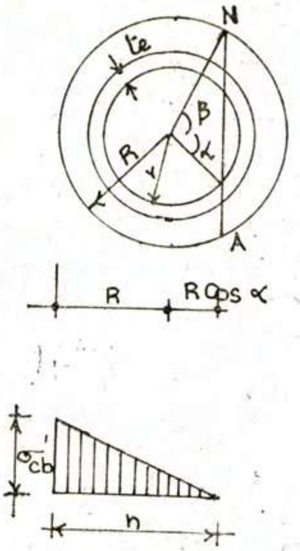
D is the overall depth of column.

From the above cubic equation 'n' can be found out by trial and error.

Knowing 'n', σcb can be found from

$$\frac{bn}{2} \sigma cb' + (m-1)\, Asc\, \sigma cb' \frac{(n - dc)}{n} - m\, Ast\, \sigma cb' \frac{(D - d'c - n)}{n} = P$$

III. Circular Columns Subject to Eccentric Loads :



CIRCULAR COLUMNS SUBJECT TO ECCENTRIC LOADS

$$= \frac{2R^2 \sigma_{cb}}{1 + \cos\beta}\left(\frac{\sin^3\beta}{3} + \frac{(\pi - \beta)}{2}\cos\beta + \frac{\cos\beta \sin 2\beta}{4}\right) + \frac{2r^2 t_e (m-1)\sigma_{cb}}{R + r\cos \pounds}\left(\sin \pounds + (\pi - \pounds)\cos \pounds\right) + \frac{2r^2 t_e m \sigma'_{cb}(\sin\alpha - \pounds\cos \pounds)}{R + r\cos \pounds} \quad \ldots\ (1)$$

$$e. = \frac{2r^3 \sigma'_{cb}}{1 + \cos\beta}\left(\frac{\pi - \beta}{8} + \frac{\sin 4\beta}{32} + \frac{\cos\beta \sin\beta}{3}\right) + \frac{2r^3 t_e (m-1)\sigma'_{cb}}{R + r\cos\alpha}\left(\frac{\pi - \alpha}{2} + \frac{\sin 2L}{4}\right) + \frac{2r^3 t_e m \sigma'_{cb}}{R + \cos\alpha}\left(\frac{\alpha}{2} - \frac{\sin 2\alpha}{4}\right) \quad \ldots\ (2)$$

iere $R\cos\beta = r\cos\alpha$ ...... (3)

2α and 2β are the angles subtended by the neutral axis at the centre corresponding to equivalent steel ring and column respectively.

te—is the thickness of equivalent steel ring

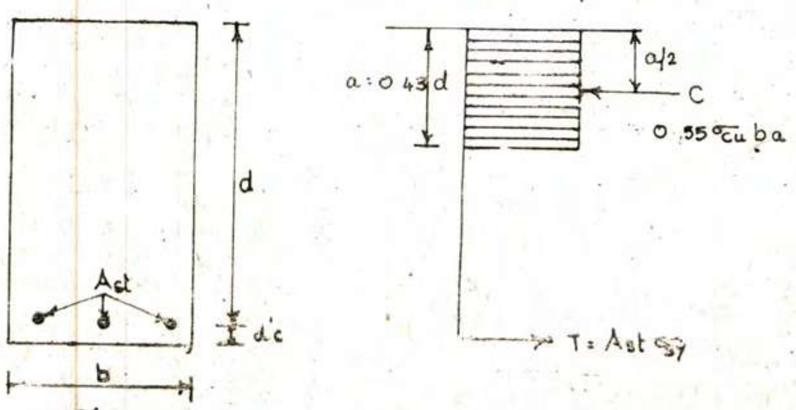
R—is the radius of the column, and

r—is the radius of the centre of steel.

Dividing the equation (2) by equation (1) and substituting arssumed values for β and obtaining corresponding values of α from equation (3) till the above equations are satisfied.

Ultimate load theory : For theory see appendix B of I.S. 456-64.

I. Rectangular Section — with tension reinforcement.



(i) $0.55\sigma_{cu}\ b.a = \sigma_{sy}\ A_{st}$

or $a = \dfrac{\sigma_{sy}\ A_{st}}{0.55\ \sigma_{cu}\ b}$

(ii) The lever arm of resisting moment

$jd = d - \dfrac{a}{2}$

If $a < 0.43$ d, jd will be $= d - \dfrac{a}{2}$

If $a \geq 0.43$ d, assume $a = 0.43$ d; and jd $= d - \dfrac{0.43d}{2} = 0.785d.$

(iii) Ultimate moment of resistance of the section

(*a*) in terms of tensile force steel

$M_u = A_{st}\ \sigma_{sy}\left(d - \dfrac{a}{2}\right)$

(*b*) in terms of compressive force in concrete

$M_u = 0.55\ \sigma_{cu}\ b\ a\left(d - \dfrac{a}{2}\right)$

For balanced section:

$a = 0.43d$

(iv) and $M_u = 0.185\ \sigma_{cu}\ bd^2$

(v) and Ast, the maximum area of steel for balanced section $= \dfrac{0.236\,\sigma_{cu}\ bd}{\sigma_{sy}}$

(vi) $$P_{st} = \frac{1 - \sqrt{1 - 3.64\dfrac{K}{\sigma_{cu}}}}{1.82\dfrac{\sigma_{sy}}{\sigma_{cu}}} = \frac{A_{st}}{bd}$$

Where $K = \dfrac{M_u}{bd^2} = P_{st}\ \sigma_{sy}\left(1 - \dfrac{P_t + \sigma_{sy}}{1.1\ \sigma_{cu}}\right)$

From the ultimate strength design tables available, P_{st} can be readily read for various grades of concrete and for different type of steel used.

Doubly reinforced rectangular section :

(i) $M_u = 0.185\sigma_{cu}\ bd^2 + \sigma_{cu}\ A_{sc}\ (d - d_c)$

(ii) $P_{sc} = \dfrac{A_{sc}}{bd} = \dfrac{K - 0.185\ \sigma_{cu}}{\sigma_{sc}\ \dfrac{(d - d_c)}{d}}$

(iii) $A_{st}\ \sigma_{sy} = 0.55\ \sigma_{cu}\ b.a + A_{sc}\ \sigma_{sc}$

$$\frac{A_{st}}{bd} = 0.236\ \frac{\sigma_{cu}}{\sigma_{sy}} + \frac{A_{sc}}{bd}\ \frac{\sigma_{sc}}{\sigma_{sy}}$$

(iv) $$P_{st} = \frac{K - 0.185\ \sigma_{cu}}{\sigma_{sy}\ \dfrac{(d - d_c)}{d}} + 0.236\ \frac{\sigma_{cu}}{\sigma_{sy}}$$

From the ultimate strength Design Tables available P_{st} and P_{sc} for various values of K can be read directly, for different grades of concrete

and different types of steel according to the values of $\dfrac{d - d_c}{d}$

III. *T and L Sections — Singly reinforced*

(a) If thickness of flange $d_s \geq a$ the section is designed as a rectangular section with breadth equal to B

(b) If $d_s < a$

$$M_u = 0.55\ \sigma_{cu}\ (B - b_r)\ d_s\left(d - \frac{d_s}{2}\right) + 0.55\sigma_{cu}\ b_r\ a\left(d - \frac{a}{2}\right)$$

Maximum value of M_u for sections with tension reinforcement only is obtained when a 0.43d.

$$K = \frac{M_u}{\sigma_{cu}\ Bd^2} = 0.185\ \frac{b_r}{B} + 0.275\left(1 - \frac{b_r}{B}\right)\left\{2\ \frac{d_s}{d} - \left(\frac{d_s}{d}\right)^2\right\}$$

For different values of $\dfrac{d_s}{d}$ and $\dfrac{b_r}{B}$, the values of K_t can be read from the ready made tables available.

(i) If $\dfrac{M_u}{\sigma_{cu}\ Bd^2} \leq K_t$ and $\dfrac{d_s}{d} > 0.15$ and $\dfrac{b_r}{B}$ between 0.10 and 0.35.

$$A_{st} = \frac{M_u}{\sigma_{sy}\left(d - \dfrac{d_s}{2}\right)}$$

For value of $\dfrac{d_s}{d} < 0.15$ and $\dfrac{b_r}{B} > 0.35$

$$A_{st} = \frac{M_u}{\sigma_{sy}\ jd} \text{ where } j = \frac{\left(1 - \dfrac{b_r}{B}\right)\dfrac{(d_s)}{d}\left(1 - 1/2\ \dfrac{d_s}{d}\right) + \dfrac{b_r}{B}\ \dfrac{a}{d}\left(1 - \dfrac{1}{2}\ \dfrac{a}{d}\right)}{\left(1 - \dfrac{b_r}{B}\right)\dfrac{d_s}{d} + \left(\dfrac{b_r}{B} \times \dfrac{a}{d}\right)}$$

If $\dfrac{M_u}{\sigma_u Bd^2} > K_t$, increase the size of the section and repeat the process if the section cannot be increased, the section has to be provided with compression reinforcement also.

For design of column with direct compression and bending tables and charts available in "Hand Book for Ultimate Strength Design of Reinforced Concrete Members" published by Structural Engineering research Centre, Roorkee, U.P. may be referred to

Note :—The advantage of using high strength deformed bars can be fully realised only if R.C.C. members are designed on the basis of ultimate load theory.)

CIRCULAR SLAB FREELY SUPPORTED AT THE EDGES AND LOADED UNFORMLY.

In this case the maximum radial and circumferential moments Mr and Mo respectively are equal, and occur at the centre of the slab. Their magnitude per unit width of the slab is given by

$$Mr = Mo = \frac{3}{16} W/R^2$$

in which W=total load per unit area of the slab and

R=Radius of the slab.

Mr reduces parabolically to zero at the edges. M_o reduces parabolically to $\frac{2}{16}$ w R^2 at the edges. The radial shear force at any radius-r is equal to 1/2 wr per unit width. Knowing the maximum bending moments, the depth of the slab and the area of reinforcement required can be calculated as usual. The reinforcement may be provided in two mutually perpendicular directions.

Circular slab fixed at edges and loaded uniformly.—The maximum positive radial and circumferential moments occur at the centre and are given by :

$$Mr = M_o = \frac{1}{16} \text{ w } R^2 \text{ per unit width of the slab}$$

Mr becomes zero at $r = \frac{R}{\sqrt{3}}$ and becomes negative thereafter, the maximum value of the negative moment at the edges being $\frac{2}{16}$ w R^2.

Mo decreases parabolically to zero at the edges, The shear force is $\frac{1}{2}$ w r, at any radius r. The depth of the slab is calculated as usual considering the maximum value of the bending moment on the slab. At the centre of the slab, reinforcement in the form of a mesh can be provided for the bending moments as in the case of a freely supported circular slab. However, at the edges, the reinforcement placed near the proper face of the slab, should be circumferential or radial depending upon whether the bending moment desired to be resisted is circumferential or radial. In the case of the circumferential reinforcement, it need be provided only over a distance, measured radially from the edge, sufficient for the mesh reinforcement to develop by bonds its design stress near the circumference. In the case of the radial reinforcement it has to resist negative bending moment. Therefore it should extend over the whole region of negative bending moment and also over an additional length required by it to develop its design stress by bond.

PERMISSIBLE STRESSES IN CONCRETE.

(ALL VALUE IN KG/CM^2)

Grade of concrete.	Permissible stress in compression.		Permissible stress in shear measured as inclined tension.	Permissible stress in Bond.		Permissible bearing pressure on full area (Plain concrete only).
	Bending.	Direct.		Average.	Local.	
	σcb	σc	q	σba	σb_1	σb
(1)	(2)	(3)	(4)	(5)	(6)	(7)
M 100	30	25	3·0	4·0	7·0	20
M 150	50	40	5·0	6·0	10·0	30
M 200	70	50	7·0	8·0	13·0	40
M 250	85	60	8·0	9·0	15·0	50
M 300	100	80	9·0	10·0	17·0	60
M 350	115	90	10·0	11·0	18·0	70
M 400	130	100	11·0	12·0	19·0	80

NOTE.—Permissible stress in tension in bending (σct) may be taken to be same as permissible stress in shear q (measured as inclined tension). given above.

PERMISSIBLE STRESSES IN STEEL REINFORCEMENT.

Serial number and type of stress in steel reinforcement.	Permissible stress in Kg./cm². Mild steel conforming to grade I of IS : 432—1966 or to IS - 1139—1966	Medium tensile steel conforming to IS : 432 (Pt. I)—1966 or deformed medium tensile steel bars conforming to IS : 1139—1966 or plain round cold twisted bars conforming to IS : 1786—1966	High yield strength deformed bars conforming to IS : 1139—1966 or IS : 1786—1966	Welded wire fabric conforming to IS : 1566—1967
(1)	(2)	(3)	(4)	(5)
(i) Tension (σst) other than in (*a*) helical reinforcement, in a column and (*b*) shear reinforcement—				
Up to and including 40 mm.	1400	Half the guaranteed yield stress subject to a maximum of 1900.	..	..
Over 40 mm.	1300		..	..
Up to and including 20 mm.	..	..	2300	..
Over 20 mm.	..	..	2100	..
Welded wire fabric, all sizes	..	..	..	2300
(ii) Tension in helical reinforcment in a compression member (σsh)	1 000	1 300	1 600	..
(iii) Tension in shear reinforcement (σss)	1 400	1 400	1 750	..
(iv) Compression in column bars (σsc)	1 300	1 300	1 750	..
(v) Compression in bars in a beam or slab when the compressive resistance of the cement is taken into account.	The calculated compressive stress in the surrounding concrete multiplied by 1.5 times the modular ratio or σsc whichever is lower.			
(vi) Compression in bars in a beam or slab where the compressive resistance of the concrete is not taken into account—				
Up to and including 40 mm	1 400	Half the guaranteed yield stress subject to a maximum of 1900.	1 900	..
Over 40 mm.	1 300		1 900	..

NOTE 1.—When mild steel conforming to Grade II of IS : 432 (Part I) 1966 is used, the permissible stresses shall be 90 per cent of the permissible stress in column 3, or if the design details have already been worked out on the basis of mild steel conforming to Grade I of IS : 432 (Part I)—1966, the area of reinforcement shall be increased by 10 per cent of that required for Grade I steel.

NOTE 2.—For the purpose of this code, the yield stress of steels for which there is no clearly defined yield point should be taken to be 0·2 per cent proof stress.

NOTE 3.—Structure subject to wind or earth-quake forces, the stresses specified in the above tables may be exceeded up to a limt of 33⅓ per cent provided in no case does the direct stress In reinforcement exceed 2600 Kg./cm².

MINIMUM DISTRIBUTION REINFORCEMENT IN SLABS.

Slab thickness (cm.)	10	12	15	18	20
Minimum area (sq. cm./metre)	1·20	1·44	1·80	2·16	2·40
Reinforcement (Mild Steel)	8 mm@40 cm *or* 6 mm@20 cm	8 mm@35 cm *or* 6 mm@18 cm	10 mm@40 cm *or* 8 mm@25 cm	10 mm@35 cm *or* 8 mm@20 cm	10 mm@30 cm *or* 8 mm@20 cm
Moment carrying capacity (tonne—cm)	19·3	28·6	51·8	74·4	98·5

SHEAR REINFORCEMENT—VERTICAL BINDERS.

Values of $\frac{Q}{jd}$ —(Kg/cm) for single binders (two legs) at various spacings (S)

Spacing S (cm)	*Diameter of the bar forming the binder (mm).* *Mild steel* (σ_{ss}=1400 *kg/cm*²). 6	8	10	12	*High strength steel* (σ_{ss}=1750 *kg/cm*²). 6	8	10	12
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
5	158·3	281·5	439·8	633·3	198·0	352·0	550·0	792·0
6	131·9	234·6	366·5	527·8	164·8	293·5	458·5	660·0
7	113·1	201·1	314·2	452·4	141·2	251·5	392·5	566·0
8	99·0	175·9	274·9	395·8	123·8	219·5	344·0	494·5
9	88·0	156·4	244·3	351·9	110·0	195·8	305·5	439·5
10	79·2	140·7	219·9	316·7	99·0	176·0	275·0	396·0
11	72·0	127·9	199·9	287·9	90·0	159·8	250·0	359·5
12	66·0	117·3	183·3	263·9	82·5	148·0	229·0	330·0
13	60·9	108·3	169·2	243·6	76·1	135·3	211·5	304·5
14	56·5	100·5	157·1	226·2	70·7	125·8	196·3	282·5
15	52·8	93·8	146·6	211·1	66·0	117·3	183·1	264·00
16	49·5	88·0	137·4	197·9	61·8	110·0	171·8	247·5
17	46·6	82·8	129·4	186·3	58·2	103·5	161·8	233·0
18	44·0	78·2	122·2	175·9	55·0	97·6	152·8	220·0
19	41·7	74·1	115·7	166·7	52·1	92·6	144·2	208·5
20	39·6	70·4	110·0	158·9	49·5	88·0	137·5	198·0
25	31·7	56·3	88·0	126·7	39·6	70·4	110·0	158·4
30	26·4	46·9	73·3	105·6	33·0	58·6	91·6	132·0

LOAD CARRYING CAPACITY OF CONCRETE IN RECTANGULAR COLUMNS (Tonne).

Column size. (cm).	*Gross area Ac (sq. cm.)*	*Load on concrete.* *M*-150	*M*-200	*M*-250	*M*-300	*M* 350	*M*-400	*Load on bars. Min.*·008 σ_{sc} Ac *Max.*·040 σ_{sc} Ac *Min.*	*Max.*	*Minimum recommended ties*
(1)	(2)	(3)	(4)	(5)	(6)	(7	(8)	(9)	(10)	(11)
20×20	400	16	20	24	32	36	40	5·4	27·0	
×25	500	20	25	30	40	45	50	6·8	34·0	
×30 ..	600	24	30	36	48	54	60	8·2	41·0	
×35	700	28	35	42	56	63	70	9·5	47·5	
×40	800	32	40	48	64	72	80	10·9	54·5	6 mm @ 15 cm
25×25	625	25	31	37	50	56	62	8·5	42·5	
×30 ..	750	30	37	45	60	67	75	10·2	51·0	
×35	875	35	43	52	70	78	87	11·9	59·5	
×40	1,000	40	50	60	80	90	100	13·6	68·0	
×45	1,125	45	56	67	90	101	112	15·3	76·5	
×50	1,250	50	62	75	100	112	125	17·0	85·0	

LOAD CARRYING CAPACITY OF CONCRETE IN RECTANGULAR COLUMNS (tonne)—*cont.*

Column size. (*cm.*)	*Gross area* *Ac* (*sq. cm.*)	*Load on concrete.*						*Load on bars.* *Min.* ·008 σ_{sc} Ac *Max.* ·040 σ_{sc} Ac		*Minimum recommended ties.*
		M-150	*M*-200	*M*-250	*M*-300	*M*-350	*M*-400	*Min.*	*Max.*	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
30×30	900	36	45	54	72	81	90	12·2	61·0	
×35	1,050	42	52	63	84	94	105	14·3	71·5	
×40	1,200	48	60	72	96	108	120	16·3	81·5	8 mm@ 20 cm.
×45	1,350	54	67	81	108	121	135	18·44	91·8	
×50	1,500	60	75	90	120	135	150	20·4	102·0	
×60	1,800	72	90	108	144	162	180	24·5	122·5	
35×35	1,225	49	61	73	98	110	122	16·6	83·0	
×40	1,400	56	70	84	112	126	140	19·1	95·5	
×45	1,575	63	78	94	126	141	157	21·4	107·1	Do.
×50	1,750	70	87	105	140	157	175	23·8	119·0	
×60	2,100	84	105	126	168	189	210	28·6	143·0	
×70	2,450	98	122	147	196	220	245	33·3	166·5	
40×40	1,600	64	80	96	128	144	160	21·7	108·8	
×45	1,800	72	90	108	144	162	180	24·5	122·4	
×50	2,000	80	100	120	160	180	200	27·2	136·0	
×60	2,400	96	120	144	192	216	240	32·6	163·2	Do.
×70	2,800	112	140	168	224	252	280	38·1	190·4	
×80	3,200	128	160	192	256	288	320	43·5	217·6	
45×45	2,025	81	101	121	162	182	202	27·5	137·7	
×50	2,250	90	112	135	180	202	225	30·6	153·0	
×60	2,700	108	135	162	216	243	270	36·7	183·6	
×70	3,150	126	157	189	252	283	315	42·9	214·2	Do.
×80	3,600	144	180	216	288	324	360	49·0	244·8	
×90 ..	4,050	162	202	243	324	364	405	55·0	275·4	
50×50	2,500	100	125	150	200	225	250	34·0	170·0	
×60	3,000	120	150	180	240	270	300	40·8	204·0	
×70	3,500	140	175	210	280	315	350	47·6	238·0	10 mm @ 25 cms,
×80	4,000	160	200	240	320	360	400	54·4	272·0	
×90	4,050	180	225	270	360	405	450	61·2	306·0	
×100 ..	5,000	200	250	300	400	450	500	68·0	340·0	

LOAD CARRYING CAPACITY OF CONCRETE IN RECTANGULAR COLUMNS (Tonne)—*cont.*

Column size (cm.)	*Gross area Ac (sq. cm.)*	*Load on concrete.*						*Load on bars. Min. ·008 σsc Ac Max. ·040 σsc Ac*		*Minimum recommended ties.*
		M-150	*M*-200	*M*-250	*M*-300	*M*-350	*M*-400	*Min.*	*Max.*	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
55×55	3,025	121	151	181	242	272	302	41·1	205·7	
×60	3,300	132	165	198	264	297	330	44·8	224·4	
×70	3,850	154	192	231	308	346	385	52·4	261·8	10 mm @ 25 cms.
×80	4,400	176	220	264	352	396	440	59·8	299·0	
×90	4,950	198	247	297	396	445	495	67·3	336·6	
×100 ..	5,500	220	275	330	440	495	550	74·8	374·0	
60×60	3,600	144	180	216	288	324	360	49·0	244·8	
×70	4,200	168	210	252	336	378	420	57·1	285·6	
×80	4,800	192	240	288	384	432	480	65·3	326·4	Do.
×90	5,400	216	270	324	432	486	540	73·4	366·0	
×100 ..	6,000	240	300	360	480	540	600	81·6	408·0	
65×65	4,225	169	211	253	338	380	422	57·5	287·3	
×70	4,550	182	227	273	364	409	455	61·9	309·4	
×80 ..	5,200	208	260	312	416	468	520	70·7	355·6	Do.
×90	5,850	234	292	351	468	526	585	79·6	397·8	
×100 ..	6,500	260	325	390	520	585	650	88·4	442·0	
70×70	4,900	196	245	294	392	441	490	66·6	333·2	
×80	5,600	224	280	336	448	504	560	76·2	380·8	
×90	6,300	252	315	378	494	567	630	85·7	428·4	
×100	7,000	280	350	420	560	630	700	95·2	476·0	
75×75	5,625	225	281	337	450	506	562	76·5	382·5	
×80	6,000	240	300	360	480	540	600	81·6	408·0	
×90	6,750	270	337	405	540	607	675	91·8	459·0	
×100 ..	7,500	300	375	459	600	675	750	102·0	510·0	Do.
80×80	6,400	256	320	384	512	576	640	87·0	435·2	
×90	7,200	288	360	432	576	648	720	97·9	489·6	
×100 ..	8,000	320	400	480	640	720	800	108·8	544·0	
90×90	8,100	324	405	486	648	729	810	110·2	550·8	
×100 ..	9,000	360	450	540	720	810	900	122·4	612·0	
100×100 ..	10,000	400	500	600	800	900	1,000	136·0	680.0	

1 Minimum Diam of Ties ≮ Ø where Ø = Maximum Diam of compression bar

2 Longitudinal bars in column space ≯ 35cm.

LOAD CARRYING CAPACITY OF CONCRETE IN CIRCULAR COLUMNS (tonnes)

Column Dia (cm.)	Gross area Ac (sq. cm.)	Load on Concrete.						Load on bars. Min: ·008 σsc Ac Max: ·040 σsc Ac		Minimum recommended Ties.
		M-150	M-200	M-250	M-300	M-350	M-400	Min.	Max.	
20	314	12·5	15·7	18·8	25·1	28·2	31·4	4·2	21·3	6 mm @ 15 cm. c/c
25	491	19·6	24·5	29·4	39·2	44·2	49·1	6·6	33·4	
30	707	28·2	35·3	42·4	56·5	63·6	70·7	6·9	48·1	8 mm @ 20 cm. c/c
35	962	38·4	48·1	57·7	76·9	86·5	96·2	13·1	65·5	
40	1,257	50·2	62·8	75·4	100·5	113·1	125·7	17·1	85·5	
45	1,590	63·6	79·5	95·4	127·2	143·1	159·0	21·6	108·0	10 mm @ 25 cm. c/c
50	1,963	78·5	98·1	117·8	157·0	176·6	196·3	26·7	133·4	
60	2,827	113·0	141·3	169·6	226·2	254·4	282·7	38·4	192·0	
70	3,848	153·9	192·4	230·9	307·8	346·3	384·8	52·3	261·5	
80	5,026	201·0	251·3	301·5	402·0	452·3	502·6	68·3	341·7	
90	6,362	254·4	318·1	381·7	508·9	572·5	636·2	86·5	432·5	
100	7,854	314·1	392·7	471·2	628·3	706·8	785·4	106·8	534·0	

LOAD CARRYING CAPACITY OF LONGITUDINAL REINFORCEMENT IN COLUMNS (tonne).

Bar Dia. (mm).	Area (sq. cm.)	Force/ each bar.	Number of bars.								
			4	6	8	10	12	14	16	18	20
12	1·13	1·9	7·7	11·5	15·4	19·2	23·0	26·9	30·7	34·6	38·4
16	2·01	3·4	13·7	20·5	27·4	34·2	41·0	47·9	54·7	61·6	68·4
18	2·54	4·3	17·3	25·9	34·6	43·2	51·8	60·5	69·1	77·8	86·4
20	3·14	5·3	21·4	32·0	42·7	53·4	64·1	74·8	85·4	96·1	106·8
22	3·80	6·4	25·8	38·8	51·7	64·6	77·5	90·4	103·4	116·3	129·2
25	4·91	8·3	33·4	50·1	66·8	83·5	100·2	116·9	133·6	150·3	167·0
28	6·16	10·4	41·9	62·8	83·8	104·7	125·6	146·6	167·5	188·5	209·4
32	8·04	13·6	54·7	82·0	109·4	136·7	164·0	191·4	218·7	246·1	273·4
36	10·18	17·3	69·2	103·9	138·5	173·1	207·7	242·3	277·0	311·6	346·2
40	12·57	21·3	85·5	128·2	171·0	213·7	256·4	299·2	341·9	384·7	427·4

TABLE 4.—SQUARE SPREAD FOOTINGS.

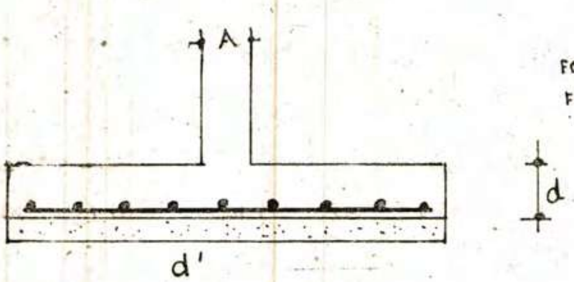
A—Width of Square Column in cm.

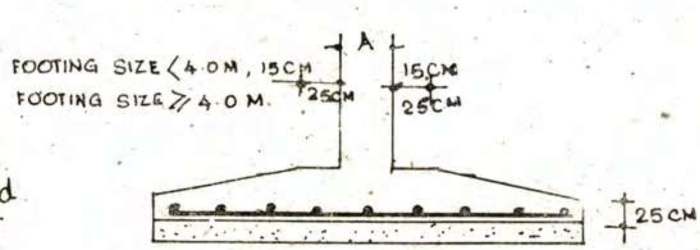
d—Depth of footing in cm.

As—Total required area of steel in sq. cm. (Each direction).

≥o—Required perimeter of reinforcing steel.

CONCRETE—M 150						CONCRETE—M 200					
Flarge width (metre).	*Total load (tonne).*	*A (cm.)*	*d (cm.)*	*As (sq. cm.)*	*≥o (cm.)*	*Flarge width (metre)*	*Total load (tonne)*	*A (cm.)*	*d (cm.)*	*As (sq. cm.)*	*≥o (cm.)*
(1)	(2)	(3)	(4)	(5)	(6)	(1)	(2)	(3)	(4)	(5)	(6)
SOIL PRESSURE 5 tonnes/sq.m. (1000 lbs/sq.ft.)											
1·00	4·5	25	25	1·0	10·3	1·00	4·5	25	25	1·0	7·7
1·20	6·5	25	25	1·9	14·2	1·20	6·5	25	25	1·0	11·6
1·40	8·9	25	25	3·3	20·6	1·40	8·9	25	25	3·3	16·7
1·60	11·6	25	25	5·1	27·0	1·60	11·6	25	25	5·1	21·8
1·80	14·7	25	25	7·6	30·0	1·80	14·7	25	25	7·6	28·4
2·00	18·1	25	30	8·4	35·0	2·00	18·1	25	25	10·8	34·8
2·20	21·9	25	35	9·3	35·2	2·20	21·9	25	30	11·4	33·0
2·40	26·1	25	35	12·4	42·2	2·40	26·1	25	35	12·7	32·7
2·60	30·7	25	40	13·5	42·2	2·60	30·7	25	35	16·0	39·2
2·80	35·6	25	45	14·9	42·5	2·80	35·6	25	40	17·4	38·8
3·00	40·9	25	50	16·4	43·5	3·00	40·9	25	45	18·6	38·4
3·20	46·5	25	55	17·9	44·0	3·20	46·5	25	45	22·7	43·4
3·40	52·5	30	55	21·0	48·5	3·40	52·5	30	50	23·4	42·8
3·60	58·9	30	60	22·0	49·5	3·60	58·9	30	50	27·0	48·0
3·80	65·6	30	65	25·0	50·2	3·80	65·6	30	55	30·1	47·2
4·00	72·7	35	65	28·4	54·5	4·00	72·7	35	60	31·0	47·0
4·20	80·1	35	70	30·4	56·8	4·20	80·1	35	60	36·3	52·0
4·40	87·9	35	75	32·8	57·0	4·40	87·9	35	65	38·3	52·5
4·60	96·1	40	75	37·0	61·5	4·60	96·1	40	65	43·2	56·0
4·80	104·7	40	80	39·3	63·0	4·80	104·7	40	70	45·6	56·5
5·00	**113·6**	**40**	85	41·8	63·5	**5·00**	**113·6**	40	75	**48·0**	**56·6**





FOR d ≤ 40CM, FOOTING OF CONSTANT DEPTH IS RECOMMENDED. REINFORCEMENT REMAINS SAME.

FOOTING WITH CONSTANT

TAPERED FOOTING

466-3—14A

SOIL PRESSURE 7·5 TONNES/sq.m. (1,500 lbs./sq.ft.)

CONCRETE—M 150						CONCRETE—M 200					
Flange width (metre)	Total load (tonne)	A (cm)	d (cm)	As (sq. cm)	≥ o (cm)	Flange width (metre)	Total load (tinne)	A (cm)	A (cm)	As (sq. cm.)	≥ o (cm)
(1)	(2)	(3)	(4)	(5)	(6)	(1)	(2)	(3)	(4)	(5)	(6)
1·00	6·8	25	25	1·5	14·2	1·00	6·8	25	25	1·5	11·5
1·20	9·8	25	25	2·8	21·9	1·20	9·8	25	25	2·8	16·7
1·40	13·3	25	25	4·9	30·9	1·40	13·3	25	25	4·9	24·5
1·60	17·4	25	25	7·7	41·2	1·60	17·4	25	25	7·7	32·2
1·80	22·0	25	30	8·8	42·0	1·80	22·0	25	30	8·8	33·0
2·00	27·2	25	35	10·3	43·3	2·00	27·2	25	30	10·5	41·0
2·20	32·9	25	40	11·9	45·0	2·20	32·9	25	35	14·0	41·0
2·40	39·2	25	45	13·7	45·5	2·40	39·2	25	40	15·8	41·5
2·60	46·0	25	50	15·5	48·0	2·60	46·0	25	45	17·6	43·2
2·80	53·4	30	50	18·9	54·3	2·80	53·4	30	45	21·4	48·5
3·00	61·3	30	55	21·2	56·1	3·00	61·3	30	50	23·6	49·2
3·20	69·8	35	55	25·2	62·3	3·20	69·8	35	50	28·2	55·0
3·40	78·8	35	60	27·6	64·3	3·40	78·8	35	55	30·6	55·5
3·60	88·3	35	65	29·6	65·8	3·60	88·3	35	60	32·4	56·4
3·80	98·4	40	70	32·4	65·6	3·80	98·4	40	60	38·5	61·4
4·00	109·0	40	75	36·4	75·0	4·00	109·0	40	65	41·5	62·5
4·20	120·2	45	75	40·0	77·0	4·20	120·2	45	65	47·1	68·5
4·40	131·9	45	80	43·44	78·8	4·40	131·9	45	70	50·5	69·4
4·60	144·2	45	85	47·0	80·0	4·60	144·2	45	75	54·0	70·0
4·80	157·0	50	90	49·5	81·5	4·80	157·0	50	80	56·3	71·0
5·00	170·4	50	95	53·3	81·5	5·00	170·4	50	85	60·0	72·0

SOIL PRESSURE 10 Tonnes/sq.m. (2,000 lbs/sq.ft.)

CONCRETE—M 150						CONCRETE—M 200					
Flange width (metre)	Total load (tonne)	A (cm)	d (cm)	As (sq. cm)	≥ o (cm)	Flange width (metre)	Total load (tinne)	A (cm)	A (cm)	As (sq. cm.)	≥ o (cm)
1·00	9·0	25	25	2·0	19	1·00	9·0	25	25	1·9	15·4
1·20	13·0	25	25	3·8	30	1·20	13·0	25	25	3·8	23·1
1·40	17·8	25	25	6·5	41	1·40	17·8	25	25	6·5	32·1
1·60	23·2	25	30	7·9	43	1·60	23·2	25	25	10·2	42·5
1·80	29·4	25	35	9·6	46	1·80	29·2	25	30	11·7	43·0
2·00	36·3	25	40	11·5	47	2·00	36·3	25	35	14·9	44·2
2·20	43·9	25	45	13·7	51	2·20	43·9	25	40	15·7	45·7
2·40	52·3	30	45	17·2	59	2·40	52·3	30	40	19·9	52·5
2·60	61·4	30	50	19·8	62	2·60	61·4	30	45	22·4	54·3
2·80	71·2	35	55	21·6	63	2·80	71·2	35	50	24·2	55·0
3·00	81·8	35	60	24·4	66	3·00	81·8	35	50	30·2	62·0
3·20	93·0	40	60	29·2	74	3·20	93·0	40	55	32·2	63·5
3·40	105·0	40	65	32·5	77	3·40	105·0	40	60	35·6	64·2
3·60	117·8	40	75	33·5	78	3·60	117·8	40	65	39·4	66·7
3·80	131·2	45	75	38·3	81	3·80	131·2	45	65	45·5	74·0
4·00	145·4	45	75	45·6	89	4·00	145·4	45	65	53·7	81·5
4·20	160·3	50	75	52·0	98	4·20	160·3	50	65	61·0	89·5
4·40	175·9	50	80	56·4	100	4·40	175·9	50	70	65·0	90·5
4·60	192·3	55	85	59·7	102	4·60	192·3	55	75	68·5	90·8
4·80	209·4	55	90	64·4	105	4·80	209.4	55	80	73·0	92·0
5·00	227·2	60	90	71·5	113	5·00	227·2	60	80	82·0	100·0

Soil Pressure 15 Tonnes/sq.m. (3,000 lbs./sq.ft.)

(1)	(2)	(3)	(4)	(5)	(6)
1·00	13·6	25	25	2·9	30
1·20	19·6	25	25	5·7	44
1·40	26·7	25	30	7·6	49
1·60	34·9	25	35	9·8	53
1·80	44·1	25	40	12·3	57
2·00	54·5	30	40	16·4	69
2·20	65·9	30	50	17·2	64
2·40	78·5	35	50	21·8	75
2·60	92·1	40	55	24·4	78
2·80	106·9	40	60	28·3	83
3·00	122·7	45	65	31·2	85
3·20	139·4	45	70	35·8	91
3·40	157·6	50	75	39·5	94
3·60	176·7	50	80	44·0	98
3·80	196·9	55	80	51·0	108
4·00	218·1	55	80	60·2	121
4·20	240·5	60	85	64·7	124
4·40	268·9	60	90	72·5	128
4·60	288·5	65	95	75·5	131
4·80	314·1	65	100	82·2	136
5·00	340·9	70	105	87·2	139

(1)	(2)	(3)	(4)	(5)	(6)
1·00	13·6	25	25	2·93	23
1·20	19·6	25	25	5·68	33
1·40	26·7	25	25	9·70	48
1·60	34·9	25	30	11·85	50
1·80	44·1	25	35	14·50	53
2·00	54·5	30	40	16·30	55
2·20	65·9	30	45	19·50	57
2·40	78·5	35	45	24·70	67
2·60	92·1	40	50	27·40	68
2·80	106·9	40	55	31·20	71
3·00	122·7	45	55	37·70	80
3·20	139·4	45	60	42·6	84
3·40	157·6	50	65	45·6	85
3·60	176·7	50	70	51·0	88
3·80	196·9	55	70	59·2	97
4·00	218·1	55	70	70·0	108
4·20	240·5	60	75	74·5	110
4·40	263·9	60	80	82·5	113
4·60	288·5	65	85	85·0	114
4·80	314·1	65	90	92·0	117
5·00	340·9	70	90	103·3	127

Soil ressure 20 tonnes/sq.m. (4,000 lbs./sq.ft.)

(1)	(2)	(3)	(4)	(5)	(6)
1·00	18·1	25	25	3·9	40
1·20	26·10	25	25	7·6	59
1·40	35·6	25	30	10·1	65
1·60	46·5	25	40	11·0	59
1·80	58·9	30	40	15·2	74
2·00	72·7	35	45	18·0	77
2·20	87·9	35	50	21·7	83
2·40	104·7	40	55	24·7	88
2·60	122·9	45	60	28·1	92
2·80	142·5	45	65	33·0	98
3·00	163·6	50	70	36·8	103
3·20	186·1	50	75	42·2	109
3·40	210·1	55	80	46·5	114
3·60	235·6	60	85	51·2	118
3·80	262·5	60	90	58·0	124
4·00	290·9	65	90	66·6	136
4·20	320·7	70	90	76·0	150
4·40	3[illegible]1·9	70	95	84·5	155
4·60	384·7	75	100	90·5	161
4·80	418·9	75	105	98·6	167
5·00	454·	80	110	105·0	172

(1)	(2)	(3)	(4)	(5)	(6)
1·00	18·1	25	25	3·9	30
1·20	26·1	25	25	7·6	45
1·40	35·6	25	30	10·0	50
1·60	46·5	25	35	13·0	55
1·80	58·9	30	35	18·0	67
2·00	72·7	35	40	20·8	69
2·20	87·9	35	46	24·6	73
2·40	104·7	40	50	27·6	76
2·60	122·9	45	50	34·8	88
2·80	142·5	45	60	36·2	89
3·00	163·6	50	60	43·7	95
3·20	186·1	50	65	49·6	100
3·40	210·1	55	70	53·8	102
3·60	235·6	60	75	58·7	105
3·80	262·5	60	80	66·0	109
4·00	290·9	65	80	75·7	120
4·20	320·7	70	80	86·5	132
4·40	351·9	70	85	95·5	137
4·60	384·7	75	90	101·0	140
4·80	418·9	75	95	110·0	144
5·00	454·5	80	95	123·0	156

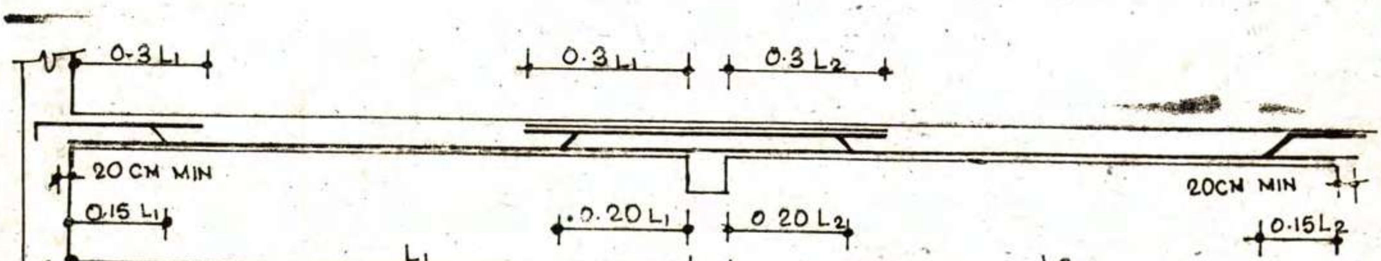
CONCRETE—M 150

SOIL PRESSURE 30 tonnes/sq.m. (6,000 lbs./sq.ft.)

Flange width (metre)	*Total load (tonne)*	*A (cm)*	*d (cm)*	*As (sq. cm)*	*Σo (cm)*
(1)	(2)	(3)	(4)	(5)	(6)
1·00	27·2	25	25	5·9	58
1·20	39·2	25	30	8·9	69
1·40	53·4	30	35	11·3	74
1·60	69·8	35	40	14·1	82
1·80	88·3	35	45	18·5	91
2·00	109·0	40	50	22·1	98
2·20	131·9	45	55	26·0	105
2·40	157·0	50	60	30·4	112
2·60	184·3	50	65	36·7	122
2·80	213·8	55	70	41·9	129
3·00	245·4	60	75	47·0	136
3·20	279·2	65	80	52·8	143
3·40	315·2	65	90	57·3	143
3·60	353·4	70	90	67·2	160
3·80	393·8	75	95	74·0	166
4·00	436·3	80	95	86·4	184
4·20	481·0	85	100	93·5	191
4·40	527·9	85	105	104·5	201
4·60	577·0	90	110	113·0	207
4·80	628·3	95	115	121·0	215
5·00	681·8	100	120	130·5	222

CONCRETE—M 150

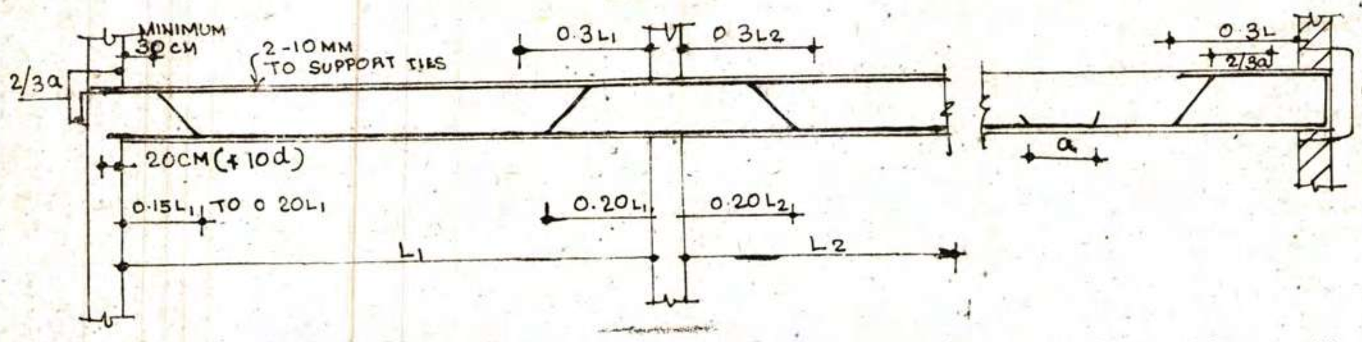
Flange width (metre)	*Total load (tonne)*	*A (cm)*	*d (cm)*	*As (sq. cm)*	*Σo (cm)*
(1)	(2)	(3)	(4)	(5)	(6)
1·00	27·2	25	25	5·9	45
1·20	39·2	25	30	8·9	53
1·40	53·4	30	30	13·8	72
1·60	69·8	35	35	16·7	76
1·80	88·3	35	40	21·4	82
2·00	109·0	40	45	25·0	86
2·20	131·9	45	50	29·2	92
2·40	157·0	50	55	33·7	96
2·60	184·3	50	60	40·0	103
2·80	213·8	55	65	45·7	109
3·00	245·4	60	65	55·0	123
3·20	279·2	65	70	61·0	128
3·40	315·2	65	75	70·0	136
3·60	353·4	70	80	76·5	140
3·80	393·8	75	85	84·0	145
4·00	436·3	80	85	97·5	161
4·20	481·0	85	85	111·5	176
4·40	527·9	85	95	116·5	172
4·60	577·0	90	95	132·0	188
4·80	628·3	95	100	141·0	193
5·00	681·8	100	105	151·0	198



NOTES:

AT LEAST 1/3 OF THE SPAN REINFORCEMENT SHOULD BE CARRIED BEYOND THE FACE OF THE SUPPORT.

TYPICAL REINFORCEMENT DETAILING OF SLAB WITH RIBBED TORSTEEL



TYPICAL REINFORCEMENT DETAILING OF BEAMS WITH RIBBED TORSTEEL

NOTES

1. AT LEAST 1/3 OF THE SPAN REINFORCEMENT SHOULD BE CARRIED BEYOND THE FACE OF THE SUPPORT.
2. WHEN SHEAR STREES q EXCEEDS THE PREMISSIBLE VALUE, NOT MORE THAN 50% OF THE SHEAR FORCE SHOULD BE CARRIED BY BENT UP BARS.
3. COMPRESSION REINFORCEMENT (ϕ) IF ANY TIED WITH BINDERS SPACED $>$ 15 ϕ
4. ANCHORAGE a = 50 D FOR TENSION
   35 D FOR COMPRESSION.
5. **FOR LIMIT STATTE DESIGN.**
   ANCHORAGE a = 57 D FOR TENSION.
   45 D FOR COMPRESSION.

REINFORCING CHARACTERISTICS.

Bar dia. (mm.)	*Area (cm^2)*	*Weight Kg/m.*	*Perimeter (cm)*
(1)	(2)	(3)	(4)
6	0·283	0·222	1·89
8	0·503	0·395	2·51
10	0·785	0·617	3·14
12	1·131	0·888	3·77
14	1·539	1·208	4·40
16	2·011	1·578	5·03
18	2·545	2·000	5·65
20	3·142	2·466	6·28
22	3·801	2·980	6·91
25	4·909	3·854	7·85
28	6·157	4·830	8·80
32	8·042	6·313	10·05
36	10·179	7·990	11·31
40	12·566	9·864	12·57
45	15·904	12·490	14·14
50	19·635	15·410	15·71

TABLE A-3.—AREAS OF GROUPS OF STANDARD BARS (IN SUQARE CENTIMETRES).

Number of bars.	*Bar diamtere in millimetres.*												
	6	8	10	12	14	16	18	20	22	25	28	32	36
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1	0·28	0·50	0·79	1·13	1·54	2·01	2·54	3·14	3·80	4·91	6·16	8·04	10·18
2	0·56	1·00	1·57	2·26	3·07	4·02	5·08	6·28	7·60	9·81	12·31	16·08	20·35
3	0·84	1·50	2·35	3·39	4·61	6·03	7·63	9·42	11·40	14·72	18·47	24·12	30·53
4	1·13	2·01	3·14	4·52	6·15	8·04	10·17	12·56	15·20	19·63	24·63	32·17	40·71
5	1·41	2·51	3·92	5·65	7·69	10·05	12·72	15·70	19·00	24·54	30·78	40·21	50·89
6	1·69	3·01	4·71	6·78	9·23	12·06	15·26	18·85	22·80	29·45	36·94	48·25	61·07
7	1·97	3·51	5·49	7·91	10·77	14·07	17·81	21·99	26·60	34·36	43·10	56·29	71·25
8	2·26	4·02	6·28	9·04	12·31	16·08	20·35	25·13	30·41	39·27	49·26	64·34	81·43
9	2·54	4·52	7·06	10·17	13·85	18·09	22·90	28·27	34·21	44·17	55·41	72·38	91·60
10	2·82	5·02	7·85	11·31	15·39	20·10	25·44	31·41	38·01	49·08	61·57	80·42	101·78
11	3·11	5·52	8·63	12·44	16·93	22·11	27·99	34·55	41·81	53·99	67·73	88·46	111·96
12	3·39	6·03	9·42	13·57	18·47	24·12	30·53	37·69	45·61	58·90	73·89	96·51	122·14
13	3·67	6·53	10·21	14·70	20·01	26·13	33·08	40·84	49·41	63·81	80·0	104·55	132·32
14	3·95	7·03	10·99	15·83	21·55	28·14	35·62	43·98	53·21	68·72	86·20	112·59	142·50
15	4·24	7·54	11·78	16·96	23·09	30·15	38·17	47·12	57·02	73·63	92·36	120·63	152·68
16	4·52	8·04	12·56	18·09	24·63	32·17	40·71	50·26	60·82	78·54	98·52	128·68	162·86
17	4·80	8·54	13·35	19·22	26·17	34·18	43·26	53·40	64·62	83·44	104·67	136·72	173·03
18	5·08	9·04	14·13	20·35	27·70	36·19	45·80	56·54	68·41	88·35	110·83	144·76	183·21
19	5·37	9·55	14·92	21·48	29·24	38·20	48·34	59·69	72·22	93·26	116·99	152·80	193·39
20	5·65	10·05	15·70	22·62	30·78	40·21	50·89	62·83	76·02	98·17	123·15	160·85	203·57

TABLE A-4—PERIMETRA OF GROUPS OF STANDAARD BARS (IN CENTIMETRES).

N mber of bars.	*Bar diameters in millimetres.*												
	6	8	10	12	14	16	18	20	22	25	28	32	36
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1	1·88	2·51	3·14	3·77	4·40	5·03	5·65	6·28	6·91	7·85	8·80	10·05	11.31
2	3.77	5·02	6·28	7·54	8·79	10·05	11·31	12·56	13·82	15·70	17·59	20·10	22·62
3	5·65	7·54	9·42	11·31	13·19	15·08	16·96	18·85	20·73	23·56	26·38	30·15	33·92
4	7·54	10·05	12·56	15·08	17·59	20·10	22·62	25·13	27·64	31·41	35·18	40·21	45·23
5	9·42	12·56	15·70	18·85	21·99	25·13	28·27	31·41	34·55	39·27	43·98	50·26	56·54
6	11·31	15·08	18·85	22·62	26·38	30·15	33·92	37·69	41·46	47·12	52·77	60·31	67·85
7	13·19	17·59	21·99	26·38	30·78	35·18	39·58	43·98	48·38	54·97	61·57	70·37	79·16
8	15·08	20·10	25·13	30·15	35·18	40·21	45·23	50·26	55·29	62·83	70·37	80·42	90·47
	16·96	22·62	28·27	33·92	39·58	45·23	50·89	56·54	62·20	70·68	79·16	90·47	101·78
10	18·85	25·13	31·41	37·69	43·98	50·26	56·54	62·83	69·11	78·54	87·96	100·53	113·09

TABLE A. 4—PERIMETER OF GROUPS OF STANDARD BARS (IN MILLIMETRES).

Number of bars.	Bar diameter in millimeters.												
	6	8	10	12	14	16	18	20	22	25	28	32	36
11	20·73	27·64	34·55	41·46	48·38	55·29	62·20	69·11	76·02	86·39	96·76	110·58	124·40
12	22·62	30·15	37·69	45·23	52·77	60·31	67·85	75·39	82·93	94·24	105·55	120·63	135·71
13	24·50	32·67	40·84	49·00	57·17	65·34	73·51	81·68	89·85	102·10	114·35	130·69	147·02
14	26·38	35·18	43·98	52·77	61·57	70·37	79·16	87·96	96·76	109·95	123·15	140·74	158·33
15	28·27	37·69	47·12	56·54	65·97	75·39	84·82	94·24	103·67	117·81	131·94	150·79	169·64
16	30·15	40·21	50·26	60·31	70·37	80·42	90·47	100·53	110·58	125·66	140·74	160·85	180·95
17	32·04	42·72	53·40	64·08	74·77	85·45	96·13	106·81	117·49	133·51	149·54	170·90	192·26
18	33·92	45·23	56·54	67·85	79·16	90·47	101·78	113·09	124·40	141·37	158·33	180·95	203·57
19	35·81	47·75	59·69	71·62	83·56	95·50	107·44	119·38	131·31	149·22	167·13	191·00	214·88
20	37·69	50·26	62·83	75·39	87·96	100·53	113·09	125·66	138·23	157·08	175·93	201·06	226·19

TABLE A. 5—AREAS OF BASE IN SLABS (IN SQURE CENTIMETERS PER METRE).

Spacing (cm).	Bar diameter in millimeters.											
	6	8	10	12	14	16	18	20	22	25	28	32
5	5·65	10·05	15·71	22·62	30·79	40·21	50·89	62·83	76·03	98·17	123·15	160·85
6	4·71	8·38	13·09	18·85	25·66	33·51	42·41	52·36	63·36	81·81	102·68	134·04
7	4·04	7·18	11·22	16·16	21·99	28·72	36·35	44·88	54·30	70·12	87·96	114·89
8	3·53	6·28	9·82	14·14	19·24	25·13	31·81	39·27	47·52	61·36	76·97	100·53
9	3·14	5·58	8·73	12·57	17·10	22·34	28·27	34·91	42·24	54·54	68·42	89·3
10	2·83	5·03	7·85	11·31	15·39	20·11	25·45	31·42	38·01	49·09	61·57	80·42
11	2·57	4·57	7·14	10·28	13·99	18·28	23·13	28·56	34·56	44·62	55·98	73·11
12	2·36	4·19	6·54	9·42	12·83	16·75	21.21	26·18	31·68	40·91	51·31	67·02
13	2·17	3·87	6·04	8·70	11·84	15·47	19·57	24·17	29·24	37·76	47·37	61·86
14	2·02	3·59	5·61	8·08	11·00	14·36	18·18	22·44	27·15	35·06	43·98	57·45
15	1·88	3·35	5·24	7·54	10·26	13·40	16·96	20·94	25·34	32·72	41·05	53·62
16	1·77	3·14	4·91	7·07	9·62	12·57	15·90	19·63	23·76	30·68	38·48	50·97
17	1·66	2·96	4·62	6·65	9·05	11·83	14·97	18·48	22·36	28·87	36·22	47·31
18	1·57	2·79	4·36	6·28	8·55	11·17	14·44	17·45	21.12	27·27	24·21	44·68
19	1·49	2·65	4·13	5·95	8·10	10·58	13·39	16·53	20·01	25·84	32·41	42·33
20	1·41	2·51	3·93	5·65	7·70	10·05	12·72	15·71	19·01	24·54	30·79	40·21

TABLE A. 5—AREAS OF BARS IN SLABS (IN SQUARE CENTIMETRES PER METRE).

Spacing (cm).	Bar diameter in millimetres.											
	6	8	10	12	14	16	18	20	22	25	28	32
21	1·35	2·39	3·74	5·39	7·33	9·57	12·12	14·96	18·10	23·37	29·32	38·30
22	1·28	2·28	3·57	5·14	7·00	9·14	11·57	14·28	17·28	22·31	27·99	36·56
23	1·23	2·18	3·41	4·92	6·69	8·74	11·06	13·66	16·53	21·34	26·77	34·97
24	1·18	2·09	3·27	4·71	6·41	8·38	10·60	13·09	15·84	20·54	25·66	33·51
25	1·13	2·01	3·14	4·52	6·16	8·04	10·18	12·57	15·20	19·63	24·63	32·17
26	1·09	1·93	3·02	4·35	5·92	7·73	9·79	12·08	14·62	18·88	23·68	30·93
27	1·05	1·86	2·91	4·19	5·70	7·45	9·42	11·64	14·08	18·18	22·81	29.79
28	1·01	1·79	2·80	4·04	5·50	7·18	9·09	11·22	13·58	17·53	21·99	28·76
29	0·97	1·73	2·71	3·90	5·31	6·93	8·77	10·83	13·11	16·93	21·23	27·73
30	0·94	1·68	2·62	3·77	5·13	6·70	8·48	10·47	12·67	16·36	20·52	26·81
32	0·88	1·57	2·45	3·53	4·81	6·28	7·95	9·82	11·88	15·34	19·24	25·13
34	0·83	1·48	2·31	3·33	4·53	5·91	7·48	9·24	11·18	14·44	18·11	23·65
36	0·78	1·40	2·18	3·14	4·28	5·58	7·07	8·73	10·56	13·63	17·10	22·34
38	0·74	1·32	2·07	2·98	4·05	5·29	6·70	8·27	10·00	12·92	16·20	21·16
40	0·71	1·26	1·96	2·83	3·85	5·03	6·36	7·85	9·50	12·27	15·39	20·11

EXTRACT FROM I.S. 2541/65.

Code of practice for buildings use of lime concrete in.

Design considerations :

General : Lime concrete may be used in building work generally for the following situations:—

(*a*) as a levelling course for foundations and for plain concrete footings for masonry walls and columns ;

(*b*) base concrete under floors ;

(*c*) for filling haunches over masonry arch work ; and

(*d*) roof finish.

4.2. For satisfactory use and proper selection of right mix for lime concrete, detailed information with regard to the following will be necessary:

(*a*) *For use of lime concrete in foundations* : Nature of soil and charactristics of ground at or near the surface, sub-soil water level and load transmitted to the foundation ;

(*b*) *For use under floor finishes* : Charactristics of ground, sub-soil water level, type of floor finish provided and load on the floor.

4.2.1. Lime concrete in foundation shall not be used for buildings where strength requirements are likely to exceed those specified in 4.6.2. Its use shall also be restricted to areas where level of sub-soil water is not very high and where soil does not contain excessive soluble salts. In areas of high water table, cement concrete or lime cement concrete will have to be used.

4.2.2. When properly prepared and laid, lime concrete applied as roof finish serves as an efficient water proofing and heat insulating material without the need of any further finishing treatment on the exposed surface.

4.3. *Mix proportions* :

4.3.1. The mix proportions for use in the preparation of lime concerte for different situtions of use shall be given in Table 1.

TABLE 1—RECOMMENDED MIXES FOR USE IN LIME CONCRETE.

(*Clauses* 3.4.2, 4.3.1., 4.4.1. and 4.6.2.)

Serial number and Situations.	*Types of mortar (All proportions by volume).*	*Class of lime as in I.S. 712–1964**	*Type of coarse aggregate.*	*Maximum size of coarse aggregate.*	*Proportion of mortar to coarse aggregate (by volume.)*	*Remarks.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(i) In foundations	1 Lime, 2 Sand	A	Stone or broken brick	50 mm	40 to 50 parts of mortar to 100 parts of aggregate depending upon the grading of aggregate.	Normally suitable for buildings not more than three storeys high and in places with dry sub-grade, that is, sub-soil water level not within 2.5 metres of foundation level.
	1 Lime, 1 Surkhi or Cinder, 1 Sand	B or C or A	Do.	50 mm		
	1 Lime, 2 Surkhi or Cinder.	B or C or A	Do.	50 mm		
	1 Cement, 3 lime, 12 Sand.	B or C	Do.	50 mm		
(ii) Base Concrete under floor finishes on ground.	1 Lime, 2 Sand	A	Stone or broken brick	50 mm	40 to 50 parts of mortar to 100 parts of aggregate depending upon the grading of aggregate.	Suitable for dry and tolerably wet sub-grades.
	1 Lime, 1 Surkhi or Cinder, 1 Sand.	B or C or A	Do.	50 mm		
	1 Lime, 2 Surkhi or Cinder	B or C or A	Do.	50 mm		
	1 Cement, 3 Lime, 12 Sand.	B or C	Do.	50 mm		
(iii) Levelling course or Cushioning layer under floor finished laid on structural slabs.	1 Lime, 2 Sand	A	Broken brick or Cinder.	20 to 25 mm	40 to 50 parts of mortar to 100 parts of aggregate.	..
	1 Lime, 1 Surkhi or Cinder, 1 Sand.	B or C or A	Do.	Do.		
	1 Lime, 2 Surkhi or Cinder.	B or C or A	Do.	Do.		
	1 Cement, 3 lime, 12 Sand.	B or C	Do.	Do.		
(iv) Filling over haunches of masonry arch work.	1 Lime, 2 Surkhi	B or C or A	Broken brick	25 mm	45 parts of mortar to 100 parts of aggregate.	..
	1 Lime, 1 Surkhi, 1 Sand.	B or C or A	Do.	25 mm		
(v) Roof terracing	1 Lime, 2 Surkhi	C	Broken brick	25 mm	40 parts of mortar to 100 parts of aggregate.	
(vi) Light filling over structural slabs.	1 Lime, 2 Sand	A	Broken brick or Cinder.	Any suitable size but usually not more than 25 mm	40 to 50 parts of mortar to 100 parts of aggregate.	..
	1 Lime, 1 Surkhi or Cinder, 1 Sand.	B or C or A	Do.			
	1 Lime, 2 Surkhi or Cinder.	B or C or A	Do.			
	1 Cement, 3 lime, 12 Sand.	B or C	Do.			

Note 1 :—The mixes given in the table are for general guidance and may be modified to suit the strength requirements for various uses to which the concrete is put to.

Note 2 :—Surkhi and Cinder need not be used where Class A lime is used.

* Specification for building limes (revised).

EXTRACT FROM I.S. 269 – 1967.

Specification for ordinary, rapid-hardening and low heat portland cement.

2. *Manufacture* :

2.1. Portland cement, whether ordinary, rapid-hardening or low heat, shall be manufactured by intimately mixing together calcareous and argillaceous and / or other silica, alumina or iron oxide bearing materials, burning them at a clinkering temperature and grinding the resultant clinker so as to produce a cement capable of employing with this specification. No materials hallbe added after burning other than gypsum or water or both, and not more than one percent of air-entraining agents or other agents, which have proved not to be harmful.

4. *Physical requirements* :

4.1. *Fineness* : When tested by either one of the method described in I.S. 4031, Methods of physical tests for hydraulic cement. The cement shall comply with the following requirements.

	Ordinary.	*Rapid hardening.*	*Low heat.*
a) After sieving, the residue by weight on 90-micron I.S. Sieve, not to exceed, per cent ..	10	5	—
(*b*) Specific surface (cm2/g) by Air Permeability Method not less than	2250	3250	3200

4.2. *Soundness* :

4.2.1. When tested by the 'Le Chatelier' Method described in I.S. 4031, unaerated ordinary rapid-hardening and low heat Portland cements shall not have an expansion of more than 10 mm.

4.2.1.1.In the event of the cements failing to comply with the above requirements a further test shall be made by the 'Le Chatelier' Method described in I.S. 4031, from another portion of the same sample, after aeration, by being spread out to a depth of 75 mm at a relative humidity of 50 to 80 percent for a total period of 7 days, when the expansion of each of the three types of cements mentioned above shall not be more than 5 mm.

4.2.2. When specified by purchaser at the time of placing the order, unaerated ordinary, rapid-hardening and low heat Portland cements shall not have an expansion of more than 0.8 per cent when tested by the autoclave test described in I.S. 4031 (see 4.2.3).

4.2.3. All cements having a magnesia content of more than 3 percent shall be tested for soundness by autoclave test described in I.S. 4031 and shall comply with the requirements specified in 4.2.2.

4.3. *Setting Time*: The setting time of the cements, when tested by the Vicat apparatus method described in I.S. 4031 shall conform to the following requirements :

	Ordinary.	*Rapid hardening.*	*Low heat.*
(*a*) Initial setting time in minutes, not less than	30	30	60
(*b*) Final setting time in minutes, not more than.	600	600	600

4·4. *Compressive strength.*—The average compressive strength of at least three mortar cubes (area of face 50 cm²) composed of one part of cement, three parts of standard sand (conforming to I.S. 650-1965 by weight and $\frac{P}{4} + 3{\cdot}0$ per cent (of combined weigh of cement plus sand) water, and prepared, stored and tested in the manner described in I.S. 4031, shall be as follows :—

	Ordinary Kg/cm.².	*Rapid-hardening Kg/cm.²*	*Low heat. Kg/cm².*
(1)	(2)	(3)	(4)
(*a*) 24 h ± 30 min, not less than.	..	160	..
(*b*) 72 ± 1 h, not less than ..	160	275	100
(*c*) 168 ± 2 h, not less than ..	220	..	160
(*d*) 672 ± 4 h, not less than ..	..	..	350

NOTE 1.—Standard sand shall conform to I.S. 650-1966.

NOTE 2.—P is the percentage of water required to produce a paste of standard consistency (*see* 10·3).

4·4·1. Alternatively the cement may be accepted based on the compressive strength limits indicated in 4·4·1·1·

4·4·1·1. The average compressive strength of at least three mortar cubes (area of face 50 cm2.) composed of one part of cement, three parts of sand (*see* Note 1 below) by weight, and P/4 + 3·5 per cent (of combined weight of cement plus sand) water, and prepared, stored and tested in the manner described in I.S. 4031—1968 Methods of Physical Tests for Hydraulic cement, shall be as follows :—

	Ordinary Kg/cm²	*Rapid-hardening Kg/cm.²*	*Low heat Kg/cm²*
(1)	(2)	(3)	(4)
(*a*) 24 h ± 30 min, not less than.	..	115	..
(*b*) 72 ± 1 h, not less than ..	115	210	70
(*c*) 168 ± 2 h, not less than ..	175	..	115
(*d*) 672 ± 4 h, not less than ..	..	..	265

NOTE 1.—The sand for the test shall conform to I.S. 650-1966 specification for Standard Sand for Testing of Cement (First revision), except that the grading of the sand shall be such that it passes through 850† micron I.S. Sieve and not more than 10 percent by weight passes through 600 micron I.S. Sieve (*see*) I.S. 460-1962 Specification for Test Sieves (Revised).

NOTE 2—P is the percentage of water required to produce a paste of standard consistency (see 10·3).

4·5. By agreement between the purchaser and the manufacturer, transverse strength test of plastic mortar in accordance with the method described in I.S. 4031 may be specified in addition to the test specified in 4·4. The permissible values of the transverse strength for ordinary and rapid-hardening Portland cement shall be mutually agreed to between the purchaser and supplier at the time of placing order.

4·6. Notwithstanding the strength requirements specified in 4·4 and 4·5, ordinary, rapid-hardening and low heat Portland cements shall show a progressive increase in strength from the strength at 24 h or 72 h depending upon the type of Portland cement.

4·7. *Heat of hydration*.—This requirement shall apply only to low heat cement. When tested by the method described in I.S. 4031 the heat of hydration of low heat Portland cement shall be as follows:—

(*a*) 7 days not more than 65 calories per gram, and

(*b*) 28 days not more than 75 calories per gram.

5. *Storage*:

5·1. The cement shall be stored in such a manner as to permit of easy access for proper inspection and in a suitable weather-tight building to protect the cement from dampness and to minimize ware house deterioration.

6. *Manufacturer's certificate*:

6·1. The manufacturer shall satisfy himself that the cement conform to the requirements of this standard, and if requested, shall furnish a certificate to this effect to the purchaser or his representative.

7. *Basis of purchase*:

7·1. The purchaser shall specify the type or types of cement desired. When no type is specified, the requirements of ordinary Portland cement shall govern.

8. *Delivery*:

8·1. The cement shall be packed in bags (gunny, multi-ply paper or cloth) bearing the manufacturer's name or his registered trade-mark, if any.

8·1·1. The bags or packages may also be marked with the I.S.I. Certification Mark.

8·2. The net weight of each bag shall be 50 kg. The permissible tolerance on the weight of cement supplied in bags shall be + 2·5 per cent per bag with an overall tolerance of ± 0·5 per cent per wagon load of 20 to 25 tonnes.

NOTE.—The weight of a gunny bag to hold 50 kg. of cement is about 500 to 550g and the weight of a 6-ply paper bag to hold 50 kg. of cement is approximately 400 g.

8·3. Supplies of cement in bulk may be made by arrangement between the purchaser and the supplier (manufacturer or stockists).

9. *Sampling*:

9·1. *Samples for testing and by whom to be taken*.—A sample or samples for testing may be taken by the purchaser or his representative, or by any person appointed to superintend the work for purpose of which the cement is required or by the latter's representative. The samples shall be taken within one week of delivery and the tests shall be made within four weeks of delivery.

9·2. Notwithstanding the requirements of 9·1 the methods and procedure of sampling shall be in accordance with I.S. : 3535-1966.

9·3. *Facilities for sampling and identifying*.—The manufacturer or supplier shall afford every facility, and shall provide all labour and materials for taking and packing the samples for testing the cement and for subsequent identification of the cement sampled.

10. *Tests*:

10·1. The sample or samples of cement for test shall be taken as described in 9 and shall be tested in the manner described in the relevant clauses.

10·2. *Temperature for testing*.—The temperature range within which physical tests may be carried out should, as far as possible, be 27° ± 2°C.

10·3. *Consistency of standard cement paste*.—The quantity of water required to produce a paste of standard consistency, to be used for the determination of the water content of mortar for the compressive strength tests and for the determination of soundness and setting time, shall be obtained by the method describedin I.S. 4031 +.

10·4. *Non-compliance with tests*.—Any cement which does not comply with any of the tests and analysis specified above, or which has not been stored in the manner provided in 5·1 may be rejected as not complying with this standard.

10·5. *Independent testing*:

10·5·1. If the purchaser or his representative requires independent tests, the samples shall be taken before or immediately after delivery at the option of the purchaser or his representative, and the tests shall be carried out in accordance with this standard on the written instructions of the purchaser or his representative.

10·5·2. *Cost of testing*.—The manufacturer shall supply, free of charge, the cement required for testing. Unless otherwise specified in the enquiry and order, the cost of the tests shall be borne as follows:

(*a*) By the manufacturer in the event of the results showing that the cement does not comply with this standard, and

(*b*) By the purchaser in the event of the results showing that the cement complies with this standard.

10·5·3. After a representative sample has been drawn, tests on the sample shall be carried out as expeditiously as possible.

EXTRACT FROM I.S. : 1791—1968.

Specification for batch type concrete mixers.

2. *Terminology*:

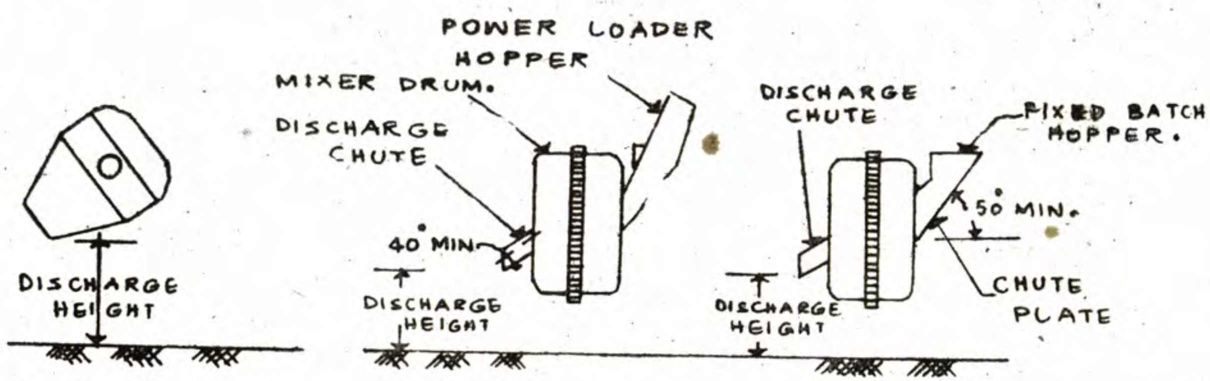
2·0. For the purpose of this standard, the following definitions shall apply. The nomenclature of the parts of concrete mixers is illustrated in Fig. 1.

2·1. *Free-Fall Mixer* (*Drum Type*).—A free-fall mixer having a drum with a series of blades fitted internally, which rotates about a horizontal or inclined axis. The mixing action is achieved by causing each part of the mix to be lifted in turn as the drum rotates and at a certain point in each revolution allowing it to be dropped or directed towards the bottom of the drum where it combines with other parts of the mix in continuously changing sequence to form a homogeneous mix. The free-fall mixer is generally of the following types—

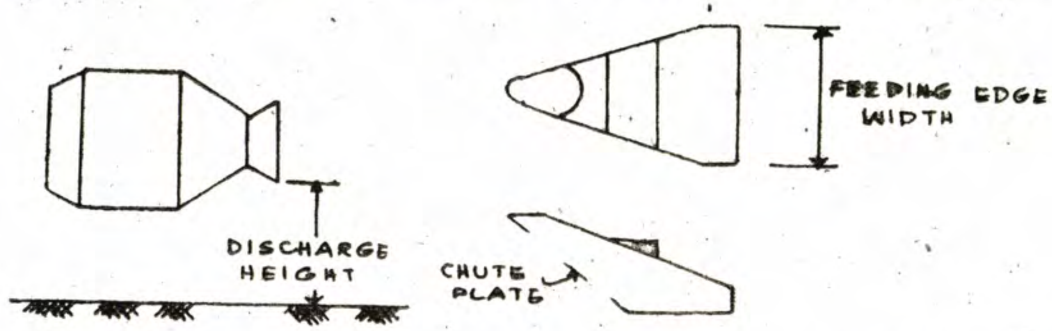
(*a*) *Tilting Type*—The free-fall mixer in which the drum has an inclinable axis and is a single compartment.

(*b*) *Non-tilting Type*.—The free-fall mixer in which the drum rotates in one direction on a horizontal axis and comprises a single compartment drum having two openings.

(*c*) *Reversing Drum Type*.—The free-fall mixer in which the drum rotates on a horizontal axis, the direction being reversed to discharge.



1A. TILTING DRUM MIXER. 1B. NON-TILTING DRUM MIXER.



1C. REVERSING DRUM MIXER 1D. POWER LOADER HOPPER.

FIG. 1. DIAGRAM INDICATING NOMENCLATURE OF CONCRETE MIXER.

2·2. *Forced action mixer*.—(Pan Type).—A forced action mixer has pan (or trough) having blades (or paddles) moving relatively, one to the other. The mixing action is accomplished by the relative movements between the mix, the pan (or trough) and the blades. (or paddles).

2·3. *Datum ground level*.—The level on which the road wheels stand, or if rail wheels are fitted, the level of the top of the rail.

2·4. *Loading point*.—The loading point is used to establish the loading height above the datum ground level and is that point to which material should be raised in order to commence changing the loading skip or mixer itself, as applicable.

2·5. *Discharge point*:

2·5·1. In a tilting mixer, the lowest point of drum opening, when the drum is tilted to the highest position at which it will effectively discharge its batch.

2·5·2. In a non-tilting mixer, the lowest point of the standard movable discharge chute when in its discharge position or the lowest point of a standard fixed chute extension, if fitted.

2·5·3. *In Reversing drum type*.—The lowest point of the discharge opening, or the lowest point of the standard fixed chute extension, if fitted.

2·6. *Water measurement*.—

2·6.1. *Automatic water tank*.—A tank which, on manipulation of a valve, is filled by and discharges a predetermined quantity of water, according to a predetermined setting, without reference to a gauge indicating the water level.

2·6·2. *Water meter*.—A meter which measures the amount of water entering a mixer where it is controlled by a valve operated either manually or automatically.

2·7. *Transportability*.

2·7·1. *Stationery mixer*.—A mixer not provided with wheels and usually built into a mixing plant.

2·7·2. *Portable mixer*.—A mixer fitted with a simple form of wheels.

2·7·3. *Trailer mixer*.—A mixer fitted with road wheels so that it can travel or be towed efficiently and safely at maximum statutory speed.

2·8. *Normal batch capacity*.—The volume in cubic metre of mixed concrete which can be held and mixed satisfactorily in one batch.

3. *Designation of size and type*.

3·1. The size of a batch type concrete mixer shall be designated by the number representing its nominal batch capacity in litres together with the letter T to indicate the tilting type, the letters NT to indicate non-tilting type or the letter R for the reversing type. Thus a mixer having a nominal batch capacity of 200 litres will have the designation 200 T if it is of tilting type, 200 NT if it is of the non-tilting type, or 200 R if it is of reversing type.

4. *Sizes*.

4·1. Concrete mixers shall be of the following sizes :—

(*a*) *Tilting Type*.—85 T, 100 T, 140 T, and 200 T.

(*b*) *Non-tilting Type*.—200 NT, 280 NT., 340 NT, 400, NT and 800 NT.

(*c*) *Reversing Type*.—200 R, 280 R, 340 R, 400 R.

4·1·1. *Margin of capacity*.—Mixers, when operating on leve shall be capable of holding and mixing an actual mixing batch 10 percent in excess of the nominal mixed batch capacity laid down in 4·1.

4·2. Sizes other than those specified in 4·1 may be supplied by mutual agreement between the purchaser and the supplier.

5. *Drum*.

5·1. The size of the drum shall be such that the ratio of the total interior drum volume (geometric solid) to the nominal size of the mixer is not less than the appropriate value given in Table 1.

5·2. The quality of material used in the construction of mixing drum and minimum thickness of drum for various sizes of concrete mixer shall be as follows :

TILTING TYPE MIXER.

Size of mixer litres.	*Minimum Thickness of Shell and quality of material.*	
	Upper conical portion of mixer drum.	*Lower portion of the mixer drum.*
(1)	(2)	(3)
85 100 140 200	3·15 mm. thick steel sheet conforming to grade St-34-1079 of I.S. 1079-1963*.	12 mm. thick cast iron conforming to grade 30 of I.S. 210-1962† or hot rolled carbon steel.

NON-TILTING TYPE MIXERS
OR
REVERSING DRUM MIXERS.

Size of the Mixer. litres.	*Minimum thickness of steel and quality of material.*
(1)	(2)
200	3·15 mm. thick steel sheet conforming to grade St-34-1079 of I.S. 1079-1963*.
280 340 400	6 mm. thick steel plate conforming to I.S. 226-1962 ‡ or I.S. 1977-1962£.
800	10 mm. thick steel plate conforming to I.S. 226-1962 ‡ or I.S. 1977-1962£.

5·3. *Drum speed*.—The manufacturer shall indicate the drum speed at which the mixer should be normally operated to give optimum performance (see 25).

5·3·1. If so desired by the purchaser, a revolution counter may also be provided for guiding the operator.

6. *Water System*.

6·1. Unless otherwise specified one or other of the types of water measuring device described in 7and 8,withthe fittings shall be supplied with each mixer of 200 litres size or larger. Where specified by the purchaser, the system and all associate equipment shall operate satisfactorily with water of any temperature upto 90° C. The system shall be manually operated or automatic as specified. The water measurements shall be expressed in litres. Provision shall be made to facilitate the checking of the accuracy of water system.

TABLE 7—MINIMUM RATIO OF DRUM VOLUME TO NOMINAL SIZES FOR THE PREFERRED SIZE OR FREE-FALL MIXER

(Clause 5·1.)

Nominal size of mixer T, NT or R) Litres.	Minimum ratio of drum volume of size..		
	Tilting type.	*Non-tilting type.*	*Reversing type.*
(1)	(2)	(3)	(4)
85	2·5	..	..
100	2·5	..	..
140	2·5	..	..
200	2·5	4·0	4·5
280	..	4·0	4·5
340	..	4·0	4·4
400	..	3·9	4·3
800	.	3·8	..

7. *Water Tanks.*

7·1. The tanks shall be capable of holding and delivering at leaste the quantities of water specified in Col. 2 of Table 2. The gauge or other device for indicating the quantity of water in or leaving the Tank shall be accurate to within + 3 per cent of the indicated quantitvabove the minimum quantity of water shown in Column 3 of Table 2.

TABLE 2—CAPACITY OF TANKS AND INCREMENT OF DISCHARGE.

(*Clauses* 7·1, 7·2 *and* 11·1.)

Size of the mixer (T, NT or R) Litres.	*Minimum capacity of tanks liitres.*	*Automatic tanks only.*	
		Minimum initial discharge.	*Increment of discharge.*
(1)	(2)	(3)	(4)
200	35	7	1
280	55	10	1
340	65	10	1
400	75.	15	1
800	150	25	2

7·2. Automatic tanks shall be capable of delivering the minimum quantity of water shown in Column 3 of Table 2, and any quantity between this and the total capacity in increments as shown in Column 4 of Table 2. The scale should be graduated in increments as shown in Column 4 of Table 2. The quantity delivered shall not vary from the predetermined quantity by more than +3 per cent of the indicated quantity above the minimum quantity of water shown in column 3 of Table 2. The gauge or other cevice shall be so positioned that it can be conveniently read by the operator.

7·3. Measuring tanks, whether automatic or non-automatic and their fittings, shall be such that the total time-cycle for feeding the tank under the lowest pressure specified in 9.1 with the quantities specified in Column 2 of Table 2, and for discharging these quantities into the mixer, does not exeed two minutes and the time for discharging these quantities shall not exceed half of the manufactureis stated mini mummixing time.

7.4. If specified by the purchaser, a device of a type agreed to between the purchaser and the manufacturer for locating the discharge setting of the automatic tank shall be provided on mixers above 280–litre size.

EXTRACT FROM : I.S. 3370 (PART III)– 1967.

Code of practice for concrete structures for the storage of liquids.

PART III—PRESTRESSED CONCRETE STRUCTURES.

3. *Design* :

3.1. *General* : Provisions shall be made for all conditions of stresses that may occur in accordance with the principles of mechanics; recognised methods of design and sound engineering practice. In particular, adequate consideration shall be given to the effects of monolithic construction in the assessment of bending moments and shear.

3.1.1. Before taking up the detailed design the designer should satisfy himself on the correct estimation of loads and on the adequate statical equilibrium of the structure, particularly in regard to safety against over-turning of overhanging members; in the latter case the general arrangement should be such that statical equilibrium should be satisfied even when the overturning moment is doubled.

3.2. *Basis of design* :

3.2.1. General basis of design shall be in line with the recommendations of I. S. 1343-1960 + except where otherwise specified in this Code. The members other than those specified in 3.22. shall be designed in accordance with the requirements of I.S. 1343– 1960*.

3.2.2. The design of members in contact with the liquid on any face or enclosing the space above the liquid shall be based on consideration of adequate resistance to cracking as well as adequate strength and the following basic requirements, should also satisfied :

(a) The computed stresses in the concrete and in the steel shall not exceed the permissible stresses given in 3.3 and 3.4 during transfer, handling and construction, and under working loads.

(b) Cracking of the liquid retaining face should be entirely avoided. The liquid retaining face should be checked against cracking with a load factor [that is the ratio of the total (dead +live) load at cracking to the total (dead + live) working load] of 1.2.

(c) In estimating the resistance to cracking, the stresses in any cross-section should be calculated as for a homogeneous material, making allowance for all losses in steel tension.

(d) The ultimate load at failure (dead + live) should not be less than twice the working (dead + live) load

(e) Where found necessary provision should be made by suitable joints or otherwise to allow for elastic distortions of the structure during the process of prestressing.

3.2.3. For cylindrical tanks, additional requirements as specified in 7.1 should also be satisfied.

3.3. *Permissible stresses in concrete* :

3.3.1. The permissible stresses in the concrete due to prestressing operations and working loads, and the modulus of elasticity of concrete shall be as specified in I.S. 1343-1960.

3.3.2. For estimation of resistance to cracking, the limiting tensile strength of concrete shall be assumed to have the values specified in Table 1.

TABLE : LIMITING TENSILE STRENGTH OF CONCRETE FOR ESTIMATION TO RESISTANCE TO CRACKING IN PRESTRESSED CONCRETE MEMBERS.

Minimum work cube (15 cm side) strength of concrete at 28 days Kg./cm.²	*Direct tensile strength kg/cm.²*	*Bending tensile strength kg./cm.²*
(1)	(2)	(3)
350	16	32
400	17	34
450	18	36
500	19	38
550	20	40
600	21	42
650	22	43

3.4. *Permissible stresses in steel* :

3.4.1. The permissible stresses in prestressing steel and the modulus of elasticity of steel shall be as specified in I.S. 1343–1960.

3.4.2. Where circumferential wires or bars are tensioned by means of jacks, the losses due to friction may be found by reducing the o-efficient of friction to 80 per cet of that given in I.S. 1343–1960.

3.5. *Shrinkage and creep of concrete* : The provision regarding shrinkage and creep shall comply with the requirements of I.S. 1343–1960.

3.5.1. Where reservoirs are protected with an internal impermeable lining consideration should be given to the possibility of concrete eventually drying out. Unless the engineer is satisfied that the lining has sufficient creak-bridging properties, allowance for the increased effect of drying shrinkage should be made in the design.

3.6. *Losses in prestress* : While assessing the stresses in concrete and steel during tensioning operations and later in service, due regard shall be paid to all losses and variations in stress resulting from creep of concrete and steel, the shrinkage of concrete, the shortening of concrete at transfer, friction and slip of anchorage. Requirements in this respect specified in I.S. 1343–1960 shall be complied with.

4. *Floors* :

4.1. *Provision of movement joints* : Movement joints shall be provided in accordance with 8 of I.S. 3370 (Part I)—1965.

4.2. *Floors of tanks resting on ground* : If the tank is resting directly on ground its floor may be constructed of concrete with the nominal percentage of reinforcement (not less than 0.15 per cent of gross cross-sectional area of concrete) provided that it is establishes that the ground will carry the load without appreciable subsidence in any part and that the concrete floor is cast in panels not more than 4.5 metres square with contraction or expansion joint between. In such cases a screed layer of concrete not less than 75 mm thick shall first be placed on the ground and covered over with a sliding layer of bitumen paper or other suitable material to destroy the bond between the screed and floor concrete.

4.2.1. Under normal circumstances the screed layer shall not be o grade not leaner than M 100 specified in Table 3 of I.S. 456-1964 where injurious soils or aggressive water are expected, the screeded layer shall be of grade not leaner than M 150 specified in Table 3 of I.S. 456-1964 and if necessary a sulphate resisting or other special cement should be used.

5. *Walls* : Provision of Joints :

5.1. *Provision of joints* :

5.1.1. *Sliding joint at the base of the wall.*—Where it is desired to allow the wall to expand or contract separately from the floor, or to prevent moments at the base of the wall owing to its fixity with the floor, sliding joints may be employed.

5.1.1.1. Considerations effecting the spacing of vertial movements joints are discussed in 8 of I.S. 3370 (Part I)—1965. While the majority of these joints may be partial or complete contraction type sufficient joints of the expansion type should be provided to satisfy the requirement of 8 of I.S. 3370 (Part I)—1965.

5.2. *Effect of earth pressure* : When a reservoir walls is built in the ground or has earth embanked against it, relief in bending moment due to simultaneous action of water pressure inside the wall and earth pressure outside the wall may be made, provided that.

(a) there is no risk of slip in the embankment or fear of a reduction in the earth pressure arising from shrinkage or other cases ; and

(b) the earth pressure allowed by way of relief in the bending moment caused, by internal water pressure would be the minimum which can be relied upon under the most unfavourable conditions possible, including those under which the reservoir is to be tested for watertightness.

6. *Roofs.*

6.1. *Provision of Movement Joints.*—To avoid the possibility of sympathetic craking, it is important to ensure that movement of joints in the roof correspond with those in walls, if roof and walls are monolithic. If provision is made by means of a sliding joint for movement between the roof and the wall, correspondance of joints is not so important.

6.2. *Loading.*—Fixed covers of tanks should be designed for gravity loads, such as the weight of roofs slap, earth cover, if any, ive loads, and mechanical equipment. They should also be designed for upward load, if the tank is subjected to internal gas pressure.

6.2.1. A superficial load sufficient to ensure safety with the unequal intensity of loading which occurs during the placing of the earth cover should be allowed for in designing roofs. The engineer should specify a loading under these temporary conditions which should not be exceeded. In designing the roof, allowance should be made for the temporary condition of some spans loaded and other spans unloaded, even though in the final state the load may be small and evenly distributed.

6.2.2. In tanks having fixed or floating covers the gas pressure developed above liquied surface shall be added to liquid pressure.

6.3. *Watertightness.*—In case of tanks intended for the storage of water for domestic purposes, the roof shall be made watertight. This may be achieved by limiting the stresses as for the rest of the tank, or by the use of a covering of waterproof membrane or similar other fficient means.

6.4. *Protection against corrosion.*—Protective measures shall be provided to the underside of the roof to prevent it from corrosion due to condensation, or alternatively, the underside of the roof shall be designed as a liquid retaining face, particular care being taken that the stipulations regarding minimum cover to reinforcement are adhered to.

7. *Cylindrical tanks.*

7.1. *Stresses.*—In the design of prestressed concrete cylindrical tanks the following stresses in steel and concrete after allowing for all losses should be investigated and their values should be within the limits prescribed in 3.3 and 3.4 except where otherwise specified below :—

(*a*) Maximum tensile stress in hoop steel or longitudinal steel at working load should not exceed the limits specified in 3.4.

(*b*) The principal compressive stress in concrete should not exceed one-third of the specified works cube strength.

(*c*) The average shear stress on the gross section of the concrete should not exceed 1/50 of the specified works cube strength.

(*d*) When the tank is full there should be a compression in the concrete at all points of at least 7 kg./cm².

(*e*) When the tank is empty, there should at no point be a tensile stress greater than 10 kg./cm². Where the tank is to be emptied and filled at frequent intervals, or may be left empty for a prolonged period, it is desirable to design the tank so that there is a residual compression when the tank is empty as well as when full.

7.2 The base of the wall may be designed either fixed with the floor or as sliding or hinged at the junction with the floor.

7.2.1. Except in case of unyielding solid rocky sub-grade, care should be taken to minimize the danger or local settlement. This can be done by designing the floor as a thin membrane and by providing a foundation ring under the wall.

7.3. When at the base of the wall, hinged or sliding conditions prevail :

(*a*) any advantage offered by the restraining effects should be ignored, and

(*b*) the moments in the region of the wall base in the direction parallel to axis of the tank (usually vertical) caused by the restraining effects of prestressing at the wall base should be counted for. Values given in tables in I.S. 3370 (Part IV) may be helpful to assess these moments.

7.4. The ring prestressing should be designed in all cases on the assumption that the wall-foot is free to slide without frictional resistance. When the foot of the wall is free to slide, a longitudinal moment should be assumed on the basis of a restraint equal to one-half of that provided by a pinned foot. In other cases, the longitudinal moment should be assessed on the actual degree of restraint at the wall-foot.

7.5. Allowance should be made for the longitudinal moments induced by the transverse stressing in the partially wound condition. The maximum value of the flexural stress in the longitudinal section from this cause may be assumed to be numerically equal to 0.3 times the ring compression stress.

7.6. Prestressing should be provided in the transverse and longitudinal cross-section so as to contain these effects within the critical stresses specified.

7.7. Prestressing wire may be placed outside the wall a generally, provided this is protected with pneumatic mortar to provide 40 mm cover over the wire. In malignant atmospheres, such as in heavy industrial areas or near the sea the cables should be placed inside the walls and ground.

7.8 When the stressing of the prestressing wires is proposed to be carried out with wires in position, anchorages may advantageously be staggered and placed at suitable points of the cylinder with a view to offsetting the heavy frictional losses.

7.9 The worst conditions of stresses resulting from the pressure of contained liquid, surrounding pressure, if any, temperature, shrinkage, restraint from roof, etc., should be considered.

7.10. Necessity or prestressing the cylinder wall in the direction of the axis of the cylinder (vertical) should always be investigated.

7.11. Longitudinal prestressing may be replaced with a reinforced concrete section satisfying the requirements of I.S. 3370 (Part II) 1965.

EXTRACT FROM I.S. 432 (PART I)—1966.

Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement.

Part I.—Mild steel and medium tensile steel bars (second revision) .

3. *Types and grades.*

3.1. Reinforcement supplied in accordance with this standard shall be classified into the following types:—

(*a*) Mild steel bars, and

(*b*) Medium tensile steel bars.

3.1.1. Mild steel bars shall be supplied in the following two grades:—

(*a*) Mild steel bars, Grade I ; and

(*b*) Mild steel bars, Grade II.

5. *Freedom from defects.*

5.1. All finished bars shall be well and cleanly rolled to the dimensions and weights (*see* 7.1.1.2.) specified herein; they shall be sound and free from cracks, surface flaws, laminations and rough jagged and imperfect edges and other defects, and shall be finishing in a workman like manner.

6. *Nominal sizes.*

6.1. *Bars.*—Mild steel and medium tensile steel bars shall be supplied in the following nominal sizes :—

Diameter of round bars or side of square bars.	5, 6, 8, 10, 12, 16, 20, 22, 25, 28, 32, 36, 40, 45 and 50 mm.

7. *Tolerance.*

7.1. *Rolling tolerance.*—The rolling tolerance shall be as specified in 7.1.1 and 7.1.2. which are in accordance with I.S. 1852-1962.

7.1.1. *Bars in straight length.*

7.1.1.1. *Size.*—The tolerance on size, which is diameter in the case of round bars or side width in the case of square bar shall be as given below :—

Nominal size.	*Tolerance.*	*Total margin*
(1)	(2)	(3)
For bars upto and including 25 mm.	±0.5	1.0. mm.
For bars above 25 mm.	±0.75	1.5. mm.

7.1.1.1.2. *Weight.*—The tolerance on weight for round and square bars shall be the following percentage of the weight calculated on the basis that steel weight 0.785 kg./cm², cross sectional area per metre run. (The weights are given in Tables 2 and 3 of I.S. 1732–1961. The relevant extract is reproduced in Appendix A).

Nominal size.	*Tolerance on calculated weight.*	*Total margin.*
(1)	(2)	(3)
Upto and including 8.0 mm... ..	± 4 per cent.	8 per cent.
Over 8.0 mm.	±2.5. per cent	5 per cent.

7.1.2. *Coiled rounds and squares.*

7.1.2.1. *Size.*—The tolerance on size diameter in the case of coiled found bars and side with in the case of coiled square bar, shall be as follows :—

Nominal size.	*Tolerance. (See Note).*	*Total margin.*
(1)	(2)	(3)
Upto and including 12 mm... ..	±0.5 mm.	1 mm.

NOTE.—Measurement shall be taken at a point sufficiently away from the ends ensuring exclusion of heavy ends.

7.1.2.2. *Out of shape.*—The difference between the maximum and minimum diametres in the case of coiled round bar and between the two adjoining sides in the case of coiled square bar, at any cross section, shall not exceed 0.65 mm.

NOTE.—The weight tolerance is applicable in the case of coiled round and square bars.

7.2. *Cutting tolerance on length.*—The cutting tolerance on length shall be as specified below :—

(*a*) When the specified length is not stated to be either a maximum or a minimum. —25 mm. +75 mm.

(*b*) When the minimum length is specified .. +75 mm.

(*c*) When the maximum length is specified .. —50 mm.

8. *Physical requirements.*

8.1. *Mild steel aud medium tensile steel bars.*—The ultimate tensile stress, yield stress and percentage elongation when determined in accordance with 9.2 shall be as given in Table 1.

8.2. The bars shall also withstand the bend test specified in 9.3.

9. *Tests.*

9.1. *Selection and preparation of test samples.*—Unless otherwise specific in this standard, the requirements of I.S. : 226–1962.

466—3—16A

9.1.1. All test pieces of bars shall be selected by the purchaser or his authorized representative, either—

(*a*) from the cutting of bars, or

(*b*) if he so desires, from anybar or the coil, after it has been cut to the required or specified length and the test piece taken from any part of it.

TABLE 1—MECHANICAL (TENSILE) PROPERTIES OF BARS
(*Clause* 8.1)

Serial number and property.	*Nominal size of bars.*	*Mild steel.* Grade I.	Grade II.	*Medium tensile steel.*
(1)	(2)	(3)	(4)	(5)
(i) Ultimate tensile stress, kg./mm², Min.	All sizes	42	38	55
(ii) Yield stress, kg./mm2 Min.	For bars upto and including 20mm..	26	23.5	36
	For bars over 20mm. upto and including 40mm.	24	21.5	34
	For over 40 mm.	24	21.5	35
(iii) Elongation, per-cent, min. on gauge length 5.65.	For bars under 10 mm.	20	20	17
So where so is the cross sectional area of the test piece.	For bars 10 mm. and over.	23	23	20

9.1.1.1. In neither case, the test piece shall be detached from the bar or the coil, except in the presence of the purchaser or his authorised representative.

9.1.1.2. Before test pieces are selected, the manufacturer or the supplier shall furnish the purchaser or his authorised representative with copies of the mill records giving the number of bars in each cast with sizes as well as the identification marks whereby the bars from their cast or each coil can be identified.

9.2. *Tensile Test.*—The ultimate tensile stress, yield stress and elongation of bars shall be determined in accordance with the requirements of I.S. 1608—1960 read in conjuction with I.S. 226—1962. The test pieces shall be cut from the finished material and straightened where necessary. They shall not be annealed or otherwise subjected to heat treatment. Any slight straightening which may be required shall be done cold.

9.3. *Bend Test.*—The bend test shall be performed in accordance with the requirements of I.S. 1559—1961 read in conjuction with I.S. 226—1962.

9.4. *Re-test.*—Should any one of the test pieces first selected fail to pass any of the test specified in this standard, two further samples shall be selected for testing in respect of each failure. Should the test pieces from both these additional samples pass, the material represented by the test samples shall be deemed to comply with the requirements of that particular test. Should the test piece from either of these additional samples fail, the material represented by the test samples shall be considered as not having complied with this standard.

APPENDIX A.

(*Clause* 7.1.1.2.)

WEIGHTS OF ROUND AND SQUARE BARS.

A.1. The weights per metre of round and square bars in Kilograms calculated on the basis that steel weight 0.78 5kg./cm.2 cross-sectional area per metre run and rounded off to one decimal place in kg. are given in Tables 2 and 3.

TABLE 2—WEIGHTS OF ROUND BARS PER METRE RUN.

Nominal Diametrer. (1)	*Weight per metre run.* (2)	*Nominal diameter.* (3)	*Weight per metre run.* (4)
mm.	*kg.*	*mm.*	*kg.*
5	0.2	25	3.8
6	0.2.	28	4.8
8	0·4	32	6.3
10	0.6	36	8.0
12	0·9	40	9.9
16	1.6	45	12.5
20	2.5	50	15.4
22	3.0		

TABLE 3—WEIGHTS OF SQUARE BARS PER METRE RUN

(*Clause A* 1).

Nominal size. mm. (1)	*Weight per metre run.* (2)	*Nominal size mm.* (3)	*Weight per metre run.* (4)
	kg.		*kg.*
5	0.2	25	4.9
6	0.3	28	6.1
8	0.5	32	8.0
10	0.8	36	10.2
12	1.1	40	12.6
16	2·0	54	16.0
20	3.1	60	19.6
22	3.8		

EXTRACT FROM I.S. 432 (PART II 1966).

Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement.

Part II—Hard Drawn Steel Wire (Second Revision)

4. *Freedom from defects—*

4.1. All finished wire, subject to the provisions of 7 shall be cleanly drawn to the specified size and shall be sound, free from splits, surface flaws and other defects likely to impair its usé for concrete reinforcement, and finished in a workman like manner.

5. *Nominal sizes—*

5.1· Hard -drawn wire shall be supplied in the following nominal sizes.

Diameters of hard drawn wire.—2.65, 3.15, 3.555, 4.0, 4.5., 4.75, 5.3, 5.6, 6.3, 7.1,7.5 , 8.0, 9.0, 9.5, and 10 mm.

6. *Tolerances—*

6.1. The tolerance on the nominal diameter shall be + 2 per cent. or 1 per cent.

6.1·1. For purposes of determining whether the actual diameter of the wire is within the specified tolerance, the diameter shall be determined with a micrometer by taking two measurements at right angles to each other at three places at length of not less than 250 mm. and the average of these six measurements shall be taken as the diameter of the wire.

6.2. Cutting tolerances on length—Cutting tolerance for wire shall be as follows :—

Length.	*Tolerance.*
Over 3 m.	— 13mm.
Less than 3 m.	— 6 mm.

7. *Physical requirements—*

7.1. The ultimate tensile stress, proof stress and elongation of the wire when tested in accordance with 8.2 shall not be less than the following values—

(*a*) Ultimate tensile stress, kg./mm2	58
(*b*) Proof stress (0.2 per cent) kg./mm²	49
(*c*) Elongation over a gauge length of 8 D. (Dis. the dia. of wire) per cent.	7

7.2. The wire shall also withstand the bend test specified in 8.3.

8.2. Tensile test.—The ultimate tensile stress, proof stress and elongation of wire shall be determined in accordance with I.S. 1521—1960. The test pieces shall be cut from the finished material and straightened, where necessary. The test pieces shall not be annealed or otherwise subjected to heat treatment. Any slight straightening which may be required shall be done cold.

8.2.1. One tensile test shall be made for every 5 mt. or less in any parcel of wire.

8.3. Bend Tests.—Reverse bend test shall be made on a test piece cut from the finished product. The test pieces shall not be annealed or subjected to any heat treatment before testing. The test piece shall withstand one complete cycle of reverse bend without showing any signs of fracture when reverse bend test is carried out in accordance with the requirements of I·S. 1716—1960.

8.3·1. One reverse bend test shall be made for every 5 metric tonnes or less in any parcel of wire.

8.4. Re-tests—Should any one of the test pieces first selected fail to pass any of the tests specified in this standard, two further samples shall be selected for testing in respect of each failure. Should the test pieces from both these additional samples pass, the meterial represented by the test samples shall be deemed to copy with the requirements of that particular test. Should the test piece from either of these additional samples fail, the material represented by the test samples shall be considered as not having complied with this standard.

EXTRACT FROM I.S. 1139—1966.

Specification for hot rolle.l mild steel medium tensile steel, high yeild strength steel deformed bars for concrete reinforcement (Revised).

3. *Types—*

3.1. Reinforcement supplied in accordance with this standard shall be classified into the following types :—

(*a*) Mild steel deformed bars, and

(*b*) Medium tensile steel deformed bars.

5. *Deformations—*

5.1. The deformations shall be spaced along the bar at substantially uniform distances, the deformations on opposite sides of the bar shall be similar in size and shape.

6. *Freedom from defects—*

6.1. All finished bars shall be rolled to the dimensions, deformations and weights specified or required. They shall be sound and free from cracks, harmful surface flaws, laminations, rough and imperfect edites and all other defects, and shall be finished in work manlike manner.

7. *Weight—*

7.1. The weight of the bars shall be calculated on the basis that steel weighs 0.785 kg./cm.2 of cross-sectional area per metre run, taking into account that the nominal size of a deformed bar is equivalent to the diameter or side of a plain bar having the same weight per metre length. The weight thus calculated shall be checked against the actual weight of the deformed bar obtained by weighing a lenght of the bar one metre long.

8. *Tolerances—*

8.1. *Tolerance on weight.*—The ftolerance on weight for round snd square bars shall be the following percentage of the weight calculated as in 7.1.

Nominal size mm.	*Tolerances on calculated weight.*	*Total margin.*
(1)	(2)	(3)
Upto and including 8.0	± 4 per cent ..	8 per cent.
Over 8.0 ..	± 2.5 per cent ..	5 per cent.

8.2. *Cutting tolerance on length.*—Cutting tolerance for bars shall be as follows :—

(*a*) When the specified length is not stated to be either a maximum .. (—) 25mm (+) 75mm.

(*b*) When the minimum length is specified .. (+) 75 mm

(*c*) When the maximum length is specified .. (—) 50 mm.

9. *Physical requirements—*

9.1. The tensile strength, yeild stress and percentage elongation of bars when determined in accordance with 10.2 shall be as given in Table 1.

TABLE 1. PHYSICAL PROPERTIES OF DEFORMED BARS (CLAUSE 9.1.)

Serial number and property.	*Nominal size of bars.*	*Mild steel bars.*	*Medium tensile steel bars.*	*High yield strength steel bars.*
(1)	(2)	(3)	(4)	(5)
(i) Tensile strength kgf./mm^2, Min.	All sizes.	42	55	15 per cent greater than the measured yield stress.
(ii) Yield stress, kgf./mm^2 Min.	For bars upto and including 20mm.	26	36	42.5
	For bars over 20mm. upto and including 40mm.	24	34.5	42.5
	For bars over 40mm.	24	35	42.5
(iii) Elongation, per cent, Min. on guage length 5.65 So, where So is the Cross-sectional area All sizes of the test piece.	1	23	20	14.5

9.2. The bar shall withstand bend test specified in 10.3.2. rebend test specified in 10.4.

10.2. *Tensile test.*—The ultimate tensile stress yield stress and elongation of bars shall be determined in accordance with requirements of I.S. 1608–1960 read in Conjunction with I.S. 226-1862.

10.3. *Bend test.*—The bend test shall be performed in accordance with the requirements of I.S. 1590–1960 at read in conjunction with I.S. 226-1962.

10.4. *Rebend test.*—The test bar shall be bent to an included angle of 135 degree using a mandrel of appropriate diameter (*See* 10.4.1.) The bent bar shall be aged by keeping in boiling water (100 degree C) for 30 minutes and then allowed to cool. The bar shall then be bent back to have an included angle of 157 degrees. The specimen shall be considered to have passed in test, if there is no fracture in the bent portion.

10.4.1. The diameter of the mandrel shall be as below :—

Nominal size of the bar specimen.	*Diameter of mandrel.*
(1)	(2)
Upto 10 mm.	5d.
Over 10mm.	7d.

Where d is the nominal size in mm. of the test piece.

10.5. *Retest.*—Should any one of the tensile test pieces first selected fail to pass any of the tests specified in this standard, two further samples shall be selected for testing in respect of each failure. Should the test pieces from both these additional samples pass, the material represented by test samples shall be deemed to comply with the requirements of that particular test. Should the test piece from either of these additional samples fail, the material represented by the test sample shall be considered as not having complied with this standard,

EXTRACT FROM I.S. 456–1964.

Code of practice for plain and reinforced concrete .

(Second Revision.)

4.3. *Water.*—Water used for both mixing and curing shall be free from injurious amounts of deleterious materials. Potable waters are generally considered satisfactory for mixing and curing concrete.

4.3.1. Where water can be shown to the excess of acid, alkali or salt, the engineer-in-charge may refuse to permit its use. As a guide, the following concentration represent the maximum permissible values :—

(*a*) To neutralize 200 ml. sample it should not require more than 2 ml. of 0.1 Normal NaOH.

(*b*) To neutralize 200 ml. sample it should not require more than 10 ml. or 0.1 Normal HCI.

(*c*) Percentage of solids should not exceed the following :—

					Per cent.
Organic	..	..	..	..	0.02
Inorganic	..	..	..	..	0.30
Sulphates	..	..	..	..	0.05
Alkali chlorides	..	..	..	..	0.10

In case of doubt the engineer-in-charge may require that concrete mixed with water proposed to be used should not have a compressive strength, lower than 90 per cent of the strength of concrete mixed with distilled water.

4.4. *Admixture.*—Admixtures may be used in concrete only with the approval of the engineer-in-charge based upon evidence that, with the passage of time, neither the compressive strength of concrete is reduced by more than 10 per cent nor are other requisite qualities of concrete and steel impaired by the use of such admixtures. Calcium chloride should not be used. If the strength of the concrete is likely to be reduced within ten per cent with the passage of time, working stress should be reduced proportionately.

4.5. *Reinforcement.*—The reinforcement shall be,—

(*a*) mild steel and medium tensile steel bars and hard-drawn steel wire conforming to I.S. 432—1960 ;

(*b*) deformed bars conforming to I.S.I. 1139–1966

(*c*) cold twisted steel bars conforming to I.S. : 1786–1966

(*d*) hard-drawn steel wire fabric conforming to I.S. : 1566—1967, and

(*e*) structural steel sections conforming to I.S. : 226—1962

4.5.1. All reinforcement shall be clean and free from those mill-scales, dust, loose rust and coats of paints, oil or other coatings which may destroy or reduce bond.

4.5.2. Welded joints in reinforcement may be used but in all cases of important connections, tests shall be made to prove that the joints are of the full strength of bars connected. Welding of reinforcement shall be done in accordance with the recommendations of I.S. 2751–1966 Code of Practice for Welding of Mild steel Bars used for reinforced concrete construction. Special precautions are required in the welding of cold worked reinforcing bars.

4.5.3. *Effective diameter of a bar.*—For purposes of this code, the effective diameter of a reinforcement bar shall be calculated as below:–

(*a*) For a bar whose cross-sectional area is constant along its length (and deformed bars whose pattern of deformation is such that by visual inspection the cross-sectional area is substantially uniform along the length of the bar), the effective diameter is that of a circle having the same area as the cross-section of the bar.

(*b*) For a bar whose cross-sectional area varies along its length, the effective diameter is that of a circle having an area equal to the least area of any cross-section of the bar excluding deformation ribs. An allowance not exceeding 3 per cent may, however, be added to the least area of the cross-section on account of the ribs and/or any non-continuous sides.

4.6. *Storage of materials.*

4.6.1. The cement shall be stored at the work in such a manner as to prevent deterioration due to moisture or intrusion of foreign matter.

4.6.2. The aggregates shall be stored in such a way as to prevent the admixture of foreign materials. The heaps of fine and coarse aggregates shall be kept separate. When different sizes of fine or coarse aggregates are procured separately, they shall be stored in separate stock piles sufficiently removed from each other to prevent the material at the edges of the piles from getting intermixed.

4.6.3. Steel reinforcement shall ordinarily be stored in such a way as to avoid distortion and to prevent deterioration and corrosion. It is a good practice to coat reinforcement with cement wash before stacking to prevent scale and rust.

4.6.4. All materials shall be so stored as to prevent deterioration or intrusion of foreign matter and to ensure the preservation of their quality and fitness for the work. Any material which has deteriorated or has been damaged or is otherwise considered defective by the engineer-in-charge shall not be used for the concrete.

5. *Concrete.*

5.1. *Grades of concrete.*—The concrete shall be in seven grades designed as M100, M150, M200, M250, M300, M350 and M400.

NOTE.—In the designation of a concrete mix, letter M refers to the mix and the number to the specified 28 day works cube compressive strength of that mix expressed in kg./cm.2.

2. *Strength requirements of concrete* :

.2.1 Where ordinary portland cement conforming to I.S. 269-
3 or Portland blast-furnace slag cement conforming to I.S. 455-
2 is used, the compressive strength requirements for various les of concrete shall be as given in Table I. Where rapid-hardening tland cement is used, the 28-day compressive strength requirements cified in Table I shall be met at 7 days. Where other cements used, the engineer in-charge shall specify the corresponding uirements preferably on the basis of preliminary tests.

·2·2. The strength requirements specified in Table I shall apply both controlled concrete and ordinary concrete (see 5.3.1). Prelimi-y tests need not, however be made in the case of ordinary con-te.

5.2.2.1. In order to get a relatively quicker idea of the quality of ncrete, optional works tests on beams for modulus of rupture at ±2 hours or at 7 days or compressive strength tests at 7 days ay be carried out in addition to 28-day compressive strength tests, all cases, the 28-day compressive strength specified in Table I shall one be the criterion for acceptance or rejection of the concrete. , however, from tests carried out in a particular job over reasonably ng period, it has been established to the satisfaction of the engineer-charge that a suitable ratio between the 28-day compressive strength, id the modulus of rupture at 72±2 hours or 7 days or compressive rength at 7 days may be accepted. The engineer-in-charge may itably relax the frequency of 28-day compressive strengh test ecified in Table V, provided the expected strength values at the ecified early age are consistently met. For this purpose the values ven in Table II may be taken for general guidance in the case of oncrete made with ordinary cement.

5.2.3. Where the strength of a concrete mix as indicated by tests es in between the strength for any two grades specified in Table I, ich concrete shall be classified for all purposes as a concrete belonging the lower of the two grades between which its stregnth lies.

TABLE I.—STRENGTH REQUIREMENTS OF CONCRETE.

(*Classes* 5.2.1, 5.2.2, 5.2.2. and 5.2.3.). *All values in kg./cm²*,

Grade of concrete.	*Compressive strength of 15 cm. cubes at 28 days after mixing conducted in accordance with I.S. 516-1959.* Preliminary test Min.	Works test Min.
(1)	(2)	(3)
M 100	135	100
M 150	200	150
M 200	260	200
M 250	320	250
M 300	380	300
M 350	440	350
M 400	500	400

NOTE 1.—(*a*) Preliminary Test—A test conducted in a laboratory on the trial mix of concrete produced in the laboratory with the object of :—

(1) designing a concrete mix before the actual concreting operations start.

(2) determining the adjustments required in the designed mix when there is a change in the materials used during the execution of work, or

(3) verifying the strength of concrete mix.

(*b*) Works Test—A test conducted either in the field or in a laboratory, on the specimens made on the works, out of the concrete being used on the works.

NOTE 2.—(*a*) Size of Cub s—In the works test with the approval of the engineer-in-charge 10 cm., cubes may be used in place of 15 cm. provided the maximum nominal size of aggregate does not exceed 20 mm. Even the use of 15 cm should normally be restricted to concrete having a maximum nominal size of aggregate not exceeding 40 mm. Where concrete with aggregates larger than 40 mm. size is required to be tested, the size of cubes should be specfied by the engineer-in-charge keeping, in view that generally the length of side of the cube should be about four times the maximum nominal size of aggregate in the concrete cons ituting the cube specimen.

(*b*) Strength in Relation to size of the Cube.—Where 10 cm. cubes are used, the values obtained from tests on 10 cm. cubes shal be reduced to the extent established by comparative preliminary tests with 10 and 15 cm. cubes, or in the absence of such comparative tests, by 10 per cent of the value determined from the tests, in order, to give the equivalent strength for 15 cm. cubes. Where cubes larger than 15 cm. are adopted, generally to modification is necessary unless otherwise specified by the engineer-in-charge.

NOTE 3.—Cylinder Strength.—Compressive strength test may, with the approval of the engineer--in-charge be conducted on 15 cm. diameter and 30 cm. high cylinders in accordance with I.S. 516-1959 instead of an cubes. Where cylinder strength figures are adopted the compressive strength figures given above shall be modified according to the formula ;

Minimum cylinder compressive.

strength required 0.8 compressive strength specified for 15 cm. cubes.

The Central Road Research Institute, New Delhi, has carried out test with a view to establishing a relation between water-cement ratio and the compressive strength of concrete using ordinary Portland cement manufactured in the country in accordance with I.S. 269-1958.

As a result of these, it has been considered advisable to give graphs showing the relationship between the compressive strength of concrete mixes with different water-cement ratios and the 7-day compressive strength of cement tested in accordance with I.S. 269-1958. These graphs have been given in Appendix A as they would be of some assistance in obtaining the water-cement ratio for trial mixes of concrete.

5.3 *Proportioning and works control* :

5.3.1 Methods of proportioning.—The determination of the proportions of cement, aggregates and water to attain the required strength shall be made by one of the following :—

(*a*) With preliminary tests by designing the concrete mix, such concrete shall be called 'Controlled Concrete'.

(*b*) Without preliminary tests by adopting nominal concrete mixes, Such concrete shall be Ordinary Concrete.

5.3.2. *Controlled concrete*—

5.3.2.1. As far as possible controlled concrete should be used on all concrete work. Controlled conctere for use in plain and reinforced concrete structures shall be in grades M 100, M 150, M 200, M 250, M 300, M 350 and M 400.

TABLE II.

Optional Work Test Requirements of Concrete.

(*Clause* 5.2.2.1.)

(All values in Kg./cm.^{2})

(All tests conducted in accordance with I.S. 516-1959.)

Grade of concrete.	Compressive strength on 15 cm. Cubes Min at 7 days.	Modulus of rupture by beams Test Min. At 72+2 Hr.	At 7 days.
(1)	(2)	(3)	(4)
M 100	70	12	17
M 150	100	15	21
M 200	135	17	24
M 250	170	19	27
M 300	200	21	30
M 350	235	23	32
M 400	270	25	34

NOTE.—Notes 2 and 3 under Table I are also applicable to Table II.

5.3.2.2. The concrete mix shall be designed to have an average strength corresponding to the values specified for preliminary tets in Table I. The proportions chosen should be such that the concrete is of adequate workability for the conditions prevailing on the work in question and can be properly compacted with the means available.

The maximum total quantity of aggregate by weight per 50 kg. of cement shall not exceed 450 kg. except where otherwise specifically permitted by the engineer-in-charge.

5.3.2.3. Except where it can be shown to the satisfaction of the Engineer-in-charge that supply of properly graded aggregate of uniform quality can be maintained over the period of work the grading of aggregate should be controlled by obtaining the coarse aggregate in different sizes and blending them in the right proportions when required, the different sizes being stocked in separate stock piles. The materials should be stock piled for several hours, preferably a day before use. The grading of coarse and fine aggregate should be checked as frequently as possible, the frequency for a given job being determined by the engineer-incharge in ensure ithat the suppliers are maintaining the grading uniform with that of the samples used in the preliminary tests.

5.3.2.4. In proportioning concrete, the quantity of both cement and aggregate should be determined by weight. Where the weight of cement is determined by accepting the maker's weight per bag a reasonable number of bags should be weighted separately to check the net weight. Where the cement is weighed on the site and not in bags it should be weighed separately from the aggregates. Water should be either measured by volume in calibrated tanks or weighed. All measuring equipment should be maintained in a clean serviceable condition and their accuracy periodically checked.

5.3.2.5. It is most important to maintain the water-cement ratio constant at its correct value. To this end, determination of moisture contents in both fine and coarse aggregates should be made as frequently as possible, the frequency for a given job being determined by the Engineer in-charge according to weather conditions. The amount of the added water should be adjusted to compensate for any observed variations in the moisture contents. For the determination of moisture content in the aggregate, I.S. 2386 (Part III) 1963. Methods of Test for aggregate for concrete; Part III specific Gravity, Density, Voids Absorption and Bulking may be referred to

To allow for the variation in weight of aggregates due to variation in their moisture content, suitable adjustment in the weights of aggregates should also be made.

5.3.2.6. No substitutions in materials used on the work or alterations in the established proportions except, as permitted in 5.3.2. shall be made without additional tests to show that the quality and strength of concrete are satisfactory.

5.3.2.7. Workability of the concrete should be checked at frequent intervals. The slump test, or where facilities, exist the compacting factor test in accordance with I.S. 1199-1950 may be adopted for this purpose.

5.3.2.8. A competent person should be employed whose first duty will be to supervise all stages in the preparation and placing of the concrete. All works test specimens should be made and site tests carried out under his direct supervision.

5.3.3. *Ordinary concrete* :

5.3.3.1. Where it is considered not practicable to use controlled concrete ordinary concrete may be used for concrete of grades M 100 M 150, M 200 and M250. The proportions of materials for nominal concrete mixes for ordinary concrete shall be in accordance with Table III.

5.3.3.2. In proportioning concrete, the quantity of cement should be determined by weight. The quantities of fine and coarse aggregates may be determined by volume, but these should also preferably be determined by weight. In the latter case the weight should be determined from the volume specified in Table III and the weight per litre of dry aggregate. If fine aggregate is moist and volume batching is adopted, allowance, shall be made for bulking in accordance with I.S. 2386 (Part III)—1963.

TALBE III.

(*Clause* 5.3.3.1, 5.3.3.2., 5.3.3.3., 5.3.3.6 and 20.1.1.)

Grade of concrete.	Ordinary concrete. Total quantity of dry aggregate by volume per 50 kg. of cement, to be taken as the sum of the individual volumes of fine and coarse aggregates.	Proportion of fine aggregate to coarse aggregate.	Quantity of water per 50 kg. of cements.
	Max.		Max.
M 100 ..	300	Generally 1 : 2 for fine aggregate to coarse aggregate by volume but subject to a upper limit of 1 : 1½ and a lower limit of 1 : 3.	34
M 150 ..	220	Do.	32
M 200 ..	160	Do.	30
M 250 ..	100	Do.	27

NOTE.1.—The proportions of the aggregate should be adjusted from upper limit to lower limit progressively as the grading of the fine aggregate becomes fine and the maximum size of coarse aggregate becomes larger. Example : For an average grading of fine aggregate (that is, Zone II of I.S. 383—1963) the proportions shall be 1 : 1½, 1 : 2 and 1 : 3 for maximum size of aggregate 10 mm., 20 mm. and 40 mm respectively.

Note 2 : It may be noted for general guidance that M 100, M150, M200 and M 250 of ordinary concrete correspond approximately to 1:3:6, 1:2:4, 1:1½:3 and 1:1:2 nominal mixes of ordinary concrete currently used in the country.

5.3.3.3. The water-cement ratio shall not be more than those specified in Table III.

The cement content of the mix specified in Table III for any nominal mix may be increased if the quantity of water in a mix has to be increased to overcome the difficulties of placement and compaction so that the water cement ratio specified in Table III is not exceeded.

Note 1 : In the case of vibrated concrete, the limit specified may be suitably reduced to aviod segregation.

Note 2 : The quantity of water used in the concrete mix for reinforced concrete work should be sufficient, but not more than sufficient to produce a dense concrete of adequate workability for its purpose, which will surround and properly grip all the reinforcement. Workability of the concrete should be controlled by maintaining a water-cement ratio that is found to give a concrete which is just sufficiently wet to be placed and compacted without difficulty with the means available.

5.3.3.4. Workability of the concrete should be controlled by direct measurement of water content, making allowance for any surface water in the fine and coarse aggregates. The slump test in accordance with I.S. 1199-1959 may be used as a guide.

5.3.3.5. Allowance should be made for surface water present in the aggregate when computing the water content. Surface water shall be determined by one of the field methods described in I.S. 2336 (Part III)—1963. In the absence of exact data, the amount of surface water may be estimated from the values given in Table IV.

TABLE IV—SURFACE WATER CARRIED BY AVERAGE AGGREGATE.

Aggregate.	*Approximate quantity of surface water.* l/m^3
Very wet sand	120
Moderately wet sand..	80
Moist sand	40
Moist gravel or crushed rock	20 to 40

Coarser the aggregate, lesser the water it will carry.

5.3.3.6. If ordinary concrete made in accordance with the proportions given for a particular grade does not yield the specified strength due to proper qualities of materials not being available, such concrete shall be classified as belonging to the appropriate lower grade. Ordinary concrete proportioned for a given grade in accordance with Table III shall not however, be placed in a higher grade on the ground that the test strengths are higher than the minimum specified. No interpolation shall be permissible.

5·4. *Sample size and acceptance criteria* :

5.4.1. All tests shall be carried out in accordance with I.S. 516-1959.

5.4.2. The number of test specimens required, the frequency of sampling and the criteria for acceptance of a concrete as conforming to the specified grade shall be in accordance with Table V for both ordinary concrete and controlled concrete. No preliminary test are, however, necessary in the case of ordinary concrete.

6.2. *Stability considerations* : Before taking up detailed design of reinforced concrete structures, the engineer-in-charge shoul satisfy himself on the correct estimation of all loads and on the adequate statical equilibrium of the structure, particularly, in regard to safety against overturning of overhanging members. The anchorages or counter weights provided for overhanging memberd (during construction and service) should be such that static equilibrium should remain, even when the overturning moment is doubled.

NOTE.—However in the design of the member itself, the design load need not be taken as twice the working load. The strength of the member should, however, be checked to ensure that the member is safe against an ultimate load of twice the dead load plus the live load, or against the critical ultimate load combinations mentioned in Appendix B whichever is more severe.

6.3. *Basic theories of design.*

6.3.1. *General.*—The method of design should accord with the laws of mechanics and general principles relating to the design of reinforced concrete. Structures may be designed either by the methods based on working stress consideration or by the methods based on ultimate load considerations.

NOTE.—Designs based on experimental investigations on models sor prototypes may be accepted subject to the experimental details and the analysis connected therewith being approved by the engineer in-charge.

6.3.2. *Working stress method* : In the methods based on elastic theory, the following assumptions shall be made :

(*a*) At any cross-section, plane sections before bending remani plane after bending.

(*b*) All tensile stresses are taken up by reinforcement and non by concrete, except as otherwise specifically permitted.

(*c*) The stress-strain ralationship of steel and concrete, under working loads, is a straight line.

(d) The modular ratio m has the value $\frac{2800}{3\sigma cb}$ (rounded off to the nearest integral value in accordance with I S: 2-1960) where σcb is maximum permissible compressive stress due to bending in concrete in kilogram per square centimetre.

6.5. *Limiting stiffness of members.*—Reinforced concrete should possess adequate stiffness to prevent such deformation as might impair the strength, appearance or efficiency of the structure or produce cracks in finishes and partitions. For normal cases it may be assumed that this condition is satisfied for beams and slabs if the ratio of span to overall depth does not exceed the following values :

	Maximum value of span/depth ratio.
Beams :	
Simply supported beams	20
Continuous beams	25
Cantilever beams	10
Slabs :	
Simply supported slabs spanning in one direction ..	30
Simply supported slabs spanning in two directions ..	35
Continuous slabs spanning in one direction	35
Continuous slabs spanning in two directions ..	40
Cantilever slabs	12

NOTE 1—In cantilever beams and slabs, the span may be taken as the effective overhang.

NOTE 2—In slabs spanning in two directions, the shorter of the two spans should be used to calculate the span/depth ratio.

9. *Members in bending* :

9.1. *Effective span* :

9.1.1. *Freely supported beam or slab.*—In the case of a freely supported beam or slab, the effective span shall be the distance between centres of supports, or the clear distance between supports plus the effective depth of the beam or slab, whichever is smaller.

9.1.2. *Continuous beam or slab*—In the case of continuous beam or slab, if the width of the supports is less than 1/12 of the clear span, the effective span shall be as in 9.1.1. If the supports are wider than 1/12 the clear span for 600 mm whichever is less, the effective span shall be taken as under :

(*a*) For end span with one end fixed and the other continuous or for intermediate spans, the effective span shall be the clear span between supports; and

(*b*) For end span with one end free and the other continuous, the effective span shall be equal to the clear span plus half the effective depth of the beam or slab or the clear span plus half the width of the discontinuous support, whichever is less.

NOTE.—In the case of spans with roller or rocker bearings, the effective span shall always be the distance between the centres of bearings. In the case of monolithic frames, the effective length of any member shall be equal to the distance between intersections of the centre lines of the connecting members.

9.2. *General requirements* :

9.2.1. *Slabs* :

9.2.1.1. *Minimum reinforcement.*– In solid reinforced concrete slabs, the reinforcement in either direction shall not be less than 0·15 percent of the gross sectional area of concrete.

9.2..1.2. *Effect of wear.*—If the surface of a concrete slab is not adequately protected by a suitable finish against the effect of wear, an appropriate addition should be made to the structural thickness, required.

9.2.2. *Beams.*

9.2.2.1. *T-beam.*—In a T-beam, the breadth of the flange assumed as taking compression shall not exceed the least of the following :—

(*a*) One-sixth of the effective span of the T-beam.

(*b*) The distance between the centres of the ribs of the T-beams and

(*c*) The breadth of the rib plus 12 times the thickness of the slab.

9.2.2.2. *L-beam.*—In a L-beam, the breadth of the flange assumed as taking compression shall not exceed the least of the following. :—

(*a*) One-sixth of the effective span of the L-beam. ;

(*b*) The breadth of the rib plus one-half of the clear distance between ribs, and

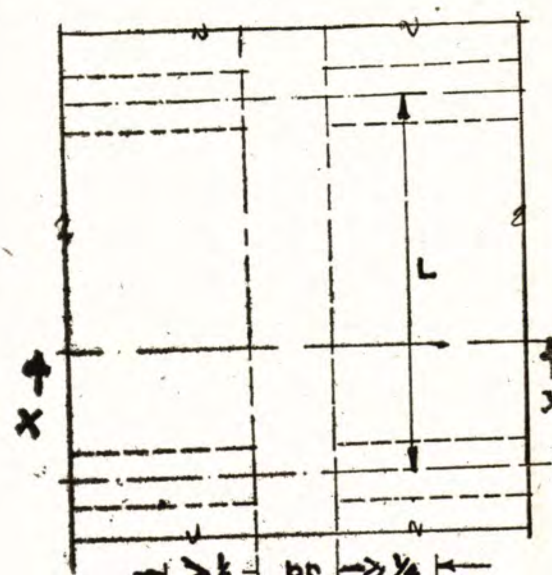
(*c*) The breadth of the rib plus four times the thickness of the slab.

9.2.2.3. *Flanges of T-beam or L-beam.*—The flanges of the T-beam or L-beam may be part of a slab which is spanning either transverse to the beam or in the same direction as the beam. In any case the flange shall have adequate reinforcement transverse to the beam, and it shall be built integrally with the beam or effectively keyed together with the beam. However, where the main reinforcement of slab, which is considered as the flange of the T-beam or L-beam is parallel to the beam, transverse reinforcement extending to the length indicated in Figure 1 shall be provided near the top surface of the slab. If the quantity of such transverse reinforcement is not specifically determined by calculation, it shall be not less than 60 per cent of the main reinforcement in the centre of the span of the slab constituting the flange.

.2.2.4. *Minimum reinforcement.*—Minimum tensile reinforcement in a beam shall be not less than 0·3 per cent of the gross sectional area of the beam, the area of the beam being calculated as total cross sectional area for rectangular beams and as the area equal to the total overall depth multiplied by the width of the web in the case of T-and L-beams.

9.2.2.5. *Deep beams.*—Beams with depth/span ratios greater than 0·4 for continuous spans or 0·8 for simple spans shall be designed as deep beams taking into account the non-linear distribution of stress, lateral buckling and other pertinent effects.

The minimum horizontal and vertical reinforcements in the faces shall be in accordance with 14·1 and the minimum tensile reinforcement as in 9.2.2.4.



" SECTION XX "

9.3. *Beams and slabs spanning in one direction.*

9.3.1. *Beams and slabs over free end supports.*—Bending moments in beams and slabs with free end supports shall be calculated for the effective span and for the loading thereon.

Single span beams and one-way slabs which carry uniformly distributed loads shall be designed to resist a positive bending moment near mid span of $\frac{Wl}{8}$ where W is the total uniformly distributed oad over the span and l is the effective span. In addition, where all member is built into a brick or masonry wall which develops only partial restraint, the member shall be designed to resist a negative moment at the face of the support of $\frac{Wl}{24}$ or such other restraining moment as may be shown to be applicable.

9.3.2. *Beams and slabs continuous over supports.*—In the case of beams and slabs continuous over supports, the bending moments to be provided for at a cross-section shall gerereally be the maximum positive and negative moments at such cross-section, allowing, in both cases, if so desired, for the reduced moments due to the width of the supports, for the following arrangements of superimposed loading:—

(*a*) Alternate spans loaded and all other spans unloaded; and

(*b*) Any two adjacent spans loaded and all other spans unloaded*

Nevertheless, except where the approximate values for bending moments given in 9.3.2.1. are used, the moments over the supports for any assumed arrangement of loading, including the dead load moments may each be increased or decreased by not more than 15 per cent, provided that these modified moments over the supports are used for the calculation of the corresponding moments in the spans.

9·3.2.1. Unless more exact estimates are made, the bending moments in uniformly loaded beams and slabs continuous over three or more approximately equal spans (two spans may be considered approximately equal when they do not differ by more than 15 per cent of the longer span) may be assumed to have the following values. :—

	Near middle of end span.	*At middle of interior spans.*	*At support next to the end support.*	*At other interior supports.*
(1)	(2)	(3)	(4)	(5)
Moment due to dead load.	$+\frac{W_d l}{12}$	$+\frac{W_d l}{24}$	$-\frac{W_d l}{10}$	$-\frac{W_d l}{12}$
Moment due to superimposed load.	$+\frac{W_s l}{10}$	$+\frac{W_s l}{12}$	$-\frac{W_s l}{9}$	$-\frac{W_s l}{9}$

Where

W_d = total dead load per span.

W_s = total superimposed uniformly distributed load per span

l = effective span.

* Positive and negative signs indicate sagging and hogging moments respectively.

NOTE.—Corresponding to the bending moments given above, the shearing forces at the supports may be assumed to have the following values :—

	At exterior face of support next to the end support.	*At faces of all other supports.*
(1)	(2)	(3)
Shearing force due to dead load.	$0{\cdot}6\ W_d$.	$0{\cdot}5\ W_d$.
Shearing force due to superimposed load.	$0{\cdot}5\ W_s$.	$0{\cdot}5\ W_s$.

10. *Members in compression.*

10.1. *Effective length.*—For the purpose of this clause, the effective column length (1) given in Table VIII shall be used where L refers to the unsupported length of the column (*See* 10.1.1.). The effective column length values given in Table VIII are in respect of typical cases only, and embody the general principles which should be employed in assessing the appropriate value for any particular column.

10.1.1. *Unsupported length.*—The unsupported length L of a column shall be taken as the clear distance between the floor or slabs except that;

(*a*) in flat slab construction, it shall be the clear distance between the floor and the lower extremity of the capital, the drop panel or the slab whichever is the least;

(*b*) in beam and slab construction, it shall be the clear distance etween the floor and the underside of the shallower beam framing into the column in each direction at the next higher floor level.

(*c*) in columns restrained laterally by struts, it shall be the clear distance between consecutive struts in each vertical plane, provided that to be an adequate support, two such struts shall meet the column at approximately the same level and the angle between vertical planes through the struts shall not vary more than 30° from a right angle Such struts shall be of adequate dimensions and shall have sufficien anchorage to restrain the column against lateral deflection.

(*d*) in columns restrained laterally by struts or beams, with brackets used at the junction, it shall be the clear distance between the floor and the lower edge of the bracket, provided the bracket width equals that of the beam or strut and is at least half that of the column.

TABLE VIII.

Effective column length.

(*Clause 10.1*)

(1)	Type of column. (2)	Effective column length. (3)
Column of one strorey.	Properly restrained at both ends in position and direction.	0·75 L
	Properly restrained at both ends in position but not in direction.	L
	Properly restrained at one end in position and direction and imperfectly restrained in both position and direction at the other end.	A value intermediate between L and 2L depending upon the efficiency of the imperfect restraint.
Columns continuing through two or more storeys.	Properly restrained at both ends in position and direction.	0·75 L
	Properly restrained at both ends in position and imperfectly restrained in direction at one or both ends.	A value intermediate between 0·75 and 1·00 depending upon the efficiency of the directional restraint.
	Properly restrained at one end in position and direction and imperfectly restrained in both position and direction at the other end.	A value intermediate L and 2 L between depending upon the efficiency of the imperfect restraint.

10.2. *Longitudinal reinforcement.*—A reinforced concrete compression member shall have longitudinal steel reinforcement, and cross-sectional area of such reinforcement shall be not less than 0·8 per cent of the area of concrete section required for direct load alone, nor more than 8 per cent of the gross-sectional area of the column required to transmit all the loading in accordance with this code.

Note.—It should be noted that the use of 8 per cent of steel may involve serious practical difficulties in placing and compacting of concrete and a lower percentage is recommended. Where bars from the column below have to be lapped with these in the column under consideration, the percentage of steel should usually not exceed 4 per cent.

10.2.1. A reinforced concrete column having helical reinforcement shall have at least six bars of longitudinal reinforcement within this helical reinforcement.

10.2.2. The bars shall be not less than 12mm. in diameter.

10.2.3. In any column that has a large cross-sectional area than that required to support the load, the minimum percentage of steel shall be based upon the area of concrete required to resist the direct stress and not upon the actual area.

10.2.4. The longtitudinal reinforcement shall not be less than 0·15 percent in the case of pedestals and columns in which the longitudinal reinforcement is ignored for the purpose of calculating the permissible load on the column.

10·3. *Transverse reinforcement.*

10.3.1. *General.*—A reinforced concrete compression member shall have transverse or helical reinforcement so disposed that every longitudinal bar nearest to the compression face has effective lateral support against buckling subject to provisions in 10.3.1.1. to 10.3.1.4. The effective lateral support given by transverse reinforcement either in the form of circular rings capable of taking up circumferential tension or by polygonal links (lateral ties) with internal angles not exceeding 135°. The ends of the transverse reinforcement should be properly anchored.

10.3.2. *Polygonal links or lateral ties.*

10.3.2.1. *Pitch.*—The pitch of transverse reinforcement shall be not more than the least of the following distances :

(*a*) The least laternal dimension of the compression member.

(*b*) K times the diameter of the longitudinal reinforcing bar nearest to the compression face of the member.

where

$$K = 12 \times \frac{\text{maximum permissible axial load on the compression member}}{\text{actual compressive load on the member (actual axial load alone being considered in the case of members subject to combined axial load and bending).}}$$

with the further provison that K shall be subject to a minimum value of 16 and a maximum value of 24.

(*c*) Forty-eight times the diameter of the transverse reinforcement.

10.3.2.2. *Diameter.*—The diameter of the polygonal links or lateral ties shall be not less than one-fourth of the diameter of the largest longitudinal bar, and in no case less than 5mm.

10.3.3. *Helical reinforcement.*

10.3.3.1. *Pitch.*—Helical reinforcement shall be of regular formation with the turns of the helix spaced evenly and its ends shall be anchored properly. Where an increased load on the column on the strength of the helical reinforcement is allowed as provided under 10.4.1.2. the pitch of the helical turns shall be not more than 75mm, nor more than one-sixth of the core diameter of the column, nor less than 25mm nor less than three times the diameter of the steel bar forming the helix. In other cases the requirements of 10.3.2. shall be complied with.

10.3.3.2. *Diameter.*—The diameter of the helical reinforcement shall be in accordance with 10.3.2.2.

10.4. *Permissible loads.*—

10.4.1. *Axially loaded columns* :

10.4.1.1. *Pedestals and short columns with lateral ties.*—The axial load P permissible on a pedestal or short column reinforced with longitudinal bars and lateral ties shall not exceed that given by the following equation :

$$P = \sigma_c\, Ac + \sigma_{sc}\, Asc$$

where

σ_c = permissible stress in concrete in direct compression.

Ac = cross-sectional area of concrete excluding any finishing material and reinforcing steel.

σ_{sc} = permissible compressive stress for column bars, and

Asc = Cross-sectional area of the longitudinal steel.

10.4.1.2. *Short columns with helical reinforcement.*—Where helical reinforcement is used, the axial load P permissible on a short column shall not exceed that given by the equation under 10.4.1.1 and the equation given below, whichever is greater :

$$P = \sigma_c\, Ak + \sigma_{sc}\, Asc + 2\, \sigma_{sh}\, Ab$$

where

σ_c = permissible stress in direct compression

Ak = cross-sectional area of concrete in the column core excluding the area of longitudinal reinforcement.

Ab = equivalent area of helical reinforcement which may be taken as the volume of helical reinforcement per unit length of the column.

Asc = cross-sectional area of steel in compression.

σ_{sh} = permissible stress in helical reinforcement, and

σ_{sc} permissible compressive stress for column bars.

The sum of the terms σ_c Ak and 2 σ_{sh} Ab should not exceed $0.5\, \sigma_{cu}\, Acs$ where σ_{cu} is the 28-day works cube compressive strength of the concrete (*see* Table I).

10.4.1.3. *Long columns.*—The maximum permissible stress in a reinforced concrete column or part thereof having a ratio of effective column length to least lateral dimension above 15 shall not exceed those which result from the multiplication of the appropriate maximum permissible stress as specified under 8.1 and 8.2. by the coefficient Cr given by the following formula :

$$Cr = 1{\cdot}5 - \frac{l}{30D}$$

where

Cr = reduction coefficient

l = effective length of column and

D = least lateral dimension of column.

NOTE.—When in a column having helical reinforcement the permissible load is based on the core area, the least lateral dimension should be taken as the diameter of the core.

For more exact calculations, the maximum permissible stresses in a reinforced concrete column or part thereof having a ratio of effective column length to least lateral radius of gyration above 50 shall not exceed those which result from the multiplication of the appropriate maximum permissible stresses specified under 8.1 and 8.2. by the coefficient Cr given by the following formula :

$$Cr = 1{\cdot}5 - \frac{1}{100\ Km}$$

where

Km = least radius of gyration

10.4.1.4. *Composite columns.*

(*a*) *Allowable Load.*—The allowable load P on a composite column, consisting of a structural steel or cast-iron column thoroughly encased in concrete reinforced with both longitudinal and spiral reinforcement, shall not exceed that given by the following formula

$$P = \sigma_c\, Ac + \sigma_{Sc}\, Asc + \sigma_m\, Am$$

where

Ac = net area of concrete section ;

= gross area of the concrete section—Asc—Am.

Asc—Cross-sectional area of longitudinal bar reinforcement.

Am—Cross-sectional area of the steel or cast iron core.

σ_m—Allowable unit stress in metal core, not to exceed 1,250 kg/cm² for a steel core, or 700 kg/cm² for a cast iron core;

σ_c = permissible stress in concrete in direct compression; and

σ_{sc}—permissible compressive stress for column bars.

(*b*) *Metal core and reinforcement.*—The cross-sectional area of the metal core shall not exceed 20 percent of the gross area of the column. If a hallow metal core is used, it shall be filled with concrete. The amounts of longitudinal and spiral reinforcement and the requirements as to spacing of bars, details of splices and thickness of protective shall outside the spiral, shall conform to 10·2 and 10·3. A clearance of at least 75 mm. shall be maintained between the spiral and the metal core at all points except that when the core consists of a structural steel H—column the minimum clearance may be reduced to 50 mm.

(*c*) *Splices and connections of metal cores.*—Metal cores in composite columns shall be accurately milled at splices and positive provisions shall be made for alignment of one core above another. At the column base, provision shall be made to transfer the load to the footing at safe unit stresses in aoccrdance With 15. The base of the metal section shall be designed to transfer the load from the entire composite columns to the footing, or it may be designed to trasnfer the load from the metal section only, provided it is placed in the pier or pedestal as to leave ample section of concrete above the base for the trasnfer of lead from the reinforced concrete section of the column by means of bond on the vertical reinforcement and by direct compression on the concrete. Transfer of loads to the metal core shall be provided for by the use of bearing members, such as billets, brackets or other positive connections; these shall be provided at the top of the metal core and at intermediate floor levels where required. The column as a whole shall satisfy the requirements of formula quoted under (*a*) of the clause at any point; in addition to this, the reinforced concrete portion shall be designed to carry, according to 10.4.1.1 or 10.4.1.2 as the case may be, all floor loads brought into the column at levels between the metal brackets or connections In applying the formul aunder 10.4.1.1 or 10.4.1.2 the gross area of columns shall be taken to be the area of the concrete section outside the metal core, and the allowable load on the reinforced concrete section shall be further limited to 0.28 σcu X gross sectional area of the column.

(*d*) *Allowable load on metal core only.*—The metal cores of composite column shall be designed to carry safely any construction or other loads to be placed upon them prior to their encashment in concrete.

10.4.1.5 *Concrete filled pipe columns:*—The allowable load P on columns consisting of steel pipe filled with concrete shall be as given below:—

$$P = Ac\,\sigma c\left(1 - 0.000025\frac{L^2}{K_c^2}\right) + \sigma sc\ Asc$$

Where

Ac = area of concrete within the pipe of the column.

σc = permissible stress in concrete in direct compression.

L = unsupported length of the column (see 10.1.1).

Kc = radius of gyration of concrete alone;

$\sigma SC = (1{,}200 - 0.034\frac{L^2}{K_s^2}$ kg/cm^2 provided yield strength of the pipe is not less than 2,400 kg/cm^2 and $\frac{L}{Ks}$ is not more than 120.

Asc = cross-sectional area of the shell of the steel pipe; and

Ks = radius of gyration of steel pipe alone.

11. *Members subject to combined axial load and bending.*

11.1. *Design based on uncracked section.*—A member subject to axial load and bending (due to excentricity of load monolithic construction, lateral forces, etc.) shall be considered following conditions is satisfied:

(*a*) $$\frac{\sigma^1 c}{\sigma c} + \frac{{}^1 cb}{\sigma cb} \leq 1$$

Where

$\sigma^1 c$ = calculated direct compressive stress in concrete.

σc = permissible axial compressive stress in concrete.

$\sigma^1 cb$ = calculated bending compressive stress in concrete and

σcb = permissible bending compressive stress in concrete.

(*b*) The reultant tension in concrete is not grater than 35 per cent and 25 per cent of the resultant compression for biaxial and unaxial bending respectively, or exceeds three, fourths the 7 day modulus of rupture of concrete.

NOTE 1— $$\sigma^1 c = \frac{P}{Ac + m\ Asc} \text{ or } \frac{P}{Ac + m\ Asc + 2m\ Ab}$$

for columns with ties and helical reinforcement respectively. P, Ac, Asc and Ab are as defined in 10.4.1.1 and 10.4.1.2 and m is the modular ratio.

Note 2— $\sigma\ ^1 cb = \frac{M}{Z}$ where M equals the moment and Z equals the modulus of section. In the case of sections subject to moments in two directions, the stresses shall be calculated seprately and added algebrically.

11.2. *Design based on cracked section.*—If the requirements specified in 11.1, are not satisfied, the stresses in concrete and steel shall be calculated by the theory of cracked section in which the tensile resistance of concrete is ignored. If the calculated stresses are within the permissible stresses specified in Tables VI and VII, the section may be assumed to be safe.

Note.—The maximum stress in concrete and steel may be found from tables and charts based on the cracked section theory or directly by determining the no-stress line which should satisfy the following requirements:—

(*a*) The direct load should be equal to the algebraic sum of the forces on concrete and steel.

(*b*) The moment of the external loads about any reference line should be equal to the algebraic sum of the moment of the forces in concrete (ignoring the tensile force in concrete) and steel about the same line, and

(*c*) The moment of the external loads about any other reference line should be equal to the algebraic sum of the moment of the forces in concrete (ignoring tensile force in concrete and steel about the same line.)

11.3. *Bending moments in columns*—

11.3.1. Bending moments in internal columns supporting an approximately symmetrical arrangements of beam and loading need not be calculated except in the case of flat slab construction.

Bending moments in external colnmn and in internal column supporting an arrangement of beam and loading not approximately symmetrical should be calculated and provided for.

In the absence of more accurate methods of analysis for computing bending moments in columns, the expression given in Table IX may be used for estimating the moments.

TABLE IX—MOMENTS IN COLUMNS.

	Moments for frames of one bay.	*Moments for frames two or more bays.*
(1)	(2)	(3)
External (and similarly loaded) columns.		
Moment at foot of upper column.	$Me \dfrac{Ku}{Ki+Ku+0{\cdot}5kb.}$	$me \dfrac{Ku}{Ki+Ku+Kb}$
Moment at head of lower column.	$Me \dfrac{Ki}{Ki+Ku+0.5Kb}$	$Me \dfrac{Ki}{Ki+Ku+Kb}$
Internal columns		
Moment at foot of upper column.	..	$Mes \dfrac{Ku}{Ki+Ku+Kb_1+Kb_2}$
Moment at head of lower column.	..	$Mes \dfrac{Ki.}{Ki+Ku+Kb_1+Kb_2}$

NOTE. 1—

Me = bending moment at the end of the beam framing into the column assuming fixity at the connetion.

Mes = Maximum difference between the moments at the ends of the two beams framing into opposite sides of the column, each calculated on the assumption that the ends of the beams are fixed and assuming one of the beams unloaded.

Ku = Stiffness of the upper column.

Ki = stiffness of the lower column.

Kb = stiffness of the beam.

Kb_1 = stiffness of the beam on one side of the column, and

Kb_2 = stiffness of the beam on the other side of the column.

NOTE. 2—For the purpose of this table, 'stiffness' of a member obtained by dividing the moment of inertia of a cross-section by the length of the member provided that the member of constant cross-section throughout its length.

NOTE 3.—The equation for the moment at the head of the lower column may be used for column in a topmost story by taking Ku as zero.

11.3.2.—Where the bending moment is calculated in the internal columns, it is permissible to take into account the reduction in load resulting from the beam on one side of the column being fully loaded and the beam on the other side being loaded with dead load only.

11.3.3 Columns subjected to direct load and bending should preferably be checked for ultimate load, especially when bending moments are caused predominantly by seismic loads or other horizontal forces.

11.4. *Reinforemcent.*

11.4.1. *Pedestals.*—Compression members where the ratio of the effective length to the least radius of gyration is less than 12, such as in pedestals, may be proportioned to resist bending moments without providing any reinforcement by permitting the maximum tensile stress in concrete equal in value to the maximum permissible inclined tension as given in Table VI.

11.4.2. *Members other than pedestals.*

11.4.2.1. Requirements regarding the minimum area of reinforcement and its size and disposition for both longitudinal and transverse reinforcements shall generally be governed by the corresponding provisions in 9 so far as bending is concerned, and provisions in 10 so far as direct compression is concerned.

12. *Shear and torsion.*

12.1. *General.*—A reinforced concrete section in any structural member shall be proportioned and reinforced to develop the resistance to shear stresses resulting from transverse shear or torsional moments or both in accordance with 12.2 to 12.4.5.

12.2 *Shear stress due to transverse shear.*—The shear stress q at any cross-section in a reinforced concrete beam or slab should be calculated from the following equation :—

$$q = \frac{Q}{bjd} \text{(for rectangular beams), or}$$

$$q = \frac{Q}{br\,jd} \text{(for } T\text{-or } L\text{-beams)}$$

Where

Q = total shear across the section.

b = breadth of a rectangular beam.

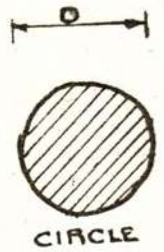
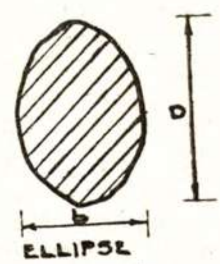
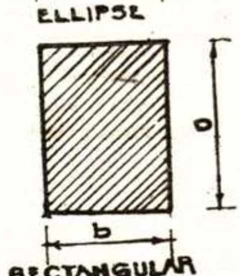
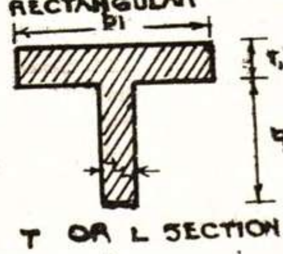
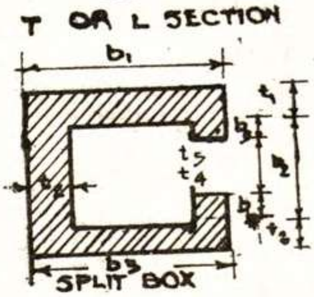
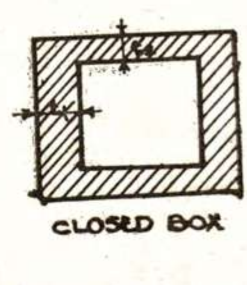
br = breadth of the rib of a T. beam or L-beam, and

jd = lever arm of the resisting moment.

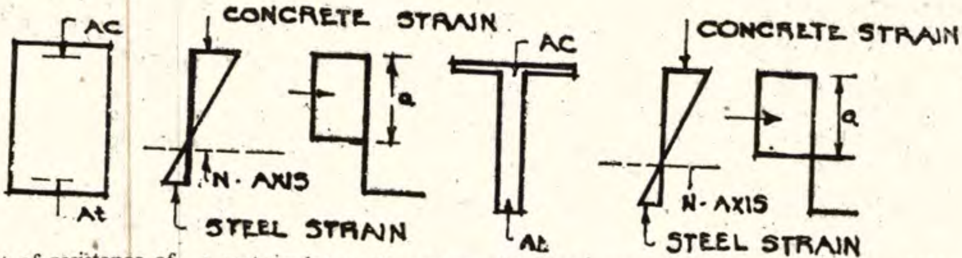
12.3. *Shear stress due to torsion.*—Shear stress resulting from torsional moment may be accurately assessed by membranc analogy or by any other recognized theory. The values given in Table X may be considered acceptable for design purposes, where **Mt** is the torsional moment.

TABLE X—SHEAR STRESS IN MEMBERS DUE TO TORSION.

(*Clause* 12.3.)

Description of section. (1)	*Shape.* (2)	*Maximum shear stress.* (3)
(*a*) Non-tubular sections (1) Circle.		$\frac{16\,Mt}{\pi\, D^3}$
(2) Ellipse.		$\frac{16Mt}{\pi\, b^2 D}$
(3) Rectangle		$\frac{Mt(3+2b/D)}{b^2 D}$
(4) Section made up of rectangles, such as T or L.		$\frac{3Mt\, ti}{\Sigma\, b_i t_i^3}$ Where ti is t_1 or t_2 according to the section under consideration.
(5) Split box.		$\frac{3Mt\, ti}{\Sigma\, b_i t_i^3}$ Where ti is t_1 or t_2 or t_3, etc., according to the section under consideration.
(6) tubular or box-sections.		$\frac{Mt}{2A\, ti}$ Where A is the mean of the areas enclosed by the inner and the outer boundaries and ti is t_1 or t_2 etc., according to the section under consideration.

B.3.2. Rectangular and T. sections under bending



Ultimate moment of resistance of a rectangular or T. section shall be calculated as follows :—

(*a*) Determine the depth "*a*" of the rectangular stress block to satisfy the following equation :—

($Ast - Asc$) $\sigma_{sy} = 0{\cdot}55\ \sigma_{cu}$ (areas of the stress block in the rectangular or T. Section).

(*b*) Calculate the ultimate moment of resistance as follows :—

(1) if $a \leqslant 0{\cdot}43d$, take the lever arm$=(d-a/_2)$ and $Mu=(A_{st}-A_{sc})\ \sigma_{sy}$ (lever arm)$+A_{sc}\sigma_{sy}\ ds$

(2) if $a \geq 0{\cdot}43\ d$, assume, a $= 0{\cdot}43$ d and lever arm$=\left(d-\frac{0{\cdot}43d}{2}\right)$

and Mu$=0{\cdot}55\ \sigma_{cu}$ (area of the stress block over the depth 0·43 d) (lever arm)$+A_{sc}\sigma_{sy}\ ds$.

Where

Ast = area of tension steel,

Asc = area of compression steel,

σ_{sy} = Yield stress of steel*,

σ_{cu} = Cube strength of concrete at 28 days,

Mu = ultimate moment of resistance,

d = effective depth of section, and

ds = distance between centroids of tension steel (Ast) and compression steel (Asc).

Note.—In a balanced rectangular section—

$Mu=0{\cdot}185\ bd^2\ \sigma_{cu}$.

and $Ast=0{\cdot}236\ bd\ \dfrac{\sigma_{cu}}{\sigma_{sy}}$

*For the purpose of design σ_{sy} shall be taken as the guaranteed yield stress, subject to a maximum limit of 3,200 kg./cm² for plain round or square bars. In the absence of a guarantee, unless otherwise established, the following values may be assumed:—

(1) Medium tensile steel conforming to I.S. : 432—1960

	Kg/cm²
Bars up to and including 25mm	3,600
Bars over 25mm up to and including 38mm	3,450
Bars over 38mm up to and including 50mm	3,300

(2) Medium tensile conforming to IS. : 1139–1966—

Bars up to and including 25mm	3,600
Bars over 25mm up to and including 38mm	3,450

(3) Cold twisted plain or deformed bars conforming to I.S. : 1786–1966—

Bars under 10mm	4,950
Bars from 10mm and above	4,250

(4) Mild steel conforming to IS. : 432–1960—

Grade I—

Bars up to and including 20mm	2,600
Bars over 20mm	2,400

Grade II.—

Bars up to and including 20mm	2,350
Bars over 20mm	2,150

(5) Mild steel conforming to IS. : 1139–1966—

Bars up to and including 20mm	2,600
Bars over to 20mm	2,400

B.3.3. *Concentrically loaded short and long columns.*—Ultimate capacity P of concentrically loaded section should be determined by the following equation :—

$P=0{\cdot}4\ \sigma_{cu}Ac+\sigma_{sy}\ Asc$.

Where—

σ_{cu} = ultimate cube strength of concrete in compression.

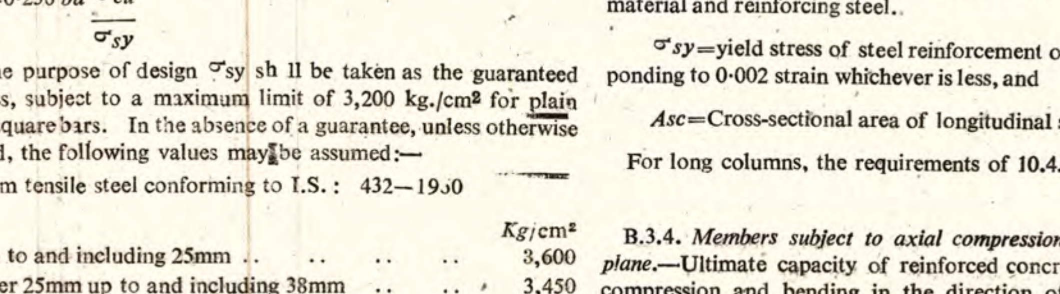
Ac = cross-sectional area of concrete excluding any finishing material and reinforcing steel.

σ_{sy} = yield stress of steel reinforcement or stress in steel corresponding to 0·002 strain whichever is less, and

Asc = Cross-sectional area of longitudinal steel.

For long columns, the requirements of 10.4.1.3. shall apply.

B.3.4. *Members subject to axial compression and bending in one plane.*—Ultimate capacity of reinforced concrete section for direct compression and bending in the direction of one of its principal areas should be calculated as follows :—



466-3—19

(*a*) The depth of the rectangular stress block should be 0·75 time the depth of the neutral axis subject to the maximum value equal to the depth of cross-section.

(*b*) The average compressive stress across the rectangular stress block should be taken as $0{\cdot}55\sigma_{cu}$, when the resisting moment due to compressive force in concrete (not taking into account contribution from compressive reinforcement) about the centroid of the tension reinforcement (or the reinforcement least in compression) does not exceed 0·75 time the moment of compressive force in concrete subjected to uniform compressive stress of $0{\cdot}55\ \sigma_{cu}$ over the effective depth of the section. For $a<d$, the average compressive stress across the rectangular stress block should be reduced so that this limiting moment is not exceeded. For $a \geq d$, the average compressive stress across the rectangular stress block should be taken as $0{\cdot}4\ \sigma_{cu}$.

(c) Stress in steel should be equal to an appropriate strain in steel XEs' or σ_{sy} whichever is less. For cold worked steel with no definite yield point, Es for this purpose may be obtained from the idealized stress-strain diagram plotted from the following data :—

The diagram is a straight line from origin to the point with ordinate equal to the stress $0{\cdot}8\ \sigma_{sy}$ and a curve starting from $0{\cdot}8\ \sigma_{sy}$ and defined by the following values of residual unit elongation :—

0·01 per cent for stress equal to $0{\cdot}85\ \sigma_{sy}$.

0·03 per cent for stress equal to $0{\cdot}90\ \sigma_{sy}$.

0·07 per cent for stress equal to $0{\cdot}95\ \sigma_{sy}$.

0·10 per cent for stress equal to $0{\cdot}975\ \sigma_{sy}$.

0·20 per cent for stress equal to σ_{sy}.

(*d*) The maximum strain in concrete may be assumed as 0·3 per cent for the purpose of calculations.

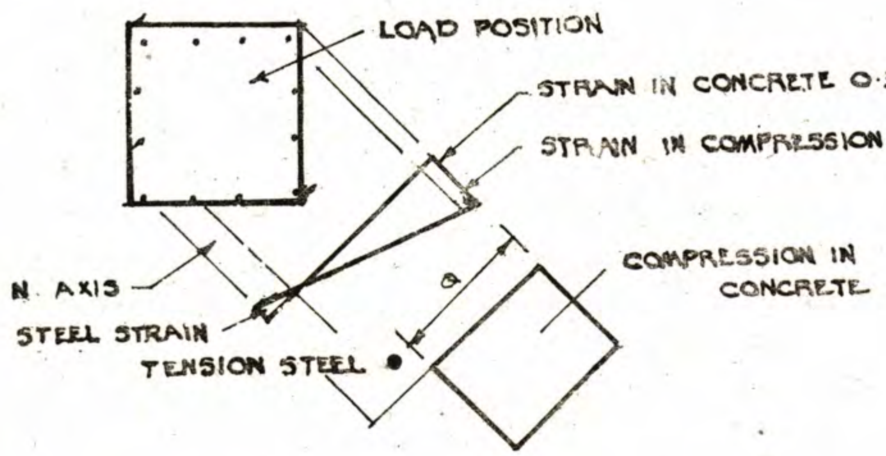
(*e*) Stress in compression steel should be determined by assuming maximum strain along the axis of most stressed reinforcement to be 0·002. Where the strain at the level of the reinforcement does not reach 0·002, the compatibility equation shall be used.

(*f*) The capacity of the section for combined direct load and bending moment should be determined from the following conditions:

(1) P=algebraic sum of the forces in concrete and steel, anp

(2) Moment of the external force P about any reference line= algebraic sum of the moments of forces in concrete and steel about the same reference line.

B.3.5. *Members subject to axial compression and bending in two planes* (*Skew bending*).—When he point of application of the resultant load does not lie along any of the two geometrical axes of the section it will be a case of combined direct load and bending in two directions.



The basic assumptions (*a*) to (*e*) of B.3.4 apply in this case also. In this case the neutral axis is so chosen that it satisfies the following conditions :—

(*a*) P=algebraic sum of forces in concrete and steel, and

(*b*) Moment of P about any two reference lines=algebraic sum of the moment of forces in concrete and steel about the same reference lines.

B.3.6. *Ultimate shear strength*.—Ultimate shear strength of reinforced concrete section without shear reinforcement both against transverse shear and torsion shall be calculated by taking the shear strength of concrete equal to two and a half times the permissible shear stress given in Table VI.

B.3.6.1. When the shear strength of a reinforced concrete section without shear reinforcement is not sufficient to resist the ultimate transverse shear and torsion, shear reinforcment should be provided as in 12 with the stress in shear steel limited to σ_{sy}.

B.3.7. *Ultimate bond strength*.—Ultimate bond strength to be assumed for ascertaining the local bond and anchorage shall be taken at 2·5 times the bond stresses permitted in Table VI.

B.3.8. *Control of cracking and deflection*.—Reinforced concrete members subject to bending shall be designed to have adequate stiffness to prevent deflections or other deformations which may adversely effect the strength or serviceability of the structure or produce unacceptable cracks in finishes or partitions carried by the structure.

B.3.8.1. Except when calculations of deflections prove that the lesser thicknesses may be used without adverse effects, the ratio of span to overall depth shall not be greater than that given in 6·5.

B.3.8.2. Beams with width of compression flange less than 1/30 of the span shall be adequately restrained laterally from buckling.

DESIGN OF SLABS SPANNING IN TWO DIRECTIONS AT RIGHT ANGLES.

C. 1 *Method* 1.

C·1·1. The bending moments in the slabs may be calculated assuming that the slab acts as a thin elastic plate and neglecting Poisson's ratio. These bending moments may be assessed either by the use of influence coefficients or ready made tables which are available, or by experimental stress analysis. The resisting moments of the slabs may be calculated by the commonly applied theory of thin plates.

C.2 *Method* 2.

C·2·1. Rectangular slabs which are two-way reinforced may be considered to be made of two sets of mutually perpendicular strips. The individual strip is to be considered as simply supported, fixed or continuous depending upon the support conditions of the slab. The uniformly distributed load w is carried between the strips in such proportions that the deflection at the centre of slab is same for both the middle strips. The bending moments calculated on this basis have to be corrected for torsion and corner restraint. Mid-span moments and edge moments for the different cases and span lengths of slabs are given in Table XIV and illustrated in Figure. The mid span moments shall be calculated as follows :—

$$M_x = \frac{wl_x^2}{m_x^2}$$

$$\text{and } M_y = \frac{wl_y^2}{m_y}$$

where

w = total uniformly distributed load per unit area.

l_x, l_y = lengths of sides (*See* Table XIV), and

m_x, m_y = coefficients given in table XIV.

C·2·2. If the slab is fixed at edge beams or is continuous, no torsional reinforcement need be provided at the corners. But for a slab which is neither continuous nor fixed at some of its edges the torsional reinforcement may be dropped only when the slab is designed for increased bending moment in accordance with Table XIV.

NOTE 1.—For approximately equal panels, smallest span not being less than 80 per cent of the largest, the negative B.M. at edges may be taken as

$$\frac{\alpha_x l_x^2}{8}, \quad \frac{\alpha_x l_x^2}{10}, \quad \frac{\alpha_x l_x^2}{12}$$

$$\frac{(1-\alpha_x)\, l_y^2}{8}, \quad \frac{(1-\alpha_x)\, l_y^2}{10}, \quad \frac{(1-\alpha_x)\, l_y^2}{12}$$

according to the position of the edge. The circled figures 8, 10 and 12 indicate the denominator for the negative moment expression for the corresponding edges. (Vide P 145)

NOTE 2.—Negative moments on the common edge from adjoining panels should be averaged.

NOTE 3.—When the panel length variation is more than 80 per cent, negative moment should be found as for a continuous beam, the appropriate values for share of loads in l_x, and l_y directions being taken.

NOTE 4.—Maximum and minimum moments can be conveniently found by placing live loads in alternate panels by use of the following equation :

Maximum moment = moment due to (dead load + half live load) + moment due to half live load acting vertically upwards and downwards in alternate panels.

Minimum moment = Do.

C·2·3. For slabs, edges of which are discontinuous, top and bottom reinforcement shall be provided for torsion at unrestrained corners for a length equal to one-fifth the slab span in each direction. Both top and bottom reinforcement shall consist of two layers of bars placed either perpendicular and parallel respectively to the diagonals through the corner or parallel to the respective slab edges. The area of reinforcement in each of the four layers, per unit width of the slab, shall be equal to main reinforcement at mid-span.

C·3· *Method* 3.

C·3·1. This method is based on mathematical analyses supplemented by experimental date. The effects of redistribution of bending moments have been partially allowed for. The following provisions shall apply for slabs restrained on four sides.

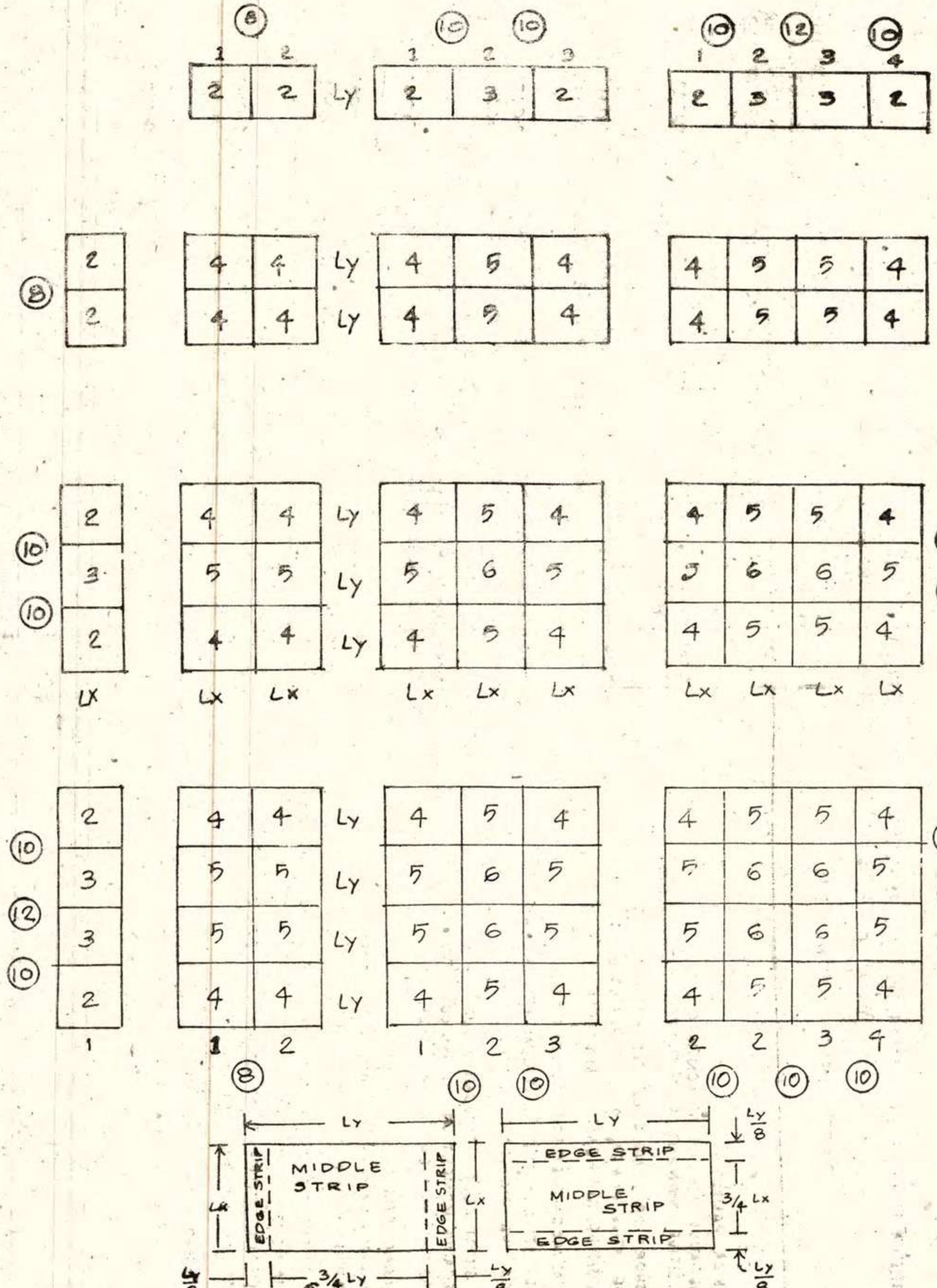
(*a*) Where the corners of a slab are prevented from lifting and adequate provision for torsion in accordance with (*e*) of this clause is made, the bending moments may be assumed to have the values given in accordance with (*b*) and (*c*) below :—

TABLE XIV MOMENT COEFFICIENTS FOR TWO WAY REINFORCED SLABS WITH AND WITHOUT TORSION REINFORCEMENT

l_y/l_x	1 αx_1	mx_1	my_1	2 αx_2	mx_2	my_2	3 αx_3	mx_3	my_3	4 αx_4	mx_4	my_4	5 αx_5	mx_5	my_5	6 αx_6	mx_6	my_6
0.6	0.115	98.8 / 60.5	12.3 / 10.4	0.245	88.8 / 59.0	13.7 / 11.9	0.393	87.6	16.1	0.115	146 / 133	18.9 / 17.4	0.206	138	20.7	0.115	229	29.8
0.7	0.194	61.6 / 49.5	14.8 / 11.9	0.375	59.1 / 46.3	17.2 / 14.7	0.546	63.7	21.6	0.194	90.2 / 80.7	21.6 / 19.5	0.324	90.7	24.8	0.194	139	33.4
0.8	0.291	44.3 / 33.9	18.1 / 13.9	0.506	44.7 / 34.6	21.9 / 18.7	0.672	50.4	29.6	0.291	62.2 / 54.6	25.4 / 22.4	0.450	66.3	31.0	[illegible]	94.5	38.8
0.9	0.396	34.1 / 25.4	22.4 / 16.6	0.621	35.7 / 27.9	28.8 / 24.2	0.766	42.5	40.6	0.396	46.6 / 40.5	30.6 / 26.6	0.568	52.5	39.4	0.396	70.1	46.0
1.0	0.500	27.4 / 20.8	27.4 / 20.2	0.714	29.9 / 23.9	36.8 / 31.8	0.833	37.5	55.7	0.500	37.2 / 32.2	37.2 / 32.2	0.667	44.2	50.6	0.500	55.7	55.7
1.1	0.594	22.8 / 16.9	33.3 / 24.8	0.785	26.0 / 21.44	47.5 / 2.0	0.880	34.2	75.5	0.594	31.1 / 27.0	45.5 / 39.6	0.745	38.9	65.2	0.594	46.8	68.5
1.2	0.675	19.4 / 14.7	40.3 / 30.6	0.838	23.3 / 19.6	61.5 / 55.0	0.912	31.9	102	0.675	27.0 / 23.7	56.0 / 49.2	0.806	35.3	84.2	0.675	40.9	85.0
1.3	0.741	17.0 / 13.2	48.5 / 37.6	0.877	21.4 / 18.4	78.8 / 71.0	0.934	30.3	135	0.741	24.2 / 21.4	69.0 / 61.0	0.851	32.8	103	0.741	36.9	105
1.4	0.794	15.2 / 12.1	58.4 / 46.6	0.906	20.0 / 17.6	100.0 / 91.5	0.951	29.2	176	0.794	22.1 / 19.8	85.0 / 76.0	0.885	31.0	138	0.794	34.1	131
1.5	0.835	15.9 / 11.3	70.2 / 57.5	0.927	19.0 / 17.0	127 / 118	0.961	28.3	227	0.835	20.6 / 18.7	104.0 / 95.0	0.910	29.7	175	0.835	32.0	162
1.6	0.868	12.9 / 10.9	84.5 / 70.6	0.942	18.2 / 16.5	159 / 148	0.970	27.6	288	0.868	19.5 / 17.8	128 / 117	0.929	28.7	219	0.868	30.6	200

NOTE—1 αx is the load coefficient for edge moment in lx direction, and $(1-\alpha x)$ is the load coefficient for edge moment in ly direction.

NOTE—2 Bottom figures under horizondal line for cases 1, 2 and 4 are the values of mx and when the required torsion reinforcement at the corner of discontinuous edge is not provided.



DIVISION OF A SLAB INTO MIDDLE AND EDGE STRIP

TABLE % V BENDING MOMENT CO-EFFICIENT FOR RECTANGULAR PANELS SUPPORTED ON FOUR SIDES WITH PROVISION FOR TORSION AT CORNERS (CLAUSE c-3-1)

CASE NO	TYPE OF PANEL AND MOMENTS	BENDING MOMENT COEFFICIENT Z_x FOR SHORT SPAN (VALUES OF L_y/L_x)								BENDING MOMENT COEFFICIENT Z_y FOR LONG SPAN (FOR ALL VALUES OF L_y/L_x)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1	INTERIOR PANELS									
	NEGATIVE MOMENT AT CONTINUOUS EDGE	0.033	0.040	0.045	0.050	0.054	0.059	0.071	0.083	0.033
	POSITIVE MOMENT AT MID SPAN	0.025	0.030	0.034	0.038	0.041	0.045	0.053	0.062	0.025
2	ONE SHORT OR LONG EDGE DISCONTINUOUS									
	NEGATIVE MOMENT AT CONTINUOUS EDGE	0.041	0.047	0.053	0.057	0.061	0.065	0.075	0.085	0.041
	POSITIVE MOMENT AT MID SPAN	0.031	0.035	0.040	0.043	0.046	0.049	0.056	0.064	0.031
3	TWO ADJACENT EDGES DISCONTINUOUS									
	NEGATIVE MOMENT AT CONTINUOUS EDGE	0.049	0.056	0.062	0.066	0.070	0.073	0.082	0.090	0.049
	POSITIVE MOMENT AT MID SPAN	0.037	0.042	0.047	0.050	0.053	0.055	0.062	0.068	0.037
4	TWO SHORT EDGES DISCONTINUOUS									
	NEGATIVE MOMENT AT CONTINUOUS EDGE	0.056	0.061	0.065	0.069	0.071	0.073	0.077	0.080	
	POSITIVE MOMENT AT MID SPAN	0.044	0.046	0.049	0.051	0.053	0.055	0.058	0.060	0.044
5	TWO LONG EDGES DISCONTINUOUS									
	NEGATIVE MOMENT AT CONTINUOUS EDGE									0.056
	POSITIVE MOMENT AT MID SPAN	0.044	0.053	0.060	0.065	0.068	0.071	0.077	0.080	0.044
6	THREE EDGES DISCONTINUOUS (ONE SHORT OR LONG EDGE CONTINUOUS)									
	NEGATIVE MOMENT AT CONTINUOUS EDGE	0.058	0.065	0.071	0.077	0.081	0.085	0.092	0.098	0.058
	POSITIVE MOMENT AT MID SPAN	0.044	0.049	0.054	0.058	0.061	0.064	0.069	0.074	0.049
7	FOUR EDGES DISCONTINUOUS									
	POSITIVE MOMENT AT MID SPAN	0.050	0.057	0.062	0.067	0.071	0.075	0.081	0.083	0.050
	$\frac{l_y}{l_x}$	1.0	1.1	1.2	1.3	1.4	1.5	1.75	2.00	

(*b*) Slabs are considered as being divided in each direction into middle strips and edge strips as shown in Figure 16 the middle strips having a width of three-quarters the width of the slab and each edge strip having a width of one-eighth of the width of the slab, with the provision that no edge strip should exceed $\frac{l_x}{2}$ in width.

(*c*) The maximum bending moments per unit width in the middle strip of a slab are given by the following equations :

$$M_x = Z^1{}_x \, Wl_x^2.$$

$$\text{and } M_y = Z^1{}_y \, Wl_y^2.$$

Where

M_x = Maximum bending moments on strips of unit width in the direction of span l_x.

M_y = Maximum bending moments on strips of unit width in the direction of span l_y.

$Z^1{}_x$ = Coefficients shown in Table XV.

$Z^1{}_y$ = Do.

w = total load per unit area.

l_y = length of the longer span, and

l_x = length of the shorter span.

(*d*) No reinforcement parallel to the adjacent edges of the slab need be inserted in the edge strips above that required to comply with 9·2·1·1; 18·3, 18·3·4 and (*e*) of this clause.

(*e*) Torsion reinforcement should be provided at the corners of a slab except at corners contained by edges over both of which the slab is continuous.

At corners contained by edges over neither of which the slab is continuous, top and bottom reinforcement should be provided for torsion at the corners of the slabs. Both top and bottom reinforcement should consist of two layers of bars placed parallel to the sides of the slab and extending in these directions for a distance of one-fifth of the shorter span. The area of the bars in each of the four layers, per unit width of the slab, should be three-quarters of the area required for the maximum positive moment in the slab.

At corners contained by edges over only one of which the slab is continuous, the torsional reinforcement may be reduced to one-half of that required by the preceding paragraph.

Any reinforcement provided for the purpose of complying with other clauses of this code may be included as part of the reinforcement required to comply with this clause.

(*f*) Where a slab ends and there is monolithic connection betwee the slab and the supporting beam or wall, provision shall be made for the negative moments that may occur in the slab at such support. The negative moment to be assumed in these cases depends on the degree of fixity afforded to the edge of the slab, but for general purposes it may be taken as two-thirds of the moment given in Table XV for the mid-span of the slab.

C·4. *Method 4:*

C·4·1. This method is based on the ultimate load method of design. The ultimate load should be obtained by using the load factors as given in B·3·1·1. The ultimate bending moments to be allowed should be deduced from the analysis in which due regard is given to redistribution of moments that would occur before failure of slab or beam, by the use of Johansen's yield line theory or by any other applicable method. The resistance moments of the slab and beam section should be calulated in accordance with B·3·2.

EXTRACT FROM I.S. 456—1978.

(*Code of practice for plain and reinforced concrete.*)

0.4. This revision incorporates a number of important changes. The major thrust in the revision is on the following lines :—

(*a*) Whilst designers are aleady aware of the need for basing designs on requirements of adequate strength and satisfactory serviceability, the concept of limit state which provides a rational approach, taking into account variations in material strengths and loads on semi-probabilistic basis has now been introduced. This, in fact is a rationalization of the ultimate load method which was briefly covered in Appendix B of IS: 456-1964. The working stress method as practised earlier has been retained with the design for shear and torsion being aligned with the corresponding provisions for limit state method of design.

(*b*) The clauses dealing with sampling and acceptance criteria for concrete have been revised by elaborating the concepts of statistical quality control and introducing characteristic strength of concrete, to bring it in line with the latest trends in quality control of concrete.

(*c*) Method of design for shear and torsion has been completely revised, incorporating the results of the latest research on the subject.

(*d*) The concept of development length for reinforcement has been introduced. The requirement regarding checking of local bond streass has now been replaced by an extension of the concept of development length.

0.4.1. The significant changes incorporated in section 2 are as follows:

(*a*) The additional materials now permitted are more types of cement, pozzolanas, light weight aggregates, and cold twisted deformed bars of Grade F. 500.

(*b*) Regarding durability, guidance concerning minimum cement-content and maximum water cement ratio for different environmental conditions, including types of cement to be used for resisting sulphate attack has been given in an appendix. Limitations on the toatal chloride and sulphate content of concrete have also been given.

(*c*) Information regarding properties of concerete such as modulus of elasticity, tensile strength shrinkage, creep and co-efficient of thermal expansion has been given for guidance.

(*d*) Rcecommendations regarding construction tolerances relating to form work and placing of steel have been given.

(*e*) Recommendation regarding acceptance criteria for hardened concrete represented by core tests has been given.

(*f*) The clauses on load testing of structures have been modified.

0.4.2. Section 3 on general design requirements has grouped together design rules which are generally applicable to all structures designed by any method. The significant changes incorporated in Section 3 are as follows :—

(a) Recommendations regarding prototype testing have been added.

(b) Recommendations regarding stability of the structures as a whole have been given in addition to the one regarding the stability of overhanging members.

(*c*) Some recommendations regarding frame analysis such as substitute frames have been given.

(d) The rules for effective width of flange for T and L beams have been changed.

(e) The recommendation regarding slender beams have been changed.

(f) The slenderness limits for columns have been changed.

(g) Minimum eccentricity for the design of compression members has been specified.

(h) Rules governing the use bundled bars have been added.

(j) Curtailment rules for reinforcement in beams and slabs have been given.

(k) Recommendations regarding critical sections for shear and minimum web reinforcement have been added.

(m) The recommendation regarding minimum tensile reinforcement in beams has been modified.

(n) Recommendations regarding side face reinforcement n beams have been added.

(p) The clause on span to depth ratio for controlling deflection has been modified and elaborated to take into account the type and percentage of reinforcement provided. Method for calculating the short term as well as long term deflection has been added.

(q) Detailing rules for crack control have been given in tne code. These rules are expected to lead to a satisfactory design for most of the structures under normal environmental conditions. Detailed investigat ons of crack width may however be required for unusual cases or structures in aggressive environments.

(r) Guidance on the determination of effective length of columns in framed structures has been added.

0.4.3. Section 4 includes special design requirements for structures such as flat slabs, deep beams, etc, and these are in addition to superseding the rules of Section 3, as applicable. The significant changes incorporated in Section 4 are as follows :

(a) Recommendations for the design of deep beams have been added.

(b) Guidance for the design of ribbed and voided slabs has been included.

(c) The clauses on design of flat slabs have been revised. Shear in flat slabs and openings in flat slabs are now covered in some detail.

(d) The clauses on footings have also undergone some changes regarding design for shear and transfer of load at the base of the column.

0.4.4. In Section 5 on limit state method, a unified approach has been made to cover members in flexure and flexure combined with axial force. A method for design of compression members wih biaxial bending has also been added. Slenderness effects are taken into account by augmenting the moments to be considered in design.

0.4.5. In Section 6 on working stress method, the permissible stresses in steel have been modified to make them more rational and to reflect the provisions of the basic standards on steel. Permissible stresses in concrete for shear have been completely revised in order to bring the procedure for design in accordance with the recommendations in Section 5. Values of local bond stresses have been deleted as these are not required according to the new rules given in Section 3. Values of bearing stress in concrete have also been deleted from the table of permissible stresses, since it has been given in the clause on design of footings in Section 4.

1. *Scope* :

1.1 This code deals with the general structural use of plain and reinforced concrete.

1.2. Special requirements of structures, such as shells, folded plates, arches, bridges, chimneys, blast resistant structures, hydraulic structures and liquid retaining structures, covered in respective codes have not been covered in this code ; these codes shall be used in conjunction with this code.

2. *Terminology :*

2.1. For the purpose of this standard, the definitions given in IS : 4845-1968 and IS : 6461 (Parts I to XII) shall generally apply.

3. *Symbols :*

3.1. For the purpose of this standard, the following letter symbols shall have the meaning indicated against each ; where other symbols are used, they are expalined at the appropriate place :

A	Area
b	Breadth of beam, or shorter dimension of a rectang ula column.
be	Effective width of slab
bf	Effective width of flange
bw	Breadth of web or rib

12.3.1. In case of sections made up of rectangles, shear stress is maximum at the middle of the longer sides of rectangles.

12.4. *Design for shear.*—In proportioning and reinforcing a reinforced concrete section subjected to shear, the following conditions shall be satisfied :—

(*a*) No shear reinforcement is necessary if—

$q + q^1 \ngtr$ permissible shear stress as given in Table VI.

Note 1.—It is a practice to provide nominal shear reinforcement in the whole span of the beam in the form of stirrups at a pitch not greater than the lever arm, even if q + q' is less than the permissible shear stress in concrete.

Note 2.—In the case of slender beams, however, requirements specified in 12.4.5. shall apply.

(*b*) Provide full shear reinforcement to resist the whole shearing force due to transverse shear and the shear resulting from torsion if—

$q + q^1 >$ permissible shear stress as given in Table VI.

(*c*) Redesign the section if—

$q + q^1 >$ four times the permissible shear stress as gvien in Table VI.

Where

q=Shear stress on the section due to transverse shear calculated in accordance with 12.2.

q^1=shear stress on the section resulting from torsional moment calculated in accordance with 12.3.

12.4.1. Reinforcement for resisting transverse shear shall be calculated in accordance with 12.4.2. and 12.4.3.

12.4.2. *Shear reinforcement.*—

12.4.2.1. A stirrup in reinforced concrete shall pass round or be otherwise adequately secured to the appropriate tensile reinforcement and such stirrup should have both its ends anchored properly.

12.4.2.2. Tensile reinforcement which is inclined and carried through the depth of beam equal to the lever arm of the resisting moment shall be considered also to act as shear reinforcement provided it is anchored sufficiently.

12.4.2.3. Where two or more types of shear reinforcement are used in conjunction, the total shearing resistance of the beam shall be assumed to be the sum of the sharing resistances computed for each type separately.

12.4.2.4. The spacing of stirrups shall not exceed a distance equal to the lever arm of the resisting moment. The reistance to shear Q shall then be calculated from the following equation :—

$$Q = \frac{ss\ Aw\ jd}{S}$$

Where

σ_{ss}=permissble tensile stress in the shear reinforcement.

Aw=total cross sectional area of the stirrup legs effective in shear.

jd=lever arm of the resisting moment, and

S=pitch or spacing of stirrups.

12.4.2.5. When the shear reinforcement consists of a single bent bar or of a group of bent bars, the total shear resistance Q of such bar or bars shall be calculated from the formula :—

$$Q = \sigma_{ss} As \ \sin \alpha$$

Where

σ_{ss}=permissible tensile stress in the shear reinforcement.

As=total cross sectional area of the bent bar or bars, and

α=angle between the inclined bar and the axis of the beam

12.4.2.6. The resistance to shear at any section of a beam reinforced with inclined bars may be calculated on the assumption that the inclined bars form the tension members of one or more single system of lattice girders in which the concrete forms the compression members. The shear resistance at any vertical section shall then be taken as the sum of the vertical components of the tension and compression forces cut by the section. Care shall be taken that such assumptions do not involve greater stresses in the horizontal portion of the inclined bars than the permissible stresses.

12.4.3. *Beams of varying depth.*—The equation for shear stress given under 12.2. strictly applies to beams of uniform depth. In the case of beams of varying depth, the equation shall be modified as:—

$$q = \frac{Q \pm \frac{M}{d} \tan \beta}{bjd}$$

Where

q=shear stress at a section of varying depth.

Q=shear at the section.

M=bending moment at the section.

d=effective depth at the section.

β= angle between the top and the bottom edges of the beam

b=breadth of the beam, and

jd=lever arm.

The negative sign in the formula applies when the bending moment M increases numerically in the same direction as the effective depthd increases, and the positive sign when the moment decreases numerically in this direction.

12.4.4. *Reinforcement for shear due to torsion.*—Reinforcement for resisting shear resulting from torsional moments shall be provided in the form of stirrup and longitudinal bars and shall be calculated in accordance with 12.4.4.1. and 12.4.4.2.

12.4.4.1. Stirrup reinforcement for resisting shear resulting from torsional moments shall be situated as near to the surface of concrete as possible :—

(*a*) In case of rectangular section the area of the two legs in a closed stirrup shall be calculated by the equation :—

$$Aw = \frac{Mts}{0.8\ \sigma_{ss}\ X_1 Y_1}$$

Where—

Mt=δtorsional moment.

s=pitch.

σ_{ss}=permissible tensile stress in the shear reinforcement.

$X_1 Y_1$=sides of the rectangular stirrup, and

Aw=total cross sectional area of the two legs of the rectangular stirrup.

(*b*) In case of box sections the area of the two legs in any arm of the box shall be caluclated by the equation :

$$Aw = \frac{Mts}{\sigma_{ss}\ X_1 Y_1}$$

Where

$X_1 Y_1$—sides of the rectangle representing the mean of the areas enclosed by the inner and outer boundaries of the tube (or) box.

12.4.4.2. For resisting the diagonal tension resulting from the torsional shear, longitudinal steel shall be provided in addition to the stirrups as stated in 12.4.4.1. Longitudinal steel shall be provided as near to the surface of concrete as possible and shall have the same volume per unit length as the volume contained in the corresponding legs of the stirrups.

12.4.5. *Shear stress in slender beams.*—In slender beams, irrespective of the magnitude of the shear stress, the whole shearing resistance shall be provided by shear reinforcement.

18. *Requirements governing detailing.*

18.1. *Detailing of reinforcement.*—In addition to provision of adequate anchorage length and cover, and compliance with I. S. 2502-1963 Code of Practice for bending and fixing of bars for concrete reinforcement, the following precautions should be taken in detailing the reinforcement:—

(*a*) Tension reinforcement should be either carried over the supports or shall be bent so that it shall end in the zone of compression or in case of deep beams in the zone and reduced tension.

(*b*) If a change in the direction of tension or compression reinforcement induces a third force acting outward tending to split the concrete, such force should be taken up by additional or links stirrups. Bent tension member at a re-entrant angle should be avoided.

(*c*) Tendency to buckling of compression reinforcement shall be resisted by provision of restraints like ties and stirrups.

(*d*) Where laps and joints are provided in the reinforcing bars, they shall be staggered and the following requirements should generally be satisfied:—

(1) No splices of reinforcement shall be made except as shown on the design drawings or as specified by the engineer-in-charge.

(2) *Splices in tensile reinforcement.*—Splices at points of maximum tensile stress shall be avoided wherever possible, splices where used shall be welded, lapped or otherwise fully developed. In any case the splice shall transfer the entire computed stress from bar to bar and shall comply with the requirements specified in 18.4.3. Lapped splices in tension shall not be used for bars of sizes larger than 36 mm diameter, such splices shall preferably be welded.

For contact splices, spaced laterally closer than 12-bar diameters or located closer than 15 cm. or 6-bar diameters from the outside edge, the lap shall be increased by 20 per cent or stirrups or closely-spaced spirals shall enclose the splice for its full length.

Where more than one-half of the bars are spliced within a length of 40-bar diameter or where splices are made at points of maximum stress, special precautions shall be taken, such as increasing the length of lap and/or using spirals or closely spaced stirrups around and for the length of the splice.

(3) *Splices in compression reinforcement.*—Where lapped splices are used, the lap lengths shall conform to the requirements of 18.4.3.3. Welded splices or other positive connections may be used instead of lapped splices. Where bar size exceeds 36 mm. diameter, welded splices or other positive connections shall preferably be used. In bars required for compression only, the compressive stress may be transmitted by bearing of square cut ends held in concentric contact by a suitably welded sleeve or mechanical device.

In columns where longitudinal bars are offset at a splice, the slope of the inclined portion of the bar with the axis of the column shall not exceed 1 in 6, and the portions of the bar above and below the offset shall be parallel, to the axis of the column. Adequate horizontal support at the offset bends shall be treated as a matter of design, and shall be provided by metal ties spirals or parts, of the floor construction. Metal ties or spirals so designed shall be placed near (not more than eight-bar diameters from) the point of bend. The horizontal thrust to be resisted shall be assumed as $1\frac{1}{2}$ times the horizontal component of the nominal stress in the inclined portion of the bar. Offset bars shall be bent before they are placed in the forms. Where column faces are offset 7.5 cm. or more splices of vertical bars adjacent to the offset face shall be made by separate dowels overlapped as specified above.

(4) *Approved welded splices and positive connection*—An approved welded splice is one in which the bars are battered and welded so that it will develop in tension at least 125 per cent of the specified yield strength of the reinforcing bar. Approved positive connections for bars designed to carry critical tension or compression shall be equivalent in strength to an approved welded splice.

(5) *Splices in metal cores in composite columns.*—Metal cores in composite columns shall be accurately milled at splices and positive provision shall be made for alignment of one core above another. At the column base, provision shall be made to transfer the load to the footing at safe unit stresses in accordance with Table VI. The base of the metal section shall be designed to transfer the load from the entire composite column to the footing, or it may be designed to transfer the load from the metal section only provided it is so placed in the pier or pedestal as to leave ample section of concrete above the base for the transfer of load from the reinforced concrete section of the column by means of bond on the vertical reinforcement and by direct compression on the concrete.

(6) *Splices in welded wire fabric.*—Lapped splices of wires in region of maximum stress (where they are carrying more than one-half of the permissible stress) shall be avoided wherever possible; such splices, where used shall be so made that the overlap measured between outermost cross wires of each fabric sheet is not less than the spacing of the cross wire plus 10 cm. Splices of wires stressed at not more than one-half the permissible stress shall be so made that the overlap measured between outermost cross wires is not less than 10 cm.

(*e*) Where reinforcement bars are bent aside at construction joints and afterwards bent back into approximately their original positions, care should be taken to ensure that at no time is the radius of the bend less than 4 bar diameters for plain mild steel or 6 bar diameters for deformed bars. Care shall also be taken when bending back bars, particularly in light weight aggregate concrete, to ensure that the concrete around the bar is not damaged.

18.2. *Cover.*—Reinforcement shall have concrete cover and the thickness of such cover (exclusive of plaster or other decorative finish) shall be as follows :—

(*a*) At each end of reinforcing bar not less than 25 mm. or less than twice the diameter such rod or bar ;

(*b*) For a longitudinal reinforcing bar in a column not less than 40 mm, nor less than the diameter of such rod or bar. In the case of columns of minimum dimension of 20 cm. or under, whose reinforcing bars do not exceed 13 mm, the cover of 25 mm, may be used;

(*c*) For longitudinal reinforcing bar in a beam not less than 25mm nor less than the diameter of such rod or bar;

(*d*) For tensile, compressive, shear, or other reinforcement in a slab, not less than 13 mm, nor less than the diameter of such reinforcement ; and

(*e*) For any other reinforcement not less than 13 mm, nor less than the diameter of such reinforcement.

18.2.1. Increased cover thickness may be provided when surface of concrete members are exposed to the action of harmful chemical as in case of concrete in contact with earth faces contaminated with such chemicals, acid vapour, saline atmosphere, Sulphurous Smoke (as in case of steam operated railways), etc., and such increase of over may be between 15 mm. and 40 mm. beyond the figures given in 18.2 as may be specified by the engineer-in-charge.

18.2.2. For reinforced concrete members, totally or periodically immersed in sea-water or subject to sea spray, the cover of concrete shall be 50 mm. more than that specified in 18.2.

18.2.3. Protection to reinforcement in case of concrete exposed to harmful surroundings as mentioned in 18.2.1. and 18.2.2. can also be given by providing a dense concrete impermeable to water. The engineer-in-charge may reduce the extra cover mentioned in 18.2.1. and 18.2.2. if the concrete mix is designed to ensure impermeable concrete.

18.3. *Spacing of reinforcement.*—The horizontal distance between two parallel main reinforcement bars in reinforced concrete shall usually be not less than the greatest of the following :

(*a*) The diameter of the bar if the diameters are equal,

(*b*) The diameter of the larger bar if, the diameters are unequal, and

(*c*) 6 mm. more than the nominal maximum size of the coarse aggregate used in the concrete.

Note.—This does not preclude the use of larger size of aggregates beyond the congested reinforcement in the same number; and size of the coarse aggregates may be reduced around the congested reinforcement to comply with the above provisions.

18.3.1. Greater horizontal distance than the minimum specified in 18.3 should be provided, where possible. However, when needle vibrators are intended to be used, the horizontal distance between bars of a group may be reduced to two-thirds of the nominal maximum size of the coarse aggregate provided that sufficient space is left between groups of bars to enable the vibrator to be immersed.

18.3.2. The minimum vertical distance between two horizontal main reinforcing bars shall normally be 15 mm. the maximum size of the coarse aggregate or the maximum size of the bar whichever is the greatest. In locations where reinforcement is congested grouping of bars by touching one another may be permitted provided the requirements of minimum horizontal distance as specified in 18.3. are complied with the provided further that bond length is adequately increased.

18.3.3. The pitch of bars of main tensile reinforcement in solid slabs shall be not more than three times the effective depth of such slab or 600 mm whichever is smaller.

18.3.4. The pitch of distributing bars in a reinforced concrete solid slab or the pitch of bars provided against shrinkage and temperature shall be not more than five times the effective depth of such slab or 600 mm whichever is smaller.

18.3.5. In the case of bars which are not round or in the case of deformed or crimped bars, the diameter shall be taken for the purpose of this clause as the diameter of a circle giving an equivalent effective area.

466—3—18A

18.4. *Bond and anchorage:*

18.4.1. *Local bond stress.*—The local bond stress calculated from the following equation shall not exceed the value for permissible local bond stress given in Table VI :—

$$\sigma bl = \frac{Q \pm \frac{M}{d} \tan \beta}{jd\ \Sigma 0}$$

Where

Q = Maximum shear force at the section under consideration,

M = bending moment at the section,

d = effective depth,

β—the angle between the top and bottom faces of the beam,

jd = lever arm, and

$\Sigma 0$ = total perimeter of the tension bars actually at the section with the lever arm jd.

NOTE.—The positive sign applied where the bending moment decreases numerically with the increase in 'd' (as at haunches of freely supported beams); the negative sign applies when the bending moment increases numerically with the increase in 'd' (as at haunches adjacent to the interior supports of continuous beams).

When the beam is of uniform depth throughout or the top and bottom edges are parallel, the expression reduces to

$$\text{Local bond stress } \sigma bl = \frac{Q}{jd\ \ \Sigma 0}$$

Where

Q, jd and $\Sigma 0$ are as defined above.

18.4.2. *Anchorage.*—A bar used as reinforcement shall have adequate anchorage on both sides of any section of the bar so as to develop the designed force in the bar at that section.

18.4.3. *Anchorage length.*—Anchorage length of a reinforcing bar shall be considered adequate if the conditions given in 18.4.3.1, 18.4.3.2. and 18.4.3.3. are satisfied in the respective cases.

18.4.3.1. *Bars in tension.*—In the tensile reinforecement the length measured from any section to the end of the bar plus the equivalent anchorage value of the hook or any other anchorage (*see* 18.4.4. and 18.4.5.) shall be such that the average bond stress induced to develop the actual stress at the section shall not exceed the permissible average bond stress given in Table VI.

In the case of the tensile reinforcement of circular cross-section, the length measured from such section upto the beginning of the hook shall at least be equal to 'n' times the diameter of the bar minus the value of the hook as given in 18.4.5.1.

Where

$$n = \frac{\text{actual tensile stress in the bar}}{\text{four times the permissible average bond stress given in Table VI.}}$$

In no case shall such value of 'n' be less than 12.

18.4.3.2. *Bars in compression.*—In compressive reinforcement, the length measured from any section to the end of the bar shall be such that the average bond stress induced to develop the actual stress at the section shall not exceed one and a quarter times the permissible average bond stress given in Table VI.

In the case of compressive reinforcement of circular cross-section, the length measured from such section shall at least be equal to 'n' times the diameter of bar.

Where

$$n = \frac{\text{actual compressive stress in the bar}}{\text{five times the permissible average bond stress given in Table VI.}}$$

In no case shall the value of 'n' be less than 12.

No hook need be provided for a bar in compression ; and if one is provided, it shall not be accounted for anchorage purposes.

18.4.3.3. *Laps in bars.*—The length of lap in reinforcement shall not be less than :

(*a*) For bars in tension :

$$\text{bar diameter X } \frac{\text{actual tensile stress}}{\text{four times the permissible average bond stress given in Table VI.}}, \text{ or}$$

30-bar diameters whichever is greater.

(*b*) For bars in compression :

$$\text{bar diameter X } \frac{\text{actual compressive stress}}{\text{five times the permissible average bond stress given in Table VI.}}, \text{ or}$$

24-bar diameters whichever is greater.

18.4.3.4. *Lap length for reinforcement of sections other than circular.* For reinforcement of sections other than circular, the lap length should be sufficient to develop by bond the actual stress in the bar or two-thirds the maximum permissible stress in that bar whichever is greater.

18.4.3.5. *Anchorage value of bars.*– Anchorage value of a straight bar shall be taken at not more than the perimeter area of the bar multiplied by the appropriate permissible average bond stress given in Table VI.

18.4.4. *Anchorage value of bends.*– A bend in a reinforcing bar may be assumed to have an anchorage value equivalent to that of the length of bar equal to four time the diameter of the round bar for each 45° the bar is bent, provided that ;—

(*a*) the radius of the bend be not less than twice the diameter of the round bar ;

(*b*) the length of the straight part of the bar beyond the end of the curve be at least four times the diameter of the rund bar ; and

(*c*) whatever the angle through which the bar is bent, the assumed anchorage value of the bend should not be taken as more than equivalent to a length of bar equal to sixteen times the diameter of the round bar.

NOTE.– In the case of deformed bars and bars which are not circular in section, the diameter may be taken as nominal size of the bars.

13.4.5. *Hooks and other anchorages.*—Hooks and other anchorages of reinforcement in reinforced concrete shall be of such form, dimensions and arrangement as will ensure their adequacy without overstressing the concrete or the steel.

18·4·5·1· *Dimensions of hooks.*—For plain mild steel reinforceing bars, when hooks are used they should be of the U-type or L-type, but usually the U-type. The dimensions of hooks shall be such that they satisfy the requirements specified in 18.4.4.

For further details about bends and hooks, reference to I.S. 2502–1963 may be made.

Deformed bars may be used without hooks, provided anchorage requirements are adequately met with. Where hooks are for med in deformed bars (*see* 8.1.4.), the internal radius of the bend should be at least three times the diameter of the bar. The length of straight bar beyond the end of the curve should be at least four times the diameter of the bars.

18.4.6. *Bearing stresses in concrete.*– In bends in reinforcing bars, the local stress on the concrete may be increased to three times the value specified in Table VI for the concrete in direct compression.

18·4.7. *Mechanical devices or anchorage.*– Any mechanical or other device capable of developing the strength of the bar without damage to concrete may be used in lieu of anchorage with the approval of the engineer-in-charge. Welding to longitudinal reinforecement provision of anchor plates, provision of anchor pin not less than the diameter of the bar, coupling in lieu of laps, etc. are some of the devices which may be found useful.

18·4·8. *Secondary reinforcement.*—Notwithstanding any of the provisions of this code, in the case of secondary reinforcements, such as stirrups and transverse ties, complete bond lengths and anchorage shall be deemed to have been provided when the bar is bent through an angle of at least 90° round a bar of at least its own diameter and is continued beyond the end of the curve for a length of at least eight diameters, or alternatively, when the bar is bent through an angle of 180° and is continued beyond the end of the curve for a length of at least four bar diameters.

18.4.9. *Anchorage of inclined bars for resisting shear.*—Inclined reinforcing bars used to act as shear reinforcement shall have their anchorage lengths measured as under :

(*a*) In the tension zone from the end of the sloping or inclined portion of the bar, and

(*b*) in the compression zone from mid depth of the beam.

18.5. *Compression reinforcement in beams.*—The compression reinforcement shall be effectively anchored in two directions at right angles over the distance where it is required to act in compression, at points not further apart, centre-to-centre, than 16 times the diameter of the anchored bar or 48 times the diameter of the anchoring bar whichever is less. The secondary reinforcement used for this purpose should pass round, or be hooked over, both the compressive and tensile reinforcement and shall further comply with the requirements of 10·3·1·1. to 10.3.1.4.

18·5·1. *Percentage of compression reinforcement.*—The percentage of steel in compression should preferably not exceed 4 per cent, but if it does, only 4 per cent should be allowed for in the calculation of the resisting moment of the beam. This percentage should be calculated on the basis of total cross-sectional area of a rectangle of depth and width equivalent to the maximum depth and width of the beam. In the case of T- and L-beams maximum width of the beam shall be maximum width of the rib.

18·6. *Extending positive reinforecement beyond the face of support.*— In any beam at least one-quarter of the positive reinforcement shall be extended beyond the face of the support so as to provide an embedment sufficient to develop one-third of the allowable stress in the bar.

18·7. *Column reinforcement.*—In a helically reinforced column the longitudinal bars shall be in contact with the helical reinforcement and equidistant around its inner circumference.

18·7·1· *Splice in longitudinal reinforcement.*—At a splice in a longitudinal reinforcement, the spliced bars shall overlap longitudinally through a distance of not less than the lap length given in 18·4·3·3 (b).

19. *Expansion joints* :

19.1. In view of the large number of factors involved in deciding the location, spacing and nature of expansion joints, the provision of expansion joint in reinforced cement concrete structures should be left to the discretion of the reinforced concrete designer.

19.2. For purposes of general guidance, however, it is recommended that structures exceeding 45 m. in length shall be divided by one or more expansion joints. Structures in which marked changes in plan dimensions take place abruptly shall be provided with expansion joints at the section where such changes occur. Expansion joints shall be so provided that the necessary movement occurs with a minimum resistance at the joint. The structures adjacent to the joint should preferably be supported on separate columns or walls but not necessarily on separate foundations. Reinforecement shall not extend across an expansion joint and the break between the section shall be complete.

19.3. The details as to the length of a structure where expansion joints have to be provided can be determined after taking into consideration various factors, such as temperature, exposure to whethers the time and season of the laying of the concrete, etc. Under no circumstances shall a structure of 45m or more be without an expansion joint.

20. *Workmanship—*

20.1. *Concrete—*

20.1.1. *Measuring.*—The quantity of cement shall be determined by weight. Ordinary Portland cement shall be taken to weigh 1440 kg/m^3, and rapid-hardening Portland cement to weigh 1210kg/m^3. The quantities of fine and coarse aggregates shall be determined either by volume or preferably by weight. The proportions given in Table III are based on the assumption that the aggregates are dry. If aggregates are wet, due allowance shall be made for bulking in accordance with I. S. 2386 (Part III) 1963 Methods of Test for Aggregates for Concrete; Part III Specific Gravity, Density, Voids, Absorption and Bulking.

20.1.2.—*Mixing.*—Concrete shall normally be mixed in a mechanical mixer.

20.1.2.1. Mixing shall be continued until there is a uniform distribution of the materials and the mass is uniform in colour and consistency, but in no case shall the mixing be done for less than two minutes.

20.1.2.2. When hand mixing is permitted by the engineer-in-charge it shall be carried out on a water-tight platform and care shall be taken to ensure that mixing is continued until the mass is uniform in colour and consistency.

20.1.3. *Transporting.*—Concrete shall be handled from the place of mixing to the place of final deposit as rapidly as practicable by methods which will prevent the segregation or loss of any of the ingredients. If segregation does occcur during transport, the concrete shall be re-mixed before being placed.

20.1.3.1. During hot or cold weather, concrete shall be transported in deep containers, on account of their lower ratio of surface area to mass, reduce the rate of loss of water by evaporation during hot weather and loss of heat during cold weather.

20.1.4. *Placing and compacting—*

20.1.4.1. *General.*—The concrete shall be placed and compacted. before setting commences and should not be subsequently disturbed method of placing should be such as to preclude segregation.

20·1·4·2. *Construction joints.*—Concreting shall be carried out continuously up to construction joints, the position and arrangement of which shall be predetermined by the designer.

When the work has to be resumed on a surface which has hardened, such surface shall be roughened, It shall then be swept clean, thoroughly wetted,and covered with a 13 mm. layer of mortar composed of cement and sand in the same ratio as the cement and sand in the concrete mix. This 13 mm. layer of mortar shall be freely mixed and placed immediately before the placing of the concrete.

Where the concrete has not fully hardened, all laitance shall be removed by scrubbing the wet surface with wire or bristle brushes, care being taken to avoid dislodgement of particles of aggregate. The surface shall be thoroughly wetted and all free water removed. The surface shall then be coated with neat cement grout. The first layer of concrete to be placed on this surface shall not exceed 150 mm. in thickness, and shall be well rammed against old work, particular attention being paid to corners and close spots.

20·1·4·3. *Compacting.*—Concrete shall be thoroughly compacted, during the operation of placing, and thoroughly worked around the reinforcement, around embedded fixtures and into corners of the form work.

20·1·4·4. *Mechanical vibration.*—The use of mechanical vibrators for compacting concrete is recommended, provided that the reduced water content recommended under 5·3·3·3. is adopted. Over-vibration or vibration of very wet mixes is harmful and should be avoided.

20·1·5. *Curing.*—The concrete shall be covered with a layer of sacking, canvas, hessian or similar absorbent materials, and kept constantly wet for seven days from the date of placing of concrete. Alternatively, the concrete being thoroughly wetted may be covered by a layer of approved waterproof materials which should be kept in contact with it for seven days.

20·1·6. *Work in extreme weather—*

20·1·6·1. When depositing concrete at or near freezing temperature, precautions shall be taken to ensure that the concrete at the time of placing has a temperature of at least 4·5° C and that the temperature of the concrete after having been placed and compacted is maintained above 2° C until it has thoroughly hardened. When necessary, concrete materials should be heated before mixing and carefully protected after placing in general, heating of mixing water alone to about 60°C may be sufficient for this purpose. Dependence should not be placed on salt or other chemicals for the prevention of freezing Calcium chloride, upto 1½ per cent of the weight of cement, may be used to accelerate the rate of hardening. Use of calcium chloride in excess of 1½ per cent is harmful. No frozen material, or materials containing ice shall be used. All concrete damaged by frost shall be removed. It is recommended that concrete exposed to the action of freezing weather should have entrained air and the water content of the mix should not exceed 30 litres per 50 kg. of cement.

20·1·6·2. When depositing concrete in very hot weather, precautions shall be taken to see that the temperature of wet concrete does not exceed 30° C while placing.

20.1.7. Sub-aqueous concrete.

20.1.7.1 When it is necessary to deposit concrete under water, the methods, equipment, materials and proportions of the mix to be used shall be submitted to and approved by the engineer in charge before the work is started. In no case shall such concrete be considered as controlled concrete.

20.1.7.2 Concrete shall not be placed in water having a temperature below 4·5°C. The temparature of concrete, when deposited shall be not less than 16°C, not more than 38°C.

20·1·7·3. The concrete shall contain at least 10 per cent more cement than that required for the same mix placed in the dry, the quantity of extra cement varying with conditions of placing. The volume or weight of the coarse aggregate shall be not less than one and a half times, nor more than twice that of the fine aggregate. The materials shall be so proportioned as to produce a concrete having a slump of not less than 100 mm., and not more than 180 mm.

20·1·7·4. Coffer-dams or forms shall be sufficiently tight to ensure still water if practicable, and in any case to reduce the flow of water to less than 3 m. per minute through the space into which concrete is to be deposited. Coffer-dams or forms in still water shall be sufficiently tight to prevent loss of mortar through the walls. Pumping shall not be done while concrete is being placed, or until 24 hours thereafter.

20·1·7·5. Concrete shall be deposited continuously until it is brought to the required height. While depositing, the top surface shall be kept as nearly level as possible and the formation of seams avoided. The methods to be used for depositing concrete under water shall be one of the following :

(a) *Tremie.*—When concrete is to be deposited under water by means of a tremie, the top section of the tremie shall be a hopper large enough to hold one entire batch of the mix or the entire contents of the transporting bucket if any. The tremie pipe shall be not less than 200 mm. in diameter and shall be large enough to allow a free flow of concrete and strong enough to withstand the external pressure of the water in which it is suspended, even if a partial vacuum develop inside the pipe. preferably, flanged steel pipe of adequate strength for the job should be used. A separate lifting device shall be provided for each tremie pipe with its hopper at the upper end. Unless the lower end of the pipe is equipped with an approved automatic check, valve, the upper end of the pipe shall be plugged with a wadding of gunny sacking or other approved material before delivering the concrete to the termie pipe through the hopper, so that when the concrete is forced down from the hopper to the pipe it will force the plug (and along with it any water in the pipe) down the pipe and out of the bottom end thus establishing a continuous stream of concrete It will be necessary to raise slowly the tremie in order to cause a uniform flow of the concrete, but the tremie shall not be emptied so that water enters above the concrete in the pipe. At all times after the placing of concrete is started and until all the concrete is placed, the lower end of the tremie pipe shall be below the top surface of the plastic concrete. This will cause the concrete to build up from below instead of flowing out over the surface. and thus avoid formation of laitance layers. If the charge in the tremie is lost while depositing, the tremie shall be raised above the concrete surface, and unless sealed by a check valve it shall be re-plugged at the top end, as at the beginning, before refilling for. depositing concrete.

(b) *Drop bottom bucket.*– The top of the bucket shall be open The bottom doors shall open freely downward and outward when tripped. The bucket shall be filled completely and lowered slowly to avoid backwash. It shall not be dumped until it rests on the surface upon which the concrete is to be deposited and when discharged shall be withdrawn slowly until well above the concrete.

(c) *Bags.*– Bags of at least 0·028 cum capacity of jute or other coarse cloth shall be filled about two-thirds full of concrete, the spare end turned under so that bag is square ended and securely tied. They shall be placed carefully in header and stretcher courses to that the whole mass is interlocked. Bags used for this purpose shall be free from deleterious materials.

(d) *Grouting.*– A series of round cages made from 50 mm. mesh of 6 mm.steel and extending over the full height to be concreted shall be prepared and laid vertically over the area to be concreted so that the distance between centres of the cages and also to the faces of the concrete shall not exceed one metre.

Stone aggregate of not less than 50 mm nor more than 200mm size shall be deposited outside the steel cages over the full area and height to be concreted with due care to prevent dis-placement of the cages.

A stable 1:2 cement sand grout with a water-cement ratio of not less than 0·6 and not more than 0·8 shall be prepared in mechanical mixer and sent down under pressure (about 2 kg/cm^2) through 38 to 50 mm.diameter pipes terminating into steel cages, about 50mm above the bottom of the concrete. As the grouting proceeds, the pipe shall be raised gradually upto a height of not more than 600mm above its starting level, after which it may be withdrawn and placed into the next cage for further grouting by the same procedure.

After grouting the whole area for a height of about 600 mm., the same operation shall be repeated, if necessary, for the next layer of 600 mm. and so on.

The amount of grout to be sent down shall be sufficient to fill all the voids of the stone which may be either ascertained or safely assumed as 55 per cent of the volume to be concreted.

20.1.7.6. To minimize the formation of laitance, great care shall be exercised to disturb the concrete as little as possible while it is being deposited.

20·1·8. *Concrete in sea-water.*– Concrete in sea-water or exposed directly along the sea-coast shall be at least of M 150 Grade in the case of plain concrete and of M 200 inthe case of reinforced concrete. The use of blast-furnace slag cement is advantageous under such conditions.

20·1·8·1. Special attention shall be given to the design of the mix to obtain the densest possible concrete ; slag, broken brick, soft limestone, soft sandstone, or other porous or weak aggregates shall not be used.

20·1·8·2. As far as possible preference shall be given to precast members unreinforced, well-cured and hardened, without sharp corners, and having trowel-smooth finished surfaces free from crazing, cracks or other defects : plastering should be avoided.

20·1·8·3. No construction joints shall be allowed within 600 mm. below low water-level or within 600 mm. of the upper and lower planes of wave action. Where unusually severe conditions or abrasion are anticipated, such parts of the work shall be protected by bituminous or silico fluoride coatings or stone facing bedded with bitumen.

20·1·8·4. In reinforced concrete structures, care shall be taken to protect the reinforcement from exposure to salty atmosphere during storage and fabrication.

20·1·9. *Concrete in alkali soils and alkaline water.*

20·1·9·1. *General.*– The destructive action of alkaline waters on concrete is progressive. The rate of deterioration which varies with the alkali-resisting property of the cement used, decreases as the concrete is made stronger and more impermeable, and increases as the sulphate content of the water increases. Where structures are only partially immersed or are in contact with alkali soils or waters on one side only, evaporation may cause serious concentrations of sulphate salts with subsequent deterioration, even where the original sulphate content of the soil or water is not high.

20·1·9·2. *Proportions.*—Where concrete structures are directly exposed to waters of moderate alkali concentrations, a high alkali-resisting cement like high alumina cement shall be used.The concrete shall be designed for a minimum compressive strength of 245 kg/cm^2 and shall contain not less than 370 kg. of cement per cubic metre of concrete in place.

20·1·9·3. *Drainage.*—At sites where alkali concentrations are or may become very high, Portland cement concrete is not recommended and if used, the ground water shall be lowered by drainage so that it will not come into direct contact with the concrete.

Additional protection may be obtained by the use of a chemically resistant stone facing or a layer of plaster of Paris covered with suitable fabric, such as jute, thoroughly impregnated with tar.

20·2. *Form work.*

20·2·1. *General.*– The formwork shall conform to the shape, lines and dimensions as shown on the plans, and be so constructed as to remain sufficiently rigid during the placing and compacting of the concrete, and shall be sufficiently tight to prevent loss of liquid from the concrete.

20·2·2. *Cleaning and treatment of forms.*– All rubbish, particulary chippings, shavings and sawdust, shall be removed from the interior of the forms before the concrete is placed and the formwork in contact with the concrete shall be cleaned and thoroughly wetted or treated with an approved composition. Care shall be taken that such approved composition is kept out of content with the reinforcement.

20.2.3 *Stripping time.*– In no circumstances shall forms be struck until the concrete reaches a strength of at least twice the stress to which the concrete may be subjected at the time of striking.

20.2.3.1. The strength referred to shall be that of concrete using the same cement and aggregates, with the same proportions, and cured under conditions of temperature and moisture similar to these existing on the work. Where possible the form work should be left longer, as it would assist the curing.

20.2.3.2. In normal circumstances (generally where temperatures are have 20°C), and where ordinary cement is used, forms may be struck, after expiry of following periods ;

(*a*) Walls, columns, and vertical sides of beams.		24 to 48 hours as may be decided by the engineer in charge.
(*b*) Slabs (props left under)	..	3 days.
(*c*) Beam soffits (props left under).		7 days.
(*d*) Removal of props to slabs :—		
(1) Spanning up to 4·5m	..	7 days.
(2) Spanning over 4·5m	..	14 days.
(*e*) Removal of props to beams and arches :—		
(1) Spanning up to 6 m	..	14 days.
(2) Spanning over 6m	..	21 days.

For rapid hardening cement 3/7 of the above period will be sufficient in all cases except vertical sides of slabs, beams and columns which should be retained for 24 hours.

NOTE.—The number of props, their sizes and disposition shall be such as to be able to safely carry the full dead lead of the slab, beam or arch as the case may be.

20.2.4. *Procedure when removing the form work.*—All form work shall be removed without such shock or vibration as would damaged the reinforced concrete. Before the soffit and struts are removed, the concrete surface shall be exposed, where necessary in order to ascertain that the concrete has sufficiently hardened. Proper precautions shall be taken to allow for the decrease in the rate of hardening that occurs with all cements in the cold weather.

20.2.5. *Camber.*—It is generally desirable to give forms an upward camber to ensure that the beams do not have sag when they have taken up their deflection, but this should not be done unless allowed for in the design calculations of the beams.

20.2.6. *Tolerances.*—Formwork shall be so constructed that the internal dimensions are within the permissible tolerance specified by the designer.

20.3. *Steel.*

20.3.1. *Cleaning.*—All metal for reinforcement shall be free from loose mill scale, locse rust, oil and grease or other harmful matter immediately before placing the concrete.

20.3.2. *Placing.*—All reinforcment shall be placed and maintained in the position shown in the drawings.

20.3.3. *Bending.—Reinforcement* shall be bent in accordance with procedure specified in I.S. 2502–1963 Code of practice for bending and fixing of bars for concrete reinforcement and shall not be straightened in a manner that will injure the material.

20.3.3.1. Bending hot at a cherry-red heat (not exceeding 845 °C) may be allowed, except for bars which depend for their strength on cold working. Bars bent hot should not be cooled by quenching.

20. 3.4. *Welding.*—Welding by gas or electricity may be permitted under suitable conditions and with suitable safeguards. For guidance in welding, relevant Indian Standards for welding of mild steel bars used in reinforced concrete construction may be referred to.

20.3.4.1. In the case of tack welding used for fixing reinforcements in their position, no special precautions in regard to stress need be taken.

20.3.4.2. But welding between the ends of a rod in line, whereby stress is transferred across the section, is recommended to be allowed for mild steel bars only. In the case of rods of mild steel which have their strength increased by cold working, the stress at the weld should be limited to the strength of mild steel before cold working, and the additional strength obtained by cold working should be ignored at and near the weld.

20. 4. *Supervision.*—It is exceedingly difficult and costly to alter concrete once placed. Hence, constant and strict supervision of all the items of the construction is necessary during the progress of the work, including the proportioning and mixing of the concrete. Supervision is also of extreme importance to check the reinforcement and its placing before being covered.

20.4.1. Before any important operation, such as concreting or stripping of the formwork is started, adequate notice shall be given to the construction supervisor

APPENDIX 'B',

(*Clause* 6. 3. 3.)

Ultimate Load Method of Design.

B-1. *Design principles.*

B. 1. 1. In the ultimate load method of design, structures shall be designed to have the required ultimate load carrying capacity with appropriate load factors for the operating loads and the constituent members of the structure shall be designed to develop the corresponding ultimate strength with appropriate load factors.

B. 1. 2. In case of statically determinate structures, the ultimate load carrying capacity is governed by the ultimate strength of the section subjected to critical combination of loads and moments.

B. 1. 3. But in case of statically indeterminate structures, the load carrying capacity of the structure does not come to an end by failure of one section. Redistribution of moments takes place as a result of formation of plastic hinges. The methods of determining the collapse mechanism of an indeterminate structure for different combinations of ultimate loads and for the given properties of the structure and its members are not covered by this code.

B. 2. *Assumptions.*

B. 2.1. Ultimate strength design of reinforced concrete sections is based on the following assumptions :—

(*a*) Plane sections normal to the axis remain plane after bending.

(*b*) Unless otherwise specified, tensile strength in concrete is neglected in sections subjected to bending.

(*c*) At ultimate strength, stresses and strains are not proportional and the distribution of compressive stresses in a section subject to bending is non-linear. The diagram of compressive concrete stress distribution may be assumed a rectangle trapezoid, parabola or any other shape which results in ultimate strength in reasonable agreement with tests.

(*d*) Maximum fibre stress in concrete does not exceed $0{\cdot}68\sigma cu$.

B. 3. *Proportioning.*

B. 3. 1. *General.*—Members should be proportioned so that (a) they should be capable of carrying without failure the critical load combination given in B. 3. 1. 1. thereby insuring an ample margin of safety against increase in superimposed service loads and (b) the strains under working loads should not be so large as to cause excessive cracking.

B. 3. 1. 1. Unless otherwise specified by the engineer-in-charge or appropriate authority, every member should be designed to carry without failure the effects of the following critical load conditions.

(*a*) For those structures in which the effects of wind and earthquake loads can be neglected:

$U = 1{\cdot}5\ DL + 2{\cdot}2\ LL.$

(*b*) For those structures in which wind load should be considered ;

$U = 1{\cdot}5\ DL + 2{\cdot}2\ LL + 0{\cdot}5\ WL.$

or $U = 1{\cdot}5\ DL + 0{\cdot}5\ LL + 2{\cdot}2\ WL$, which ever gives critical conditions, provided that no member shall have a capacity less than that required by the condition in (a) above.

(*c*) For those structures in which earthquake load should be considered, substitute EL for WL in the preceding equations.

Where.

U = Ultimate load.

$DL.$ = Dead load.

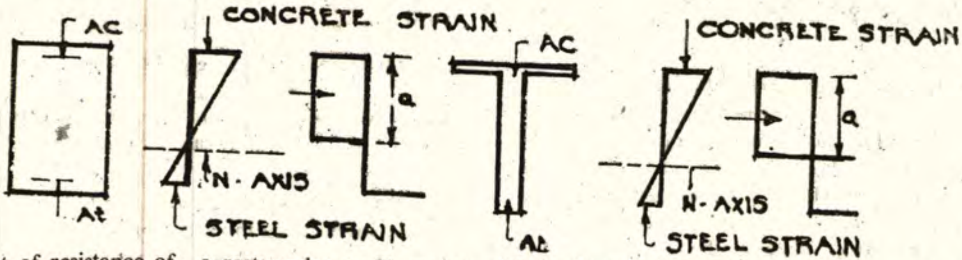
$LL.$ = Live load.

$WL.$ = Wind load, and

EL = Earthquake load.

Note.—These equations are applicable to both dynamic and static loads provided in the case of dynamic loads, the equivalent static loads are used after allowing for impact.

B.3.2. *Rectangular and T. sections under bending*



Ultimate moment of resistance of a rectangular or T. section shall be calculated as follows :—

(*a*) Determine the depth "*a*" of the rectangular stress block to satisfy the following equation :—

$(Ast-Asc)\ \sigma sy = 0{\cdot}55\ \sigma cu$ (areas of the stress block in the rectangular or T. Section).

(*b*) Calculate the ultimate moment of resistance as follows :—

(1) if $a \leqslant 0{\cdot}43d$, take the lever arm $=(d-a/_2)$ and $Mu=(A_{st}-A_{sc})\ \sigma sy$ (lever arm) $+A_{sc}\sigma_{sy}\ ds$

(2) if $a \geq 0{\cdot}43\ d$, assume, a $= 0{\cdot}43$ d and lever arm $=\left(d-\frac{0{\cdot}43d}{2}\right)$

and $Mu=0{\cdot}55\ \sigma cu$ (area of the stress block over the depth $0{\cdot}43$ d) (lever arm) $+A_{sc}\sigma_{sy}\ ds$.

Where

Ast = area of tension steel,

Asc = area of compression steel,

σsy = Yield stress of steel*,

σcu = Cube strength of concrete at 28 days,

Mu = ultimate moment of resistance,

d = effective depth of section, and

ds = distance between centroids of tension steel (Ast) and compression steel (Asc).

Note.—In a balanced rectangular section—

$Mu=0{\cdot}185\ bd^2\ \sigma cu$.

and $Ast=0{\cdot}236\ bd\ \dfrac{\sigma cu}{\sigma sy}$

*For the purpose of design σsy shall be taken as the guaranteed yield stress, subject to a maximum limit of 3,200 kg./cm² for plain round or square bars. In the absence of a guarantee, unless otherwise established, the following values may be assumed:—

(1) Medium tensile steel conforming to I.S. : 432—1960

	Kg/cm²
Bars up to and including 25mm ..	3,600
Bars over 25mm up to and including 38mm ..	3,450
Bars over 38mm up to and including 50mm ..	3,300

(2) Medium tensile conforming to IS. : 1139–1966—

Bars up to and including 25mm ..	3,600
Bars over 25mm up to and including 38mm ..	3,450

(3) Cold twisted plain or deformed bars conforming to I.S. : 1786–1966—

Bars under 10mm ..	4,950
Bars from 10mm and above ..	4,250

(4) Mild steel conforming to IS. : 432–1960—

Grade I—

Bars up to and including 20mm ..	2,600
Bars over 20mm ..	2,400

Grade II.—

Bars up to and including 20mm ..	2,350
Bars over 20mm ..	2,150

(5) Mild steel conforming to IS. : 1139–1966—

Bars up to and including 20mm ..	2,600
Bars over to 20mm ..	2,400

B.3.3. *Concentrically loaded short and long columns.*—Ultimate capacity P of concentrically loaded section should be determined by the following equation :—

$P=0{\cdot}4\ \sigma cuAc+\sigma sy\ Asc.$

Where—

σcu = ultimate cube strength of concrete in compression.

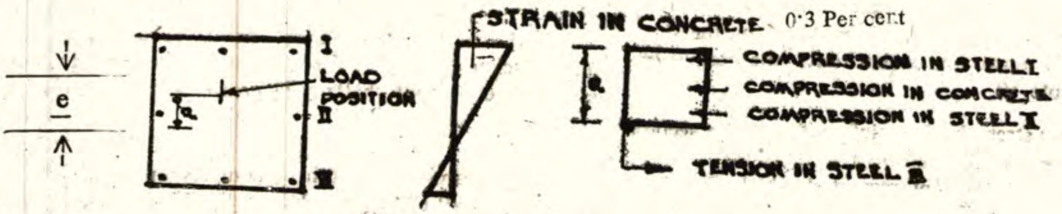
Ac = cross-sectional area of concrete excluding any finishing material and reinforcing steel.

σsy = yield stress of steel reinforcement or stress in steel corresponding to 0·002 strain whichever is less, and

Asc = Cross-sectional area of longitudinal steel.

For long columns, the requirements of 10.4.1.3. shall apply.

B.3.4. *Members subject to axial compression and bending in one plane.*—Ultimate capacity of reinforced concrete section for direct compression and bending in the direction of one of its principal areas should be calculated as follows :—



(*a*) The depth of the rectangular stress block should be 0·75 time the depth of the neutral axis subject to the maximum value equal to the depth of cross-section.

(*b*) The average compressive stress across the rectangular stress block should be taken as $0{\cdot}55\sigma_{cu}$, when the resisting moment due to compressive force in concrete (not taking into account contribution from compressive reinforcement) about the centroid of the tension reinforcement (or the reinforcement least in compression) does not exceed 0·75 time the moment of compressive force inconcrete subjected to uniform compressive stress of $0{\cdot}55\ \sigma_{cu}$ over the effective depth of the section. For $a<d$, the average compressive stress across the rectangular stress block should be reduced so that this limiting moment is not exceeded. For $a \geq d$, the average compressive stress across the rectangular stress block should be taken as $0{\cdot}4\ \sigma_{cu}$.

(*c*) Stress in steel should be equal to an appropriate strain in steel XE_s' or σ_{sy} whichever is less. For cold worked steel with no definite yield point, E_s for this purpose may be obtained from the idealized stress-strain diagram plotted from the following data :—

The diagram is a straight line from origin to the point with ordinate equal to the stress $0{\cdot}8\ \sigma_{sy}$ and a curve starting from $0{\cdot}8\ \sigma_{sy}$ and defined by the following values of residual unit elongation :—

0·01 per cent for stress equal to $0{\cdot}85\ \sigma_{sy}$.

0·03 per cent for stress equal to $0{\cdot}90\ \sigma_{sy}$.

0·07 per cent for stress equal to $0{\cdot}95\ \sigma_{sy}$.

0·10 per cent for stress equal to $0{\cdot}975\ \sigma_{sy}$.

0·20 per cent for stress equal to σ_{sy}.

(*d*) The maximum strain in concrete may be assumed as 0·3 per cent for the purpose of calculations.

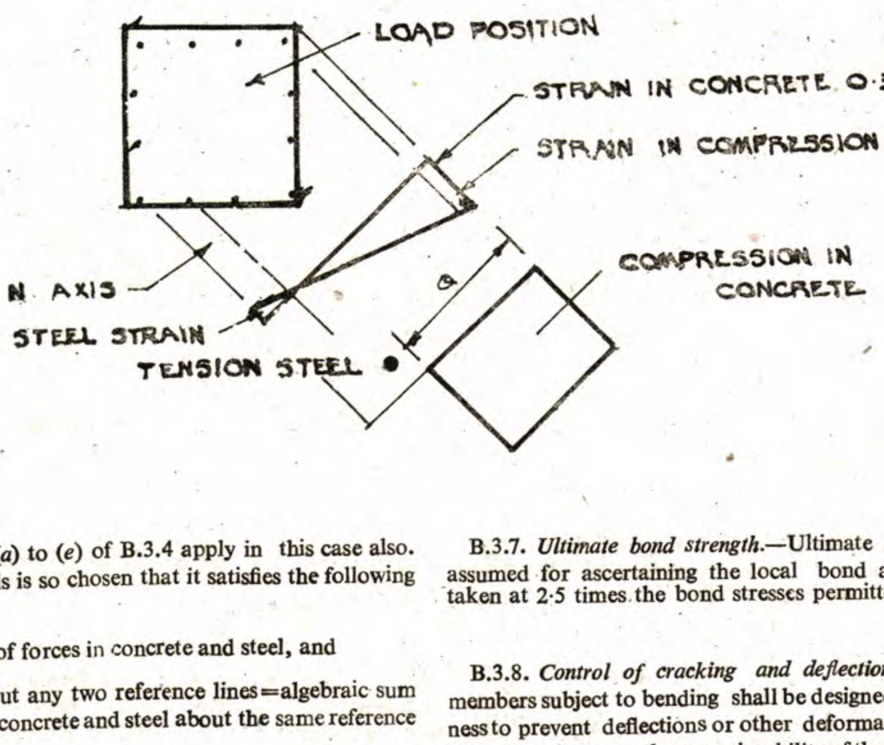
(*e*) Stress in compression steel should be determined by assuming maximum strain along the axis of most stressed reinforcement to be 0·002. Where the strain at the level of the reinforcement does not reach 0·002, the compatibility equation shall be used.

(*f*) The capacity of the section for combined direct load and bending moment should be determined from the following conditions:

(1) P=algebraic sum of the forces in concrete and steel, anp

(2) Moment of the external force P about any reference line= algebraic sum of the moments of forces in concrete and steel about the same reference line.

B.3.5. *Members subject to axial compression and bending in two planes* (*Skew bending*).—When he point of application of the resultant load does not lie along any of the two geometrical axes of the section it will be a case of combined direct load and bending in two directions.



The basic assumptions (*a*) to (*e*) of B.3.4 apply in this case also. In this case the neutral axis is so chosen that it satisfies the following conditions :—

(*a*) P=algebraic sum of forces in concrete and steel, and

(*b*) Moment of P about any two reference lines=algebraic sum of the moment of forces in concrete and steel about the same reference lines.

B.3.6. *Ultimate shear strength*.—Ultimate shear strength of reinforced concrete section without shear reinforcement both against transverse shear and torsion shall be calculated by taking the shear strength of concrete equal to two and a half times the permissible shear stress given in Table VI.

B.3.6.1. When the shear strength of a reinforced concrete section without shear reinforcement is not sufficient to resist the ultimate transverse shear and torsion, shear reinforcment should be provided as in 12 with the stress in shear steel limited to σ_{sy}.

B.3.7. *Ultimate bond strength*.—Ultimate bond strength to be assumed for ascertaining the local bond and anchorage shall be taken at 2·5 times the bond stresses permitted in Table VI.

B.3.8. *Control of cracking and deflection*.—Reinforced concrete members subject to bending shall be designed to have adequate stiffness to prevent deflections or other deformations which may adversely effect the strength or serviceability of the structure or produce unacceptable cracks in finishes or partitions carried by the structure.

B.3.8.1. Except when calculations of deflections prove that the lesser thicknesses may be used without adverse effects, the ratio of span to overall depth shall not be greater than that given in 6·5.

B.3.8.2. Beams with width of compression flange less than 1/30 of the span shall be adequately restrained laterally from buckling.

Design of Slabs Spanning in Two Directions At Right Angles.

C. 1 *Method* 1.

C·1·1. The bending moments in the slabs may be calculated assuming that the slab acts as a thin elastic plate and neglecting Poisson's ratio. These bending moments may be assessed either by the use of influence coefficients or ready made tables which are available, or by experimental stress analysis. The resisting moments of the slabs may be calculated by the commonly applied theory of thin plates.

C.2 *Method* 2.

C·2·1. Rectangular slabs which are two-way reinforced may be considered to be made of two sets of mutually perpendicular strips. The individual strip is to be considered as simply supported, fixed or continuous depending upon the support conditions of the slab. The uniformly distributed load w is carried between the strips in such proportions that the deflection at the centre of slab is same for both the middle strips. The bending moments calculated on this basis have to be corrected for torsion and corner restraint. Mid-span moments and edge moments for the different cases and span lengths of slabs are given in Table XIV and illustrated in Figure. The mid span moments shall be calculated as follows :—

$$M_x = \frac{wl_x^2}{m_x^2}$$

$$\text{and } M_y = \frac{wl_y^2}{m_y}$$

where

w = total uniformly distributed load per unit area.

l_x, l_y = lengths of sides (*See* Table XIV), and

m_x, m_y = coefficients given in table XIV.

C·2·2. If the slab is fixed at edge beams or is continuous, no torsional reinforcement need be provided at the corners. But for a slab which is neither continuous nor fixed at some of its edges the torsional reinforcement may be dropped only when the slab is designed for increased bending moment in accordance with Table XIV.

NOTE 1.—For approximately equal panels, smallest span not being less than 80 per cent of the largest, the negative B.M. at edges may be taken as

$$\frac{\alpha_x l_x^2}{8}, \quad \frac{\alpha_x l_x^2}{10}, \quad \frac{\alpha_x l_x^2}{12}$$

$$\frac{(1-\alpha_x)\, l_y^2}{8}, \quad \frac{(1-\alpha_x)\, l_y^2}{10}, \quad \frac{(1-\alpha_x)\, l_y^2}{12}$$

according to the position of the edge. The circled figures 8, 10 and 12 indicate the denominator for the negative moment expression for the corresponding edges. (Vide P 145)

NOTE 2.—Negative moments on the common edge from adjoining panels should be averaged.

NOTE 3.—When the panel length variation is more than 80 per cent, negative moment should be found as for a continuous beam, the appropriate values for share of loads in l_x, and l_y directions being taken.

NOTE 4.—Maximum and minimum moments can be conveniently found by placing live loads in alternate panels by use of the following equation :

Maximum moment = moment due to (dead load + half live load) + moment due to half live load acting vertically upwards and downwards in alternate panels.

Minimum moment = Do.

C·2·3. For slabs, edges of which are discontinuous, top and bottom reinforcement shall be provided for torsion at unrestrained corners for a length equal to one-fifth the slab span in each direction. Both top and bottom reinforcement shall consist of two layers of bars placed either perpendicular and parallel respectively to the diagonals through the corner or parallel to the respective slab edges. The area of reinforcement in each of the four layers, per unit width of the slab, shall be equal to main reinforcement at mid-span.

C·3· *Method* 3.

C·3·1. This method is based on mathematical analyses supplemented by experimental date. The effects of redistribution of bending moments have been partially allowed for. The following provisions shall apply for slabs restrained on four sides.

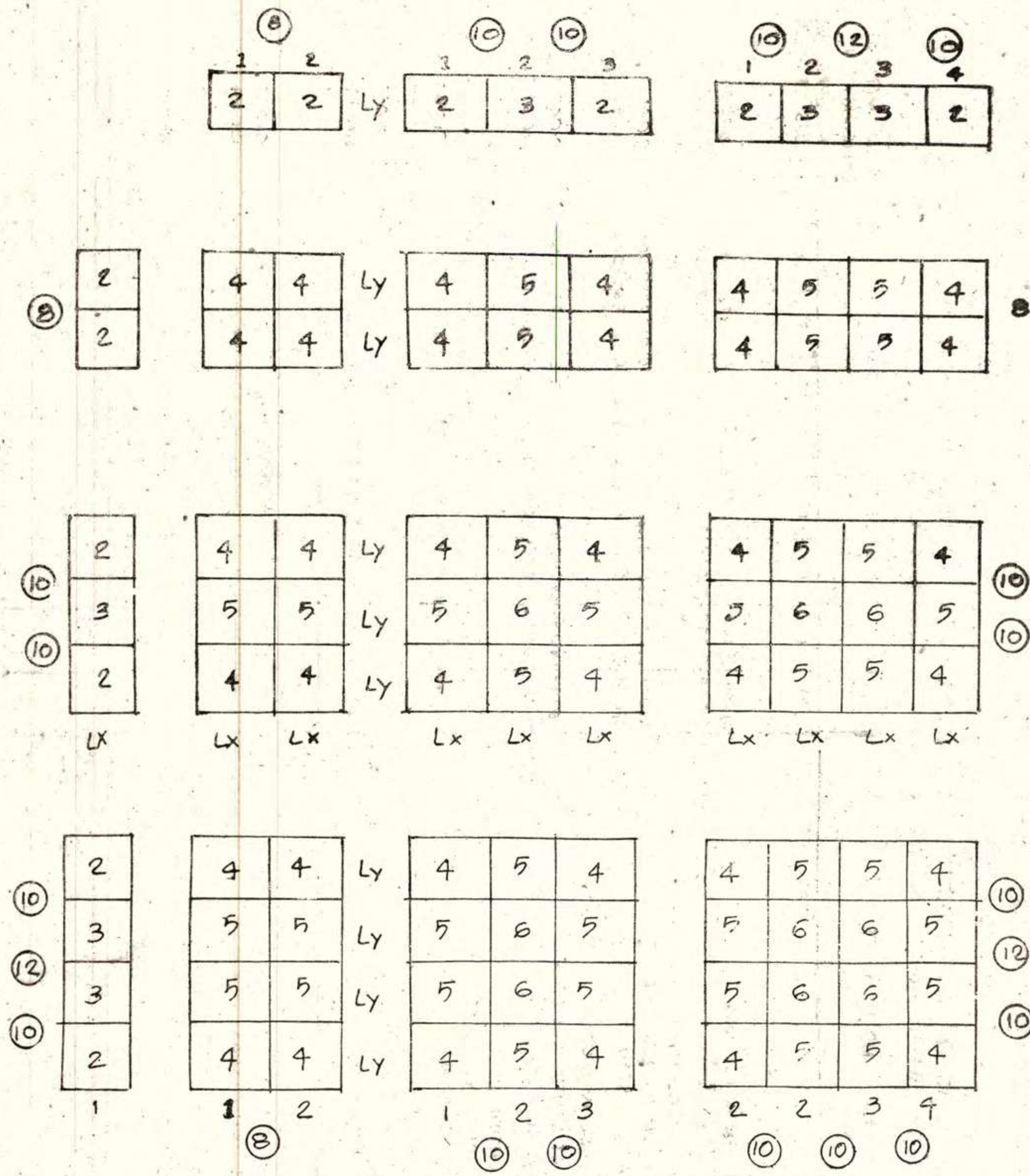
(*a*) Where the corners of a slab are prevented from lifting and adequate provision for torsion in accordance with (*e*) of this clause is made, the bending moments may be assumed to have the values given in accordance with (*b*) and (*c*) below :—

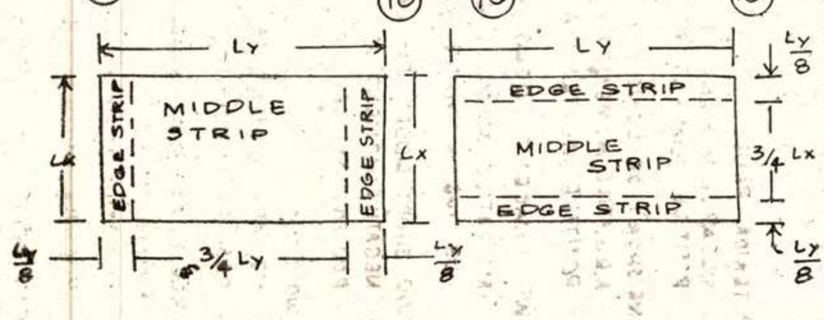
TABLE XIV MOMENT COEFFICIENTS FOR TWO WAY REINFORCED SLABS WITH AND WITHOUT TORSION REINFORCEMENT

ly/lx	1			2			3			4			5			6		
	αx_1	mx_1	my_1	αx_2	mx_2	my_2	αx_3	mx_3	my_3	αx_4	mx_4	my_4	αx_5	mx_5	my_5	αx_6	mx_6	my_6
0.6	0.115	[illegible]/60.5	12.3/10.4	0.245	[illegible]/39.0	13.7/11.9	0.393	87.6	16.1	0.115	146/133	18.9/17.4	0.206	138	20.7	0.115	229	29.8
0.7	0.194	61.6/49.5	14.0/11.9	0.375	59.1/46.3	17.2/14.7	0.546	63.7	21.6	0.194	90.2/80.7	21.6/19.5	0.324	90.7	24.8	0.194	139	33.4
0.8	0.291	44.3/33.9	18.1/13.9	0.506	44.7/34.6	21.9/18.7	0.672	50.4	29.6	0.291	62.2/54.6	25.4/22.4	0.450	66.3	31.0	[illegible]	94.5	38.8
0.9	0.396	34.1/28.4	22.4/16.6	0.621	35.7/27.9	28.3/24.2	0.766	42.5	40.6	0.396	46.6/40.5	30.6/26.6	0.568	52.5	39.4	0.396	70.1	46.0
1.0	0.500	27.4/20.8	27.4/20.2	0.714	29.9/23.9	36.8/31.8	0.833	37.5	55.7	0.500	37.2/32.2	37.2/32.2	0.667	44.2	50.6	0.500	55.7	55.7
1.1	0.594	22.6/16.9	33.3/24.8	0.785	26.0/21.44	47.5/2.0	0.880	34.2	75.5	0.594	31.8/27.0	45.5/39.6	0.745	38.9	65.2	0.594	46.8	68.5
1.2	0.675	19.6/14.7	40.3/30.6	0.838	23.3/19.6	61.5/55.0	0.912	31.9	102	0.675	27.0/23.7	56.0/49.2	0.806	35.3	84.2	0.675	40.9	85.0
1.3	0.741	17.0/13.2	48.5/37.6	0.877	21.4/18.4	78.8/71.0	0.934	30.3	135	0.741	24.2/21.4	69.0/61.0	0.851	32.8	103	0.741	36.9	105
1.4	0.794	15.2/12.1	58.4/46.6	0.906	20.0/17.6	100.0/91.5	0.951	29.2	176	0.794	22.1/19.8	85.0/76.0	0.885	31.0	138	0.794	34.1	131
1.5	0.835	13.9/11.3	70.2/57.5	0.927	19.0/17.0	127/118	0.961	28.3	227	0.835	20.6/18.7	104.0/95.0	0.910	29.7	175	0.835	32.0	162
1.6	0.868	12.9/10.8	84.5/70.6	0.942	18.2/16.5	159/148	0.970	27.6	288	0.868	19.5/17.8	128/117	0.929	28.7	219	0.868	30.6	200

NOTE—1 αx is the load coefficient for edge moment in lx direction, and $(1-\alpha x)$ is the load coefficient for edge moment in ly direction.

NOTE—2 Bottom figures under horizondal line for cases 1, 2 and 4 are the values of mx and when the required torsion reinforcement at the corner of discontinuous edge is not provided.





DIVISION OF A SLAB INTO MIDDLE AND EDGE STRIP

TABLE % V BENDING MOMENT CO-EFFICIENT FOR RECTANGULAR PANELS SUPPORTED ON FOUR SIDES WITH PROVISION FOR TORSION AT CORNERS (CLAUSE c-3-1)

CASE NO	TYPE OF PANEL AND MOMENTS	BENDING MOMENT COEFFICIENT Z'x FOR SHORT SPAN (VALUES OF LY/LX 3								BENDING MOMENT COEFFICIENT Z'Y FOR LONG SPAN(FOR ALL VALUES OF LY/LX)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1	INTERIOR PANELS									
	NEGATIVE MOMENT AT CONTINUOUS EDGE	0.033	0.040	0.045	0.050	0.054	0.059	0.071	0.083	0.033
	POSITIVE MOMENT AT MID SPAN	0.025	0.030	0.034	0.038	0.041	0.045	0.053	0.062	0.025
2	ONE SHORT OR LONG EDGE DISCONTINUOUS									
	NEGATIVE MOMENT AT CONTINUOUS EDGE	0.041	0.047	0.053	0.057	0.061	0.065	0.075	0.085	0.041
	POSITIVE MOMENT AT MID SPAN	0.031	0.032	0.040	0.043	0.046	0.049	0.056	0.064	0.031
3	TWO ADJACENT EDGES DISCONTINUOUS									
	NEGATIVE MOMENT AT CONTINUOUS EDGE	0.049	0.056	0.062	0.066	0.070	0.073	0.082	0.090	0.049
	POSITIVE MOMENT AT MID SPAN	0.037	0.042	0.047	0.050	0.053	0.055	0.062	0.068	0.037
4	TWO SHORT EDGES DISCONTINUOUS									
	NEGATIVE MOMENT AT CONTINUOUS EDGE	0.056	0.061	0.065	0.069	0.071	0.073	0.077	0.080	
	POSITIVE MOMENT AT MID SPAN	0.044	0.046	0.049	0.051	0.053	0.055	0.058	0.060	0.044
5	TWO LONG EDGES DISCONTINUOUS									
	NEGATIVE MOMENT AT CONTINUOUS EDGE									0.056
	POSITIVE MOMENT AT MID SPAN	0.044	0.053	0.060	0.065	0.068	0.071	0.077	0.080	0.044
6	THREE EDGES DISCONTINUOUS (ONE SHORT OR LONG EDGE CONTINUOUS)									
	NEGATIVE MOMENT AT CONTINUOUS EDGE	0.058	0.065	0.071	0.077	0.081	0.085	0.092	0.098	0.058
	POSITIVE MOMENT AT MID SPAN	0.044	0.049	0.054	0.058	0.061	0.064	0.069	0.074	0.049
7	FOUR EDGES DISCONTINUOUS									
	POSITIVE MOMENT AT MID SPAN	0.050	0.057	0.062	0.067	0.071	0.075	0.081	0.083	0.050
	$\frac{l_y}{l_x}$	1.0	1.1	1.2	1.3	1.4	1.5	1.75	2.00	

(*b*) Slabs are considered as being divided in each direction into middle strips and edge strips as shown in Figure 16 the middle strips having a width of three-quarters the width of the slab and each edge strip having a width of one-eighth of the width of the slab, with the provision that no edge strip should exceed $\frac{l_x}{2}$ in width.

(*c*) The maximum bending moments per unit width in the middle strip of a slab are given by the following equations :

$M_x = Z^1{}_x\, Wl_x^2.$

and $M_y = Z^1{}_y\, Wl_y^2.$

Where

M_x = Maximum bending moments on strips of unit width in the direction of span 1_x.

M_y = Maximum bending moments on strips of unit width in the direction of span $1y$.

$Z^1{}_x$ = Coefficients shown in Table XV.

$Z^1{}_y$ = Do.

w = total load per unit area.

l_y = length of the longer span, and

l_x = length of the shorter span.

(*d*) No reinforcement parallel to the adjacent edges of the slab need be inserted in the edge strips above that required to comply with 9·2·1·1; 18·3, 18·3·4 and (*e*) of this clause.

(*e*) Torsion reinforcement should be provided at the corners of a slab except at corners contained by edges over both of which the slab is continuous.

At corners contained by edges over neither of which the slab is continuous, top and bottom reinforcement should be provided for torsion at the corners of the slabs. Both top and bottom reinforcement should consist of two layers of bars placed parallel to the sides of the slab and extending in these directions for a distance of one-fifth of the shorter span. The area of the bars in each of the four layers, per unit width of the slab, should be three-quarters of the area required for the maximum positive moment in the slab.

At corners contained by edges over only one of which the slab is continuous, the torsional reinforcement may be reduced to one-half of that required by the preceding paragraph.

Any reinforcement provided for the purpose of complying with other clauses of this code may be included as part of the reinforcement required to comply with this clause.

(*f*) Where a slab ends and there is monolithic connection betwee the slab and the supporting beam or wall, provision shall be made for the negative moments that may occur in the slab at such support. The negative moment to be assumed in these cases depends on the degree of fixity afforded to the edge of the slab, but for general purposes it may be taken as two-thirds of the moment given in Table XV for the mid-span of the slab.

C·4. *Method 4:*

C·4·1. This method is based on the ultimate load method of design. The ultimate load should be obtained by using the load factors as given in B·3·1·1. The ultimate bending moments to be allowed should be deduced from the analysis in which due regard is given to redistribution of moments that would occur before failure of slab or beam, by the use of Johansen's yield line theory or by any other applicable method. The resistance moments of the slab and beam sections should be calulated in accordance with B·3·2.

EXTRACT FROM I.S. 456—1978.

(*Code of practice for plain and reinforced concrete.*)

0.4. This revision incorporates a number of important changes. The major thrust in the revision is on the following lines :—

(*a*) Whilst designers are aleady aware of the need for basing designs on requirements of adequate strength and satisfactory serviceability, the concept of limit state which provides a rational approach, taking into account variations in material strengths and loads on semi-probabilistic basis has now been introduced. This, in fact is a rationalization of the ultimate load method which was briefly covered in Appendix B of IS: 456-1964. The working stress method as practised earlier has been retained with the design for shear and torsion being aligned with the corresponding provisions for limit state method of design.

(*b*) The clauses dealing with sampling and acceptance criteria for concrete have been revised by elaborating the concepts of statistical quality control and introducing characteristic strength of concrete, to bring it in line with the latest trends in quality control of concrete.

(*c*) Method of design for shear and torsion has been completely revised, incorporating the results of the latest research on the subject.

(*d*) The concept of development length for reinforcement has been introduced. The requirement regarding checking of local bond streass has now been replaced by an extension of the concept of development length.

0.4.1. The significant changes incorporated in section 2 are as follows:

(*a*) The additional materials now permitted are more types of cement, pozzolanas, light weight aggregates, and cold twisted deformed bars of Grade F. 500.

(*b*) Regarding durability, guidance concerning minimum cement-content and maximum water cement ratio for different environmental conditions, including types of cement to be used for resisting sulphate attack has been given in an appendix. Limitations on the toatal chloride and sulphate content of conerete have also been given.

(*c*) Information regarding properties of concerete such as modulus of elasticity, tensile strength shrinkage, creep and co-efficient of thermal expansion has been given for guidance.

(*d*) Rceommendations regarding construction tolerances relating to form work and placing of steel have been given.

(*e*) Recommendation regarding acceptance criteria for hardened concrete represented by core tests has been given.

(*f*) The clauses on load testing of structures have been modified.

0.4.2. Section 3 on general design requirements has grouped together design rules which are generally applicable to all structures designed by any method. The significant changes incorporated in Section 3 are as follows :—

(a) Recommendations regarding prototype testing have been added.

(b) Recommendations regarding stability of the structures as a whole have been given in addition to the one regarding the stability of overhanging members.

(c) Some recommendations regarding frame analysis such as substitute frames have been given.

(d) The rules for effective width of flange for T and L beams have been changed.

(e) The recommendation regarding slender beams have been changed.

(f) The slenderness limits for columns have been changed.

(g) Minimum eccentricity for the design of compression members has been specified.

(h) Rules governing the use bundled bars have been added.

(j) Curtailment rules for reinforcement in beams and slabs have been given.

(k) Recommendations regarding critical sections for shear and minimum web reinforcement have been added.

(m) The recommendation regarding minimum tensile reinforcement in beams has been modified.

(n) Recommendations regarding side face reinforcement n beams have been added.

(p) The clause on span to depth ratio for controlling deflection has been modified and elaborated to take into account the type and percentage of reinforcement provided. Method for calculating the short term as well as long term deflection has been added.

(q) Detailing rules for crack control have been given in tne code. These rules are expected to lead to a satisfactory design for most of the structures under normal environmental conditions. Detailed investigat ons of crack width may however be required for unusual cases or structures in aggressive environments.

(r) Guidance on the determination of effective length of columns in framed structures has been added.

0.4.3. Section 4 includes special design requirements for structures such as flat slabs, deep beams, etc, and these are in addition to superseding the rules of Section 3, as applicable. The significant changes incorporated in Section 4 are as follows :

(a) Recommendations for the design of deep beams have been added.

(b) Guidance for the design of ribbed and voided slabs has been included.

(c) The clauses on design of flat slabs have been revised. Shear in flat slabs and openings in flat slabs are now covered in some detail.

(d) The clauses on footings have also undergone some changes regarding design for shear and transfer of load at the base of the column.

0.4.4. In Section 5 on limit state method, a unified approach has been made to cover members in flexure and flexure combined with axial force. A method for design of compression members wih biaxial bending has also been added. Slenderness effects are taken into account by augmenting the moments to be considered in design.

0.4.5. In Section 6 on working stress method, the permissible stresses in steel have been modified to make them more rational and to reflect the provisions of the basic standards on steel. Permissible stresses in concrete for shear have been completely revised in order to bring the procedure for design in accordance with the recommendations in Section 5. Values of local bond stresses have been deleted as these are not required according to the new rules given in Section 3. Values of bearing stress in concrete have also been deleted from the table of permissible stresses, since it has been given in the clause on design of footings in Section 4.

1. *Scope* :

1.1 This code deals with the general structural use of plain and reinforced concrete.

1.2. Special requirements of structures, such as shells, folded plates, arches, bridges, chimneys, blast resistant structures, hydraulic structures and liquid retaining structures, covered in respective codes have not been covered in this code ; these codes shall be used in conjunction with this code.

2. *Terminology :*

2.1. For the purpose of this standard, the definitions given in IS : 4845-1968 and IS : 6461 (Parts I to XII) shall generally apply.

3. *Symbols :*

3.1. For the purpose of this standard, the following letter symbols shall have the meaning indicated against each ; where other symbols are used, they are expalined at the appropriate place :

A	Area
b	Breadth of beam, or shorter dimension of a rectang ula column.
be	Effective width of slab
bf	Effective width of flange
bw	Breadth of web or rib

D	Overall depth of beam or slab or diameter of column ; dimention of a rectangalur column in the direction under consideration.
D_f	Thickness of flange.
DL	Dead load.
d	Effective depth of beam or slab.
d'	Depth of compression reinforcement from the highly compressed face.
E_t	Modulus of elasticity of concrete.
EL	Earthquake load.
Es	Modulus of elasticity of steel.
e	Eccentricity.
fck	Characteristic compressive strength of concrete.
fcr	Modulus of rupture of concrete (flexural tensile strength)
fct	Split tensile strength of concrete.
fd	Design strength.
fy	Characteristic strength of steel
Ief	Effective moment of inertia
I_{gr}	Moment of inertia of the gross section excluding reinforcement
I_r	Moment of intertia of cracked section
K	Stiffness of member
k	Constant or coefficient or factor
L_d	Development length
LL	Live load or imposed load
l	Length of a column or beam between adequate lateral restraints or the unsupported length of a column.
lef	Effective span of beam or slab or effective length of column
lex	Effective length about x-x axis
ley	Effective length about y-y axis
ln	Clear span, face to face of supports
ln	l_1 for shorter of the two spans at right angles
lx	Length of shorter side of slab
ly	Length of longer side of slab
l_0	Distance between points of zero moments in a beam
l_1	Span in the direction in which moments are determined centre to centre of supports
l_2	Span transverse to l_1, centre to centre of supports
l'_2	l_2 for the shorter of the continuous spans
M	Bending moment
m	Modular ratio
n	Number of samples
P	Axial load on a compression member
q_o	Calculated maximum bearing pressure of soil
r	Radius
s	Spacing of strirups or standard deviation
T	Torsional mom.nt.
V	Shear force
W	Total load
WL	Wind load
w	Distributed load per unit area
w_d	Distributed dead load per unit area
w_i	Distributed imposed load per unit area
x	Depth of neutral axis
Z	Modulus of section
z	Lever arm
$\alpha\beta$	Angle or ratio
γf	Partial safety factor for load
γm	Partial safety factor for material
δm	Percentage reduction in moment
εcc	Creep strain of concrete
σ_{cbc}	Permissible stress in concrete in bending compression
σ_{cc}	Permissible stress in concrete in direct compression
σ_{mc}	Permissible stress in metal in direct compression
σ_{sc}	Permissible stress in steel in compression
σ_{st}	Permissible stress in steel in tension
σ_{sv}	Permissible tensile stress in shear reinforcement
$\overline{tbd}$	Design bond stress
$\overline{tc}$	Shear stress in concrete
$\overline{tcmax}$	Maximum shear stress in concrete with shear reinforcement
$\overline{tv}$	Nominal shear stress
$\varnothing$	Diameter of bar

4.3.2 The pH value of water shall generally be not less than 6.

5. *Concrete.*

5.1 *Grades*—The concrete shall be in grades designated as per at Table 2.

TABLE 2—GRADES OF CONCRETE.
(*Clauses* 5.1, 5.2.1, 8.2.1., 14.1.1. *and* 35.1.)

Grade designation.	*Specified characteristic compressive strength at 28 days.*
(1)	(2) N/mm^2
M 10	10
M 15	15
M 20	20
M 25	25
M 30	30
M 35	35
M 40	49

NOTE 1—In the designation of a concrete mix, letter M refers to the mix and the number to the specified characteristic compressive strength of 15-cm cube at 28 days, expressed in N/mm^2.

NOTE 2—M 5 and M 7.5 grades of concrete may be used for lean concrete bases and simple foundations for masonry walls. These mixes need not be designed.

NOTE 3—Grades of concrete lower than M 15 shall not be used in reinforced concrete.

5.2. *Properties of concrete.*

5.2.1. *Increase in strength with age*—Where it can be shown that a member will not receive its full design load/stress within a period of 28 days after the casting of the member (for example, in foundation and lower columns in multistorey buildings) the characteristic compressive strength given in Table 2 may be increased by multiplying by the factors given below:

Minimum age of member when full design Load/stress is expected (Months).	*Age factor.*
1	1.0
3	1.10
6	1.15
12	1.20

NOTE.1— No increase in respect of age at loading should be allowed where high alumina cement concrete is used.

NOTE 2—Where members are subjected to lower direct load during construction, they should be checked for stresses resulting from combination of direct load and bending during construction.

NOTE 3—The permissible stresses or design strength shall be bassed on the increased value of compressive strength.

5.2.2. *Tensile strength of concrete*—The flexural and split tensile strengths shall be obtained as described in IS : 516-1959 and IS : 5816 -1970 respectively. When the designer wishes to use an estimate of the tensile strength from the compressive strength, the following formula may be used :

Flexural strength $,cr = 0.7 \sqrt{fck}$ N/mm^2

where f_{ck} is the characteristic compressive strength of concrete.

5.2.3. *Elastic Deformation*—The modulus of elasticity is primarily influenced by the elastic properties of the aggregate and to a lesser extent by the conditions of curing and age of the concrete, the mix proportions and the type of cement. The modulus of elasticity is normally related to the compressive strength of concrete.

5.2.3.1. In the absence of test data, the modules of elasticity for strictural concrete may be assumed as follows :

$$Ec = 5\ 700V \sqrt{fex}$$

where *Ec* is the short term static modulus of elasticity in SN/mm2 and *fck* is the characteristic cube strength of concrete in N/mm^2.

7. *Durability.*

7.1. The durability of concrete depends on its resistance to deterioration and the cuvironment in which it is placed. The resistance of concrete to weathering, chemical attack, abrasion. frost and fire depends largely upon its quality and constituent materials. Susceptibility to corrosion of the steel is governed by the cover provided and the permeability of concerete. The cube-crushing strength alone is not a reliable guide to the quality and durability of concrete; it must also have an adequate cement content and a low water-cement ratio.

7.1.1. One of the main characteristics influencing the durability of any concrete is its permeability. With strong dense aggregates, a suitably low permeability is achieved by having a sufficiently low water-cement ratio, by ensuring as thorough compaction of the concrete as possible and by ensuring sufficient hydration of cement through proper, curing methods.Therefore, for given aggregate. the cement content should be sufficientto provide adequate workability, with a low water- cement ratio so that concrete can be completely compacted with the means available.

7.2. Appendix A provides guidance regarding minimum cement content and permissible limits of chloride and sulphate in concrete.

8.2. *Design mix concrete.*

8.2.1. The mix shall be designed to produce the grade of concrete having the required workability and a characteristic strength not less than appropriate values given in Table 2. The procedure given in Indian Standard Recommended guidlines for concrete mix design (*under preparation*) may be followed.

8.2.2. As long as the qupliry of the materials does not change, a mix design done carlier may be considered adequate for later work.

8.3. *Nominal mix concrete*—Nominal mix concrete may be used for concrete of grades M 5, M 7-5, M. 10, M 15 and M 20. The proportions materials for nominal mix concrete shall be in accordance with Table 3.

TABLE - 3. PROPORTIONS FOR NOMINAL MIX CONCRETE.

(*Clauses* : 8.3, 8. 3. 1 *amd* 8.3.2.)

Grade of Concrete.	*Total quantity of dry aggregates by mass per 50 kg of cement, to be taken as the sum of the indu:idual masses of fine and coarse aggregates. Max.*	*Proportion of fine aggregate to coarse aggregate (By Mass).*	*Quantity of water per 50 kg of cement Max.*
(1)	(2)	(3)	(4)
	kg.		litres'
M 5	800	Generally	60
M 7.5	625	1 : 2 but subject to	45
M 10	480	an upper limit of	34
M 15	350	1 : 1½ and a lower	32
M 20	250	limit of 1 : 2½	30

NOTE.—The proportions of the fine to coarse aggregates should be adjusted from upper limit to lower limit progressively as the grading of the fine aggregate becomes finer and the maximum size of corase aggregate becomes larger, Graded coarse aggregate shall be used.

Example.—For an average grading of fine aggregate (that is Zone II of table 4 of IS : 383-1970), the proportions shall be 1 : 1½, 1 : 2 and 1 : 2½ for maximum size of aggregates 10 mm, 20 mm and 40 mm respectively.

8.3.1. The cement content of the mix specified in Table 3 for any nominal mix shall be proportionately increased if the quantity of water in a mix has to be increased to overcome the difficulties of placement and compaction, so that the water-cement ratio as specified is not exceeded.

NOTE 1—In the case of vibrated concrete, the limit specified may be suitably reduced to avoid segregation.

NOTE 2—The quantity of water used in the concrete mix for reinforced concrete work should be sufficeient, but not more than sufficient to produce a dense concrete of adequate workability for is purpose, which will surround and properly grip all the reinforcement, Workability of the concrete should be controlled by maintainin a water content that is found to give a cencrete which is just sufficiently wet to be placed and compacted without difficulty with the means available.

8. 3.2. If nominal mix concrete made in accordance with the proportions given for a particular grade does not yield the specified strength, such concrete shall be classified as belonging to the appropriate lower grade. Nominal mix concrete proportioned for a given grade in acordance with Table 3 shall not, however, be placed in higher grade on the ground that the test strengths are higher han the minimum specified.

10. *Form work.*

10.1. *General.*—The form work shall be designed and constructed to the shapes, lines and dimensions shown on the drawings within the tolerances given below (*see also* Indian Standard Code of practice for falsework for concrete structues (*Under preparation*) :

(*a*) Deviation from specified dimensions o cross section of columns and beams' —6 mm +12 mm (*b*) Deviation from dimension of footings (*see* Note) :

(1) Dimension in plan	—12 mm +50mm
(2) Eccentricity	0.02 times the width of the footing in the direction of deviation but not more than 50 mm.
(3) Thickness	±0.05 times the specified thickness.

NOTE.—Tolerances apply to concrete dimensions only, not to positioning of vertical reinforcing steel or dowels.

11.3. *Tolerance on Placing reinforcement*.—Unless otherwise specified by the engineer-in-charge, reinforcement shall be placed within the following tolerances :

(*a*) For effective depth 200 mm or less .. .. ±10mm

(*b*) For effective depth more than 200 mm .. ±15mm

The cover shall in no case be reduced by more than one-third of specified cover or 5 mm whichever is less.

11.4. *Welded joints or mechanical connections*.—Welded joints or mechanical connections in reinforcement may be used but in all cases of important connections, tests shall be made to prove that the joints are of the full strength of bars connected. Welding of reinforcements shall be done in accordance with the recommendations of IS: 2751-1966* and Indian Standard Recommendations for welding cold worked steel bars for reinforced concrete construction (*under preparation*).

11.5. Where reinforcement bars are bent aside at construction joints and afterwards bent into their original positions, care should be taken to ensure that at no time is the radius of the bend less than 4 bar diameteres for plain mild steel or 6 bar diameters for deformed bars. Care shall also be taken when bending back bars, to ensure that the concrete around the bar is not damaged.

* Code of practice for Welding of mild steel bars used for reinforced Concrete Construction.

13.3. *Concrete in Sea-water*—Concrete in sea-water or exposed directly along the sea-coast shall be at least M 15 Grade in the case of plain concrete and M 20 in case of reinforced concrete. The use of slag or pozzolana cement is advantageous under such conditions.

16. *Inspection and testing of structures.*

16.1. *Inspection.*—Immediately after stripping the form work, all concrete shall be carefully inspected and any defective work or small defects either removed or made good before concrete has thoroughly hardened.

16.2. In case of doubt regarding the grade of concerte used, either due to poor workmanship or based on results of cube strength tests, compressive strength tests of concrete on the basis of 16.3 and /or load test (*see* 16.5) may be carried out.

16.3. *Core test.*

16.3.1. The points from which cores are to be taken and the number of cores required shall be at the discretion of the engineer-in-charge and shall be representive of the whole of concrete concerned. In no case, however, shall fewer than three cores be tested.

16.3.2. Cores shall be prepared and tested as described in IS: 516-1959

16.3.3. Concrete in the member represented by a core test shall be considered acceptable if the averege equivalent cube strength of the cores is equal at least 85 percent of the cube strength of the grade of concrete specified for the corresponding age and no individual core has a strength less than 75 percent.

16.4. In case the core test result do not satisfy the requirements of 16.3.3. or where such tests have not been done, load test (*see 16.5*) may be resorted to.

16.5. *Load tests on parts of structures.*

16.5.1. Load tests should be carried out as soon as possible after expiry of 28 days from the time of placing of concrete.

16.5.2. The structure should be subjected to a load equal to full dead load of the structure plus 1.25 times the imposed load for a period of 24 hours and then the imposed load shall be removed.

NOTE.—Dead load includes self weight of the structural members plus weight of finishes and walls or partitions, if any, as considered in the design.

16.5.3. The deflection due to imposed load only shall be recorded. If within 24 hours of removal of the imposed load, the structure does not recover at least 75 percent of the deflection under superimposed load, the test may be repeated after a lapse of 72 hours. If the recovery is less than 80 percent, the structure shall be deemed to be unacceptable.

16.5.3.1. If the maximum deflection in mm, shown during 24 hours under load is less than $\frac{40\, l^2}{D}$, where l is the effetive span in m and D, the overall depth of the section in mm, it is not necessary for the recovery to be mesured and the reovery provisions of 16.5.3 will not apply.

16.6. Other non-destructive test methods may be adopted, in which case the acceptance criteria shall be agreed upon between the engineer-in-charge and the contractor and the tests shall be done under expert

17. *General design requirements.*

17.2. *Dead loads.*—Dead load sshall be calculated on the basis of unit weights which shall be established taking into consideration the materials specified for construction.

17.2.1. Alternatively, the dead loads may be calculated on the basis of unit weights of materials given is IS:1911-1967*. Unless more accurate calculations are warranted, the unit weghts of plain concrete and reinforced concrete made with sand and gravel or crushed natural stone aggregate may be taken as 24,000 N/m³ and 25,000 N/m³ respectively.

*Schedule of unit weights of Building Materials (first revision)

18. *Basis for design.*

18.1 *General.*—Structures and structural members shall be designed to have at all sections, strengths at least equal to the structural effects of design loads and forces that occur during construction and use as determined by the relevent method on design. Structures and structural members shall also meet all the other requirements of the code.

18.1.1. The design shall be made in accordance with the principles of mechanics, recognized methods of design and sound engineering practice, In particular, adequate consideration shall be given to the effects of contiunity on the distributiion of bending moments and shears due to monolithic constuction.

18.2 *Methods of design*—Structures and structural elements, may be designed by any of the following methods ;

(*a*) Limit state method,

(*b*) Working stress method,

(*c*) Methods based on experimental investigations.

NOTE.—Designs based on experimental investigations on models or full size structure or element (*see* 18.3) may be accpted subject to experimental details and the analysis connected therewith being appoved by the engineer-in charge.

18.3 *Design on experimental basis*—Where the designs is based on experimentsl investigation on full size structure or element, load tests shall be carried out to ensurs the following :

(*a*) The structure shall satisfy the requirements for defiection (*see* 22.2) and cracking (*see* 34.3.2) when subjected to a load for 24 hours epualto the characteristic load multiplied by 1.33 *rf* where *rf* shall be taken from Table 12, for the limit state of serviceablitiy. If within 24 hours of the removal of the load, the strucre does not show a recovery of at least 75 percent of the maximum deflection shown during the 24 hours under the load, the test loading should be repeated after a lapse of at least 72 hours. The recovery after the second test should be at least 75 percent of the maximum deflection shown during the second test.

NOTE.—If the maximum deflection is mm, shown 24 hours under load is less than 40 l^2/D, where l is the effective span in m and D the overall depth of the section in mm, it is not necessary for the recovery to be measured,

(*b*) The structure shall have adequate strength to sustain for 24 hours, a total load equal to the characteristic load multiplied by 1.33 *rf* where *rf* shall be taken from Table 12 for the limit state of collapse.

19. *Stability of the structure.*

19.1. *Overturning*—The stability of a structure as a whole agsinst overturning shall be ensured so that the restoring moment shall be not less than the sum of 1.2 times the maximum over turning moment due to the characteristic dead load and 1.4 times the maximum over turning moment due to the characteristic imposed loads. In casee where dead load provides the retoring moment, only 0.9 times the characteristic dead load shall be considered. Restoring moment due to imposed loads shall be ignored.

19.1.1. The anchorages or counterweights provided for overhanging members (during construction and service) should be such that static equilibrium should remain, even when overturning moment is doubled.

19.2. *Sliding*.—The structure shall have a factor against sliding of not less than 1.4 under the most adverse combination of the applied characteristic forces. In this case 0.9 times the characteristic dead load shall be taken into account.

19.3. To ensure stablility at all times, account shall be take of probable variations in dead load during construction, repair or other temporary measures. Wind and seismic loading shall be treated as imposed loading.

19.4. In designing the framework of a building provisions shall be made by adequate moment connections or by a system of bracings to effrctively transmit all the horizonal forces to the foundations.

21. *Analysis.*

21.1. *General.*—All structures may be analysed by the linear elastic theory to calculate internal actions produced by design loads In lieu of rigorous elastic analysis, a simplified analysis as given in 21.4 for frames and as given in 21.5 for continuous beams may be adopted.

21.2. *Effective span.*—Unless otherwise specified, the effective span of a member shall be as follows :

(*a*) *Simply supported beam or slab.*—The effective span of a member that is not built integrally with its supports shall be taken as clear span plus the effective depth of slab or beam or centre to centre of supports, whichever is less.

(*b*) *Continuous beam or slab.*—In the case of continuous beam or slab, if the width of the support is less than 1/12 of the clear span, the effective span shall be as in 21.2 (*a*). If the supports are wider than 1/12 the clear span or 600 mm whichever is less, the effective span shall be taken as under :

(1) For end span with one end fixed and other continuous or for intermediate spans, the effective span shall be the clear span between suppots ; and

(2) For end span with one end free and the other continuous, the effective span shall be equal to the clear span plus half the effective depth of the beam or slab or the clear span plus half the width of the discontinuous support, whichever is less.

NOTE.—In the case of spans with roller or rocker bearing, the effective span shall always be the distance between the centres of bearing.

(*c*) *Frames.*—In the analysis of a continuous frame, centre to centre distance shall be used.

21.3. *Stiffness*

21.3.1. *Relative stiffness.*—The relative stiffness of the members may be based on the moment of inertia of the section determined on the basis of any one of the following definitions :

(*a*) *Cross section.*—The cross-section of the member ignoring reinforcement ;

(*b*) *Transformed section.*—The concrete cross-section plus the area of reinforcement transformed on the basis of modular ratio ; or

(*c*) *Cracked section.*—The area of concrete in compression plus the area of reinforcement transformed on the basis of modular ratio.

The assumptions made shall be consistent for all the members of the structure throughout any analysis.

21.3.2. For deflection calculations, appropriate values of moment of inertia as specified in Appendix B should be used.

21.4. *Structural frames.*—The simplifying assumptions as given in 21.4.1. to 21.4.3. may be used in the analysis of frames.

21.4.1. *Arrangement of live load.*—

(*a*) Consideration may be limited to combinations of :

(1) Design dead load on all spans with full design live load on two adjacent spans ; and

(2) Design dead load on all spans with full design live load on alternate spans.

(*b*) When design live load does not exceed three-fourths of the design dead load, the load arrangement may be design dead load and design live load on all the spans.

NOTE.—For beams and slabs continuous over support 21.4.1 (*a*) may be assumed.

21.4.2. *Substitute frame.*—For determining the moments and shears at any floor or roof level due to gravity loads, the beams at that level together with columns above and below with their far ends fixed may be considered to constitute the frame.

21.4.3. For taieral loads, simplified methods may be used to obtain the moments and shears for structures that are symmetrical. For unsymmetrical or very tall structures, more rigorous methods should be used.

21.5. *Moment and shear coefficients for continuous beams.*—

21.5.1. Unless more exact estimates are made, for beams of uniform cross-section which support substantially uniformly distributed loads over three or more spans which do not differ by more than 15 per cent of the longest , the bending moments and shear forces used in design may be obtained using the coefficients given in Table 7 and Table 8 respectively.

For moments at supports where two unequal spans meet or in case where the spans are not equally loaded, the average of the two values for the negative moment at the support may be taken for design.

Where coefficients given in Table 7 are used for calculation of bending moments, redistribution referred to in 21.7 shall not be permitted.

21.5.2. *Beams and slabs over free end supports.*—Where a member is built into a masonry wall which develops only partial restraint the member shall be designed to resist a negative moment at the face of the support of $\frac{Wl}{24}$ where W is the total design load and l is the effective span, or such other restraining moment as may be shown to be applicable. For such a condition shear coefficient given in Table 8 at the end support may be increased by 0.05

TABLE—7—BENDING MOMENT COEFFICIENTS.

(*Clause* 21.5.1.)

Type of load.	*Span moments.*		*Support moments*	
	Near middle of end span.	*At middle of interior span.*	*At support next to the end support.*	*At other interior supports.*
Dead load and imposed load (fixed).	$+\frac{1}{12}$	$+\frac{1}{24}$	$-\frac{1}{10}$	$-\frac{1}{12}$
Imposed load (not fixed).	$+\frac{1}{10}$	$+\frac{1}{12}$	$-\frac{1}{9}$	$-\frac{1}{9}$

NOTE.—For obtaining the bending moment, the coefficient shall be multiplied by the total design load and effective span.

TABLE—8—SHEAR FORCE COEFFICIENTS

(*Clause* 21.5.1. *and* 21.5.2.)

Type of load.	*At end support.*	*At support next to the end support.*		*At all other interior supports.*
		Outer side	*Inner side*	
Dead load and imposed load (fixed).	0.4	0.6	0.55	0.5
Imposed load (not fixed)	0.45	0.6	0.6	0.6

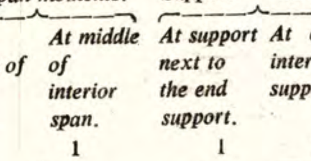
NOTE.—For obtaining the shear force, the coefficient shall be multiplied by the total design load.

21.6. *Critical sections for moment and shear.*—

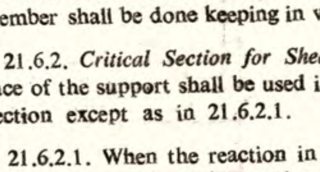
21.6.1. For monolithic, construction the moments computed at the face of the supports shall be used in the designs of the members at those sections. For non-monolithic construction the design of the member shall be done keeping in view 21.2.

21.6.2. *Critical Section for Shear.*—The shears computed at the face of the support shall be used in the design of the member at that section except as in 21.6.2.1.

21.6.2.1. When the reaction in the direction of the applied shear introduces compression into the end region of the member, sections located at a distance less than d from the face of the support may be designed for the same shear as that computed at distance d (*see* Fig. 1).



1A Critical Section at Face of the Support



1B Critical Section at Distance 'd' from the Face of the Support

FIG. 1 CRITICAL SECTIONS FOR SHEAR

21.7. *Redistribution of moments.*—Redistribution of moments may be done in accordance with 36.1.1. for limit state method and in accordance with 43.2 for working stress method. However where simplified analysis using coefficients is adopted, redistribution of moments shall not be done.

22. *Beams.*

22.0. Effective depth.—Effective depth of a beam is the distanc between the centroid of the area of tension reinforcement and the maximum compression fibre, excluding the thickness of finishing material not placed monolithically with the member and the thickness of any concerete provided to allow for wear. This will not apply to deep beams.

22.1. *T-beams and L-beams.*—

22.1.1 *General.*—A slab which is assumed to act as a flange of a T-beam or L-beam shall satisfy the following :

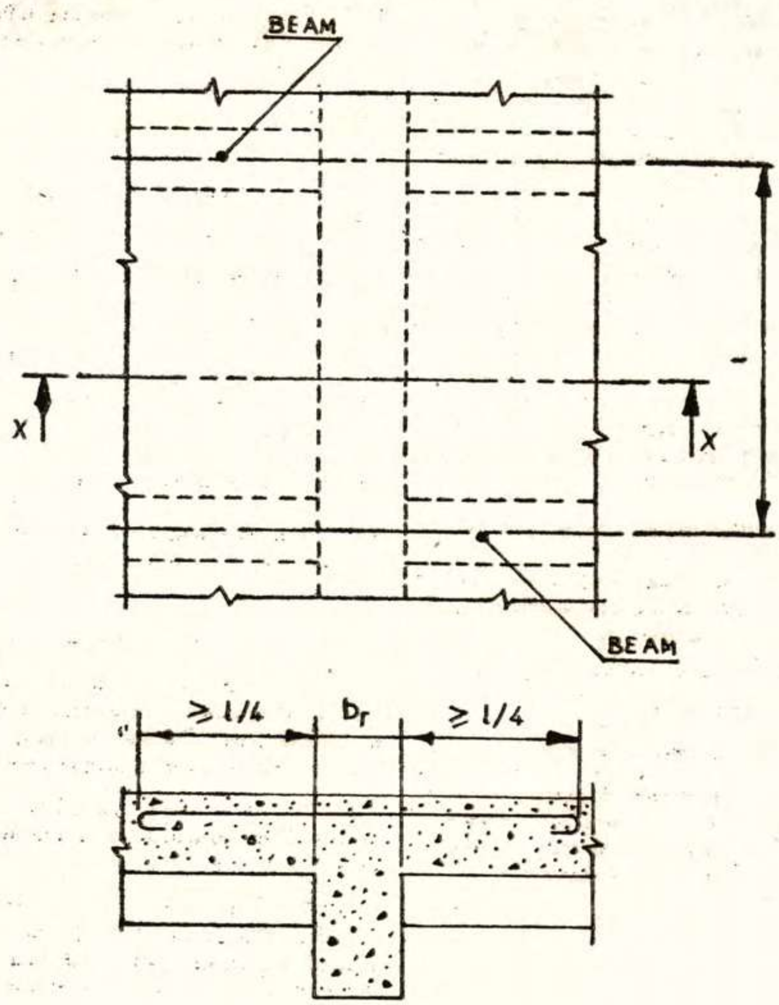
(*a*) The slab shall be cast integrally with the web, or the web and the slab shall be effectively bonded together in any other manner ; and

(*b*) If the main reinforcement of the slab is parallel to the beam transverse reinforcement shall be provided as in Fig. 2 ; such reinforcement shall not be less than 60 per cent of the main reinforcement at mid span of the slab.

22.1.2. *Effective width of flange.*—In the absence of more accurate determination, the effective width of flange may be taken as the following but in no case greater than the breadth of the web plus half the sum of the clear distances to the adjacent beams on either side:

(*a*) For T-beams, $bf = \frac{lo}{6} + bw + 6\ Df$

(*b*) For L-beams, $bf = \frac{lo}{12} + bw + 3\ Df$



SECTION XX

FIG. 2 TRANSVERSE REINFORCEMENT IN FLANGE OF T-BEAM WHEN MAIN REINFORCEMENT OF SLAB IS PARALLEL TO THE BEAM

(*c*) For isolated beams, the effective flange width shall be obtained as below but in no case greater than the actual width :

$$\text{T-beam, } b_f = \frac{l_o}{(l_o/b + 4)} + b_w$$

$$\text{L-beam, } b_f = \frac{0.5\, l_o}{(l_o/b) + 4} + b_w$$

where

b_f — effective width of flange,

l_o — distance between points of zero moments in the beam,

b_w —breadth of the web,

D_f — thickness of flange, and

b— actual width of the flange.

NOTE — For continuous beams and frames, 'l_o' may be assumed as 0.7 times the effective span.

22.2 *Control of deflection* — The deflection of a structure or part thereof shall not adversely affect the appearance or efficiency of the structure or finishes or partitions. The deflection shall generally be limited to the following :

(*a*) The final deflection due to all loads including the effects of temperature, creep and shrinkage and measured from the as-cast level of the supports of floors, roofs and all other horizontal members, should not normally exceed span/250.

(*b*) The deflection including the effects of temperature, creep and shrinkage occurring after erection of partitions and the application of finishes should not normally exceed span/350 or 20 mm whichever is less.

22.2.1. For beams and slabs, the vertical deflection limits may generally be assumed to be satisfied provided that the span to depth ratios are not greater than the values obtained as below :

(*a*) Basic values of span to effective depth ratios for spans up to 10 m :

Cantilever	7
Simply supported	20
Continuous	26

(*b*) For spans above 10 m, the values in (*a*) may be multiplied by 10/span in metres, except for cantilever in which case deflection calculations should be made.

(*c*) Depending on the area and the type of steel for tension reinforcement, the values in (*a*) or (*b*) shall be modified as per Fig. 3

(*d*) Depending on the area of compression reinforcement, the value of span to depth ratio to further modified as per Fig. 4.

(*e*) For flanged beams, the values of (*a*) or (b) be modified as per Fig. 5 and the reinforcement percentage for use in Fig. 3 and 4 should be based on area of section equal to $b_f d$.

NOTE : — When deflections are required to be calculated the method given in **Appendix B** may be used.

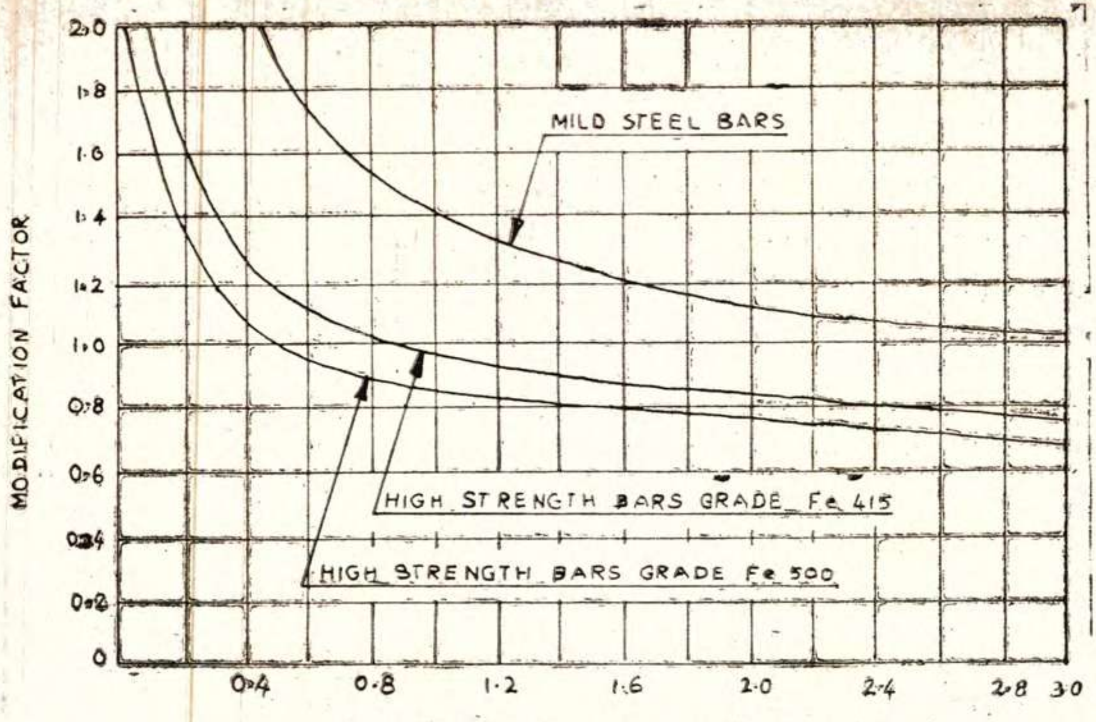


FIG 3 MODIFICATION FACTOR FOR TENSION REINFORCEMENT

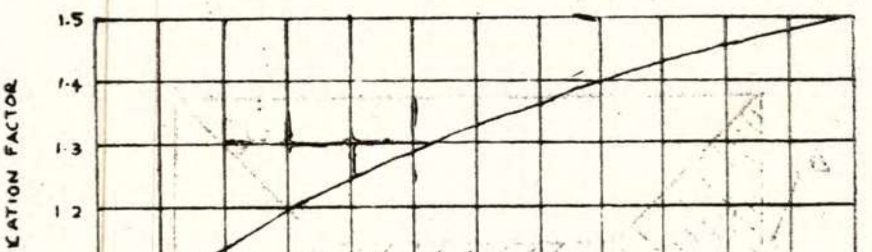


FIG. 4 MODIFICATION FACTOR FOR COMPRESSION REINFORCEMENT

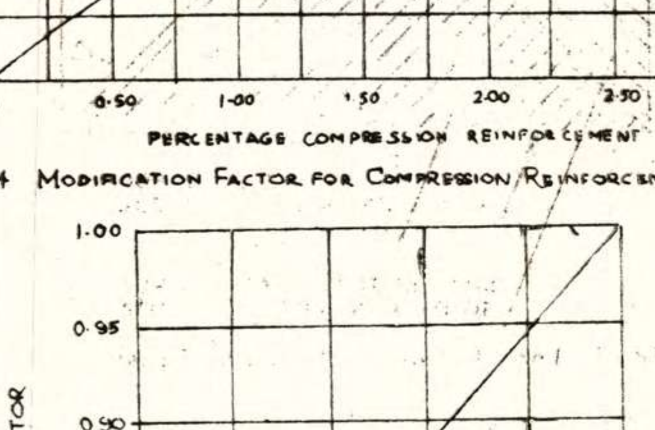


FIG. 5 REDUCTION FACTORS FOR RATIOS OF SPAN TO EFFECTIVE DEPTH FOR FLANGED BEAMS

22.3 *Slenderness limits for beams to ensure lateral stability* — A simply supported or continuous beam shall be so proportioned that the clear distance between the lateral restrains does not exceed $60\,b$ or $\frac{250\,b^2}{d}$ whichever is less, where d is the effective depth of the beam and b the breadth of the compression face midway between the lateral restraints.

For a cantilever, the clear distance from the free end of the cantilever to the lateral restraint shall not exceed 25 b or $\frac{100\,b^2}{d}$ whichever is less.

23. *Solid slabs.*

23.1 *General,*— The provisions of 22.2 for beams apply to slabs also.

NOTE 1.—For slabs spanning in two directions, the shorter of the rwo spans should be used for calculating the span to effective depth tatios.

NOTE 2. — For two-way slabs of small spans (upto 3.5 m) with mild steel reinforcement the span to overall depth ratios given below may be generally be assumed to satsify vertical deflection limits for loading class up to 3,000 N/M² (300 kg/M²) :

Simply Supported slabs	35
Continuous slabs	40

For high strength deformed bars of grade Fe 415, the values given above should be multiplied by 0.8.

23.4. *Slabs spanning in two directions at right angles* — The slabs spanning in two directions at right angles and carrying uniformly distributed load may be designed by any acceptable theory or by using coefficients given in Appendix C. For determining bending moments in slabs spanning in two directions at right angles and carrying concentrated load any accepted method approved by the engineer-in-charge may be adopted. Ribbed slabs spanning in two directions at right angles may also be treated as solid slabs provided that the spacing of ribs is not more than 12 times the flange thickness.

NOTE — The most commonly used elastic methods are based on Pigeaud's or Westergaard's theory and the most commonly used limit state of collapse method is based on Johansen's yield-line theory.

23.5 *Loads on supporting beams* — The loads on beams supporting solid slabs spanning in two directions at right angles and supporting uniformly distributed loads, may be assumed to be in accordance with Fig. 6.

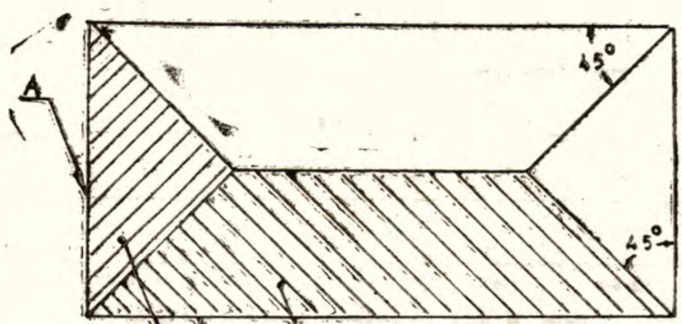


FIG. 6 LOADS CARRIED BY SUPPORTING BEAMS

24. *Compression members.*

24.1. *Definitions.*

24.1.1. Column or strut is a compression member, the effective length of which exceeds three times the least lateral dimension.

24.1.2. *Short and slender compression members*—A Compression member may be considered as short when both the Slenderness ratios $\frac{lex}{d}$ *and* $\frac{ley}{b}$ are less than 12;

where

lex—effective length in respect of the major axis,

d—depth in respect of the major axis,

ley—effective length in respect of the minor axis, and

b—width of the member.

It shall otherwise be considered as a slender compression member.

24.1.3 *Unsupported length*— The unsupported length, 1, of a compression member shall be taken as the clear distance between end restraints except that :

(*a*) in flat slab construction, it shall be clear distance between the floor and the lower extremity of the capital, the drop panel or slab whichever is the least.

(*b*) in beam and slab construction, it shall be the clear distance between the floor and the underside of the shallower beam framing into the columns in each direction at the next higher floor level.

(*c*) in columns restrained laterally, by struts, it shall be the clear distance between consecutive struts in each vertical plane, provided that to be an adequate support, two such struts shall meet the columns at approximately the same level and the angle between vertical planes through the struts shall not vary more than 30° from a right angle. Such struts shall be of adequate dimensions and shall have sufficient anchorage to restrain the member against lateral deflection.

(*d*) in columns restrained laterally by struts or beams, with brackets used at the junction, it shall be the clear distance between the floor and the lower edge of the bracket, provided that the bracket width equals that of the beam strut and is at least half that of the column.

24.2 *Effective Length of Compression Members*—In the absence of more exact analysis, the effective length l_{ef} of columns may be obtained as described in Appendix D.

24.3 *Slendernesslimits for columns.*

24.3.1. The unsupported length between end restraint shall not exceed 60 times the least lateral dimension of a column.

24.3.2. If, in any given plane, one end of a column is unrestrained, its unsupported length, 1, shall n.t exceed $\frac{100\, b^2}{D}$

where

b—width of that cross-section, and

D—depth of the cross-section measured in the plane under consideration.

24.4 *Minimum Eccentricity.*—All columns shall be designed for minimum eccentricity equal to the unuspported length of column/500 plus lateral dimension/30; subject to a minimum of 20 mm.

25. *Requirements governing Reinforcement and Detailing.*

25.1 *General.*—Reinforcing steel of same type and grade shall be used as main reinforcement in a structural member. However, simultaneous use of two different types or grades of steel for main and secondary reinforcement respectively is permissible.

25.1.1. Bars may be arranged singly, or in pairs in contact, or in groups of three or four bars bundled in contact. Bundles shall not be used in a member without stirrups. Bundled bars shall be tied together to ensure the bars remaining together. Bars larger than 36 mm diameter shall not be bundled, except in columns.

25.1.2. The recommendations for detailing for earthquake-resistant construction given in IS : 4326-1976 should be taken into consideration, where applicable.

25.2 *Development of Stress in Reinforcement.*—The calculated tension or compression in any bar at any section shall be developed on each side of the section by an appropriate development length or end anchorage or by a combination thereof.

25.2.1 *Development length of bars*—The development length *Ld* is given by

$$L_d = \frac{\varnothing \sigma_s}{4\, \tau_{bd}}$$

where

$\varnothing$—nominal diameter of the bar,

σ_s—strees in bar at the section considered at design load, and

τ_{bd}—design bond stress given in 25.2.1.1.

NOTE 1—The development length includes anchorage values of hooks in tension reinforcement.

NOTE 2.—For bars of sections other than circular, the development length should be sufficient to develope the stress in the bar by bond.

25.2.1.1. Design bond stress in limit state method for plain bar in tension shall be as below :

Grade of Concrete	M 15	M 20	M 25	M 30	M 35	M4
Design bond stress, τ_{bd}. N/mm²	1.0	1.2	1.4	1.5	1.7.	1.

For deformed bars conforming to IS: 1786-1979 or IS: 1139-1966, these values shall be increased by 60 percent.

For bars in compression, the values of bond stress for bars in tension shall be increased by 25 percent.

The values of bond stress in working stress design, are given in 44.1.

25.2.1.2 *Bars bundled in contact.*—The development length of each bar of bundled bars shall be that for the individual bar, increased by 10 percent for two bars in contact, 20 percent for three bars in contact and 33 per cent for four bars in contact.

25.2.2 *Anchoring Reinforcing Bars*

25.2.2.1 *Anchoring bars in tension*

(a) Deformed bars may be used without end anchorages provided development length requirement is satisfied. Hooks should normally be provided for plain bars in tension.

(b) *Bends and hooks.*—Bends and hooks shall conform to IS : 2502-1963 :

(1) *Bends*—The anchorage value of bend shall be taken as 4 times the diameter of the bar for each 45° bend subject to a maximum of 16 times the diameter of the bar.

(2) *Hooks*—The anchorage value of a standard U-type hook shall be equal to 16 times the diameter of the bar.

25.2.2.2 *Anchoring bars in compression*—The anchorage length of straight bar in compression shall be equal to the development length of bars in compression as specified in 25.2.1. The projected length of hooks, bends, and straight lengths beyond bends if provided for a bar in compression, shall be considered for development length.

25.2.2.3 *Mechanical devices for anchorage*—Any mechanical or other device capable of developing the strength of the bar without damage to concrete may be used as anchorage with the approval of the engineer-in-charge.

25.2.2.4 *Anchoring shear reinforcement.*

(a) *Inclined bars*—The development length shall be as for bars in tension ; thi length shall be measured as under ;

(1) In tension zone, from the end of the sloping or inclined portion of the bar, and

(2) In the compression zone, from the mid depth of the beam.

(b) *Stirrups*—Notwithstanding any of the provisions of this standard, in case of secondary reinforcement such as stirrups and transvers ties, complete development lengths and anchorage shall be deemedto have been provided when the bar is bent through an angle of at least 90° round a bar of at least its own diameter and is continued beyond the end of the curve for a length of at least eight diameters, or when the bar is bent through an angle of 135° and is continued beyond the end of the curve for a length of at least six bar diameters or when the bar is bent through an angle of 180° and is continued beyond the end of the curve for a length of at least four bar diameters.

25.2.2.5 *Bearing stresses at bends.*—The bearing stress in concrete for bend and hooks described in IS : 2502-1963 need not be checked The bearing stress inside a bend in any other bend shall be calculated

$$\text{Bearing stress} = \frac{F_{bt}}{r\varnothing}$$

where

F_{bt}—tensile force due to design loads in a bar or group of bars.

r—internal radius of the bend, and

$\varnothing$—size of the bar or, in bundle, the size of bar of equivalent area

For limit state method or design, this stress shall not exceed $\frac{1.5 f_{ck}}{1+2\varnothing/a}$

where f_{ck} is the characteristic strength of concrete and a, for a particular bar or group of bars in contact shall be taken as the centre to centre distance between bars or groups of bars perpendicular to the plane of the bend, for a bar or group, of bars adjacent to the face of the member shall be taken as the cover plus size of bar (∅). For working stress method of design, the bearing stress shall not exceed

$$\frac{f_{ck}}{1+2\varnothing/a}.$$

25.2.2.6. If a change in direction of tension or compression reinforcement induces a resultant force acting outward tending to split the concrete, such force should be taken up by additional links or stirrups Bent tension bar at a re-enrant angle should be avoided.

25.2.3. *Curtailment of tension reinforcement in flexural members.*

25.2.3.1. For curtailment, reinforcement shall extend beyond the point at which it is no longer to resist flexure for a distance equal to the effective depth of the member or 12 times the bar diameter whichever is greater except at simple support or end of cantilever In addition 25.2.3.2. to 25.2.3.5. shall also be satisfied.

NOTE.—A point at which reinforcement is no longer required to resist flexure is where the resistance moment of the section, considering only the continuing bars, is equal to the design moment.

25.2.3.2. Flexural reinforcement shall not be terminated in a tension zone unless any one of the following conditions is satisfied :

(*a*) The shear at the cut-off point does not exceed two-thirds that permitted, including the shear strength of web reinforcement provided.

(*b*) Stirrup area in excess of that required for shear and torsion is provided along each terminated bar over a distance from the cut-off point equal to three-fourths the effective depth of the member. The excess stirrup area shall be not less than $\frac{0.4b}{s/fy}$ where b is the breadth of beam, s is the spacing and fr is the characteristic strength of reinforcement in N/mm2. The resulting spacing shall not exceed $d/8\beta b$ where βb is the ratio of the area of bars cut off to the total area of bars at the section, and d is the effective depth.

(*c*) For 36 mm and smaller bars, the continuing bars provide double the area required for flexure at the cut-off point and the shear does not exceed three-fourths that permitted.

25.2.3.3. *Positive moment reinforcement.*

(*a*) At least one-third the positive moment reinforcement in simple members and one-fourth the positive moment reinforcement in continuous members shall extend along the same face of the member into the support, to a length equal to $\frac{Ld}{3}$.

(*b*) When a flexural member is part of the primary lateral load resisiting system, the positive reinforcement required to be extended into the support as described in (*a*) shall be anchored to develop its design stress in tension at the face of the support.

(*c*) At simple supports and at points of inflection, positive moment tension reinforcement shall be limited to a diameter such that Ld computed for f_d by 25.2.1 does not exceed

$$\frac{M_1}{V}+Lo$$

where

M_1.—moment of resistance of the section assuming all reinforcement at the section to be stressed to fd ;

$f_d = 0.87\ f_y$ in the case of limit state design and the permissible stress σ_{st} in the case of working stress design ;

V= Shear force at the section due to design loads ;

Lo= Sum of the anchorage beyond the centre of the support and the equivalent anchorage value of any hook or mechanical anchorage at simple support ; and at a point of inflection, Lo is limited to the effective depth of the members or 12∅ whichever is greater ; and

∅=diameter of bar.

The value of $M1/V$ in the above expression may be increased by 30 percent when the ends of the reinforcement are confined by a compressive reaction.

25.2.3.4. *Negative moment reinforcement.*—At least one-third of the total reinforcement provided for negative moment at the support shall extend beyond the point of inflection for a distance, not less than the effective depth of the member or 12 ∅or one-sixteenth of the clear span whichever is greater.

25.2.3.5. *Curtailment of bundled bars.*—Bars in a bundle shall terminate at different points spaced apart by not less than 40 times the bar diameter except for bundles stopping at a support.

25.2.4. *Special members.*—Adequate end anchorage shall be provided for tension reinforcement in flexural members where reinforcement stress is not directly proportional to moment, such as sloped, stepped, or tapered footings ; brackets ; deep beams ; and members in which the tension reinforcement is not parallel to the compression face.

25.2.5. *Reinforcement splicing.*—Where splices are provided in the reinforcing bars, they shall as far as possible be away from the sections of maximum stress and be staggered. It is recommended that splices in flexural members should not be at sections where the bending moment is more than 50 per cent of the moment of resistance ; and not more than half the bars shall be spliced at a section.

Where more than one-half of the bars are spliced at a section or where splices are made at points of maximum stress, special precautions shall be taken, such as increasing the length of lap and or sing spirals or closely-spaced strrups around the length of the splice.

25.2.5.1. *Lap splices.*

(*a*) Lap splices shall not be used for bars larger than 36 mm ; for larger diameters, bars may be welded (*see* **11.4**) ; in cases where welding is not practicable, lapping of bars larger than 36 mm may be permitted, in which case additional spirals should be provided around the lapped bars.

(*b*) Lap splice shall be considered as staggered if the centre to centre distance of the splices is not less than 1.3 times the lap length calculated as described in (*c*).

(c) Lap length including anchorage value of hooks in flexural tension shall be Ld (*see 25.2.1.*) or 30 Ø whichever is greater and for direct tension 2 Ld or 30 Ø whichever is hgreater. The straight length of the lap shall not be less than 15 Ø or 20 cm,

where
Ld is the development length as described in *25.2.1.* for *fd.*

NOTE.—Splices in tension members shall be enclosed in spirals made of bars not less than 6 mm diameter with pitch not more than 100 mm. Hooks shall be provided at the ends of bars in tension members.

(d) The lap length in compression shall be equal to the development length in compression, calculated as described in *25.2.1.*, but not less than 24Ø.

(e) When bars of two different diameters are to be spliced, the lap length shall be calculated on the basis of diameter of the smaller bar.

(f) When splicing of welded wire fabric is to be carried out, lap splices of wires shall be made so that overlap measured between the extreme cross wires shall be not less than the spacing of cross wires plus 10 cm.

(g) In case of bundled bars, lapped splices of bundled bars shall be made by splicing one bar at a time ; such individual splices within a bundle shall be staggered.

25.?.5.2. *Welded splices and mechanical connections.*—The design strength of a welded splice (*see 11.4*) or mechanical connection shall be taken as equal to 80 percent of the design strength of the bar for tension splices and 100 percent of the design strength for compression splices. However, 100 percent of the deisgn strength may be assumed in tension when the spliced area forms not more than 20 percent of the total area of steel at the section and the splices are staggered at least 60 cm.

25.2.5.3. End-bearing splices.—End bearing splices shall be used only for bars in compression. The ends of the bars shall be square cut and concentric bearing ensured by suitable devices.

25.3. *Spacing of Reinforcement.*

25.3.^. For the purpose of this clause, the diameter of a round bar shall be its nominal diameter, and in the case of bars which are not round or in the case of deformed bars or crimped bars, the diameter shall be taken as the diameter of a circle giving an equivalent effective area. Where spacing limitations and mimnimum concrete cover (*see 25.4*) are based on bar diameter, a group of bars bundled in contact shall be treated as a single bar of diameter derived from the total equivalent area.

25.3.1. *Minimum distance between individual bars.*—The following shall apply for spacing of bars :

(a) The horizontal distance between two parallel main reinforcing bars shall usually be not less than the greatest of the following :

(1) The diameter of the bar if the diameter are equal,

(2) The diameter of the larger bar if the diameters are unequal, and

(3) 5 mm more than the nominal maximum size of coarse aggregate.

NOTE.—This does not preclude the use of larger size of aggregates beyond the congested reinforcement in the same member ; the size of aggregates may be reduced around congested reinforcement to comply with this provision.

466-3—21A

(b) Greater horizontal distance than the minimum specified in (a) should be provided wherever possible. However when needle vibrators are used the horizontal distance between bars of a group may be reduced to two-thirds the nominal maximum size of the coarse aggregate, provided that sufficient space is left between groups of bars to enable the vibrator to be immersed.

(c) Where there are two or more rows of bars, the bars shall be vertically in line and the minimum vertical distance between the bars shall be 15 mm, two-thirds the nominal maximum size of aggregate or the maximum size of bar, whichever is the greatest.

25.3.2. *Maximum distance between bars in tension.*—Unless the calculation of crack widths shows that a greater spacing is acceptable, the following rules shall be applied to flexural members in normal internal or external conditions of exposure.

(a) *Beams.*—The horizontal distance between parallel reinforcement bars, or groups, near the tension face of a beam shall not be greater than the value given in Table 10 depending on the amount of redistribution carried out in analysis and the charactertistic strength of the reinforcement.

(b) *Slabs* :

(1) The horizontal distance between parallel main reinforcement bars shall not be more than three times the effective depth of a solid slab or 450 mm whichever is smaller.

(2) The horizontal distance between parallel reinforcement bars provided against shrinkage and temperature shall not be more than five times the effective depth of a solid slab or 450 mm whichever is smaller.

TABLE–10 CLEAR DISTANCE BETWEEN BARS

(*Clause* 25.32)

fy.	Percentage Redistribution to or from Section Considered				
	—30	—15	0	+15	+30
	Clear Distance Between Bars				
N/mm²	mm	mm	mm	mm	mm
250	2i5	260	300	300	300
415	125	155	180	210	235
500	105	130	150	175	195

NOTE.—The spacings given in the table are not applicable to members subjected to particularly aggressive environments unless in the calculation of the moment of resistance, *fr* has been limited to 300 N/mm² in limit state design and σst limited to 165 N/mm² in working stress design.

25.4 *Cover to Reinforcement.*

25.4.1 Reinforcement shall have concrete cover and the thickness of such cover (exclusive of plaster or other decorative finish) shall be as follows :

(a) At each end of reinforcing bar not less than 25 mm, not less than twice the diameter of such bar ;

(b) For a longitudinal reinforcing bar in a column, not less than 40 mm, not less than the diameter of such bar. In the case of columns of minimum dimension of 200 mm or under, whose reinforcing bars do not exceed 12 mm, a cover of 25 mm may be used ;

(c) For longitudinal reinforcing bar in a beam, not less than 25 mm, not less than the diameter of such bar ;

(*d*) For tensile, , compressive, shear,, or other reinforcement in a slab, not less than 15 mm, nor less than the diameter of such bar ; and

(*e*) For any other reinforcement, not less than 15 mm, nor less than the diameter of such bar.

25.4.2 Increased cover thickness may be provided when surfaces of concrete members are exposed to the action of harmful chemicals (as in the case of concrete in contact with earth faces contaminated with such chemicals), acid, vapour, saline atmosphere, sulphurous smoke (as in the case of stream-operated railways), etc., and such increase of cover may be between 15 mm and 50 mm beyond the figures given in *25 4.1* as may be specified by the engineer-in-charge.

25.4.2.1 For reinforced concrete members totally immersed in sea water, the cover shall be 40 mm more than that specified in *25.4.1*.

25.4.2.2 For reinforced concrete members, periodically immersed in sea water or subject to sea spray, the cover of concrete shall be 50 mm more than that specified in *25.4.1*.

25.4.2.3. For concrete of grade M 25 and above, the additional thickness of cover specified in *25.4.2* to *25.4.2.2* may be reduced to half.

25.5.2.4. In all such cases the cover should not exceed 75 mm.

25.5. *Requirements of Reinforcement for Structural Members.*

25.5.1 *Beams*

25.5.1.1. *Tension reinforcement*

(*a*) *Minimum reinforcement*—The minimum area of tension reinforcement shall not be less than that given by the following :

$$\frac{As}{bd} = \frac{0.85}{f_y}$$

where

As — minimum area of tension reinforcement,

b — breadth of the beam or the breadth of the web of T-beam,

d — effective depth, and

f_y — characteristic strength of reinforcement in N/mm^2.

(*b*) *Maximum reinforcement*—The maximum area of tension reinforcement shall not exceed 0.04 *bD*.

25.5.1.2 *Compression reinforcement*—The maximum area of compression reinforcement shall not exceed 0.04 *bD*. Compression reinforcement in beams shall be enclosed by stirrups for effective lateral restraint. The arrangement of stirrups shall be as specified in *25.5.2.3*.

25.5.1.3 *Side face reinforcement*—Where the depth of the web in a beam exceeds 750 mm, side face reinforcement shall be provided along the two faces. The total area of such reinforcement shall be not less than 0.1 precent of the web area and shall be distributed equally on two faces at a spacing not exceeding 300 mm or web thickness whichver is less.

25.5.1.4 *Transverse reinforcement in beams for shear and torsion*—The transverse reinforcement in beams shall be taken around the outermost tension and compression bars. In T-beams and I-beams , such reinforcement shall pass around longitudinal bars located close to the outer face of the flange.

25.5.1.5 *Maximum spacing of shear reinforcement*—The maximum spacing of shear reinforcement measured along the axis of the members shall not exceed 0.75 *d* for vertical stirrups and *d* for inclined stirrups 45°, where *d* is the effective depth of the section under consideration. In no case shall the spacing exceed 450 mm.

25.5.1.6 *Minimum shear reinforcement*—Minimum shear reinforcement in the form of stirrups shall be provided such that :

$$\frac{Asv}{bsv} \geq \frac{0.4}{f_y}$$

where

Asv — total cross-sectional area of stirrup legs effective in shear,

Sv — stirrup spacing along the length of the member,

b — breadth of the beam or breadth of the web of flanged beam, and

f_y — characteristic strength of the stirrup reinforcement in N/mm^2 which shall not be taken greater than 415 N/mm^2.

However, in members of minor structural importance such as lintels or where the maximum shear stress calculated is less than half the permissible value the provision need not be complied with.

25.5.1.7. *Distribution of torsion reinforcement*—When a member is designed for torison (*See 40* or *48*) torsion reinforcement shall be provided as below :

(*a*) Transverse reinforcement for torsion shall be rectangular closed stirrups placed perpendicular to the axis of the member. The spacing of the stirrups shall not exceed the least of $x_1, \frac{x_1+y_1}{4}$ and 300 mm, where X_1 and y_1 are respectively the short and long dimensions of the stirrup.

(*b*) Longitudinal reinforcement shall be placed as colse as is practicable to the corners of the cross-section and in all cases, there shall be at least one longitudinal bar in each corner of the ties. When the cross-sectional dimension of the member exceeds 450 mm, additional longitudinal bars shall be provided to satisfy the requirements of minimum reinforcement and spacing given in *25.5.1.3*.

25.5.1.8 Reinforcement in flanges of T and L beams shall satisfy the tequirements in *22.1.1*(b). Where flanges are in tension, a part of the main tension reinforcement shall be distributed over the effective flange width or a width equal to one tenth of the span, whichever is smaller. If the effective flange width exceeds one-tenth of the span nominal longitudinal reinforcement shall be provided in the outer portions of the flange.

25.5.2. *Slabs*—The rules given in *25.5.2.1* and *25.5.2.2* shall apply to slabs in addition to those given in the appropriate clauses.

25.5.2.1 *Minimum reinforcement.*—The reinforcement in either direction in slabs shall not be less than 0.15 percent of the total cross-sectional area. However, this value can be reduced to 0.12 percent when high strength deformed bars or welded wire fabric are used.

25.5.2.2 *Maximum diameter*—The diameter of reinforcing bars shall not exceed one eigth of the total thickness of the slab.

25.5.3 *Columns*—

25.5.3.1 *Longitudinal reinforcement*—

(*a*) The cross-sectional area of longitudinal reinforcement, shall be not less than 0.8 percent nor more than 6 percent of the gross cross sectional area of the column.

NOTE.—The use of 6 percent reinforcement may involve practical difficulties in placing and compacting of concrete ; hence lower percentage is recommended. Where bars from the column below have to be lapped with those in the column under consideration, the percentage of steel shall usually not exceed 4 percent (*b*) In any column that has a large cross-sectional area than that required to support the load, the minimum percentage of steel shall be based upon the area of concrete required to resist the direct stress and not upon the actual area.

(*c*) The minimum number of longitidinal bars provided in a column shall be four in rectangular columns and six in circular columns.

(*d*) The bars shall not be less than 12 mm in diameter.

(*e*) A reinforced concrete column having helical reinforcement shall have at least six bars of longitudinal reinforcement within the helical reinforcement.

(*f*) In a helically reinforced column, the longitudinal bars shall be in contact with the helical reinforcement and equidistant around its inner circumfrerence.

(*g*) Spacing of longitudinal bars measured along the periphery of the column shall not exceed 300 mm.

(*h*) In case of pedestals in which the longitudinal reinforcement not taken into account in strength calculations, nominal longitudinal reinforcement not less than 0.15 percent of the cross-sectional area shall be provided.

NOTE—Pedestal is a compression member, the effective length of which does not exceed three times the least lateral dimension.

25.5.3.2. *Transverse reinforcement*.

(*a*) *General*—reinforced concrete compression member shall have transverse or helical reinforcement so disposed that every longitudinal bar nearest to the compression face has effective lateral support against buckling subject to provisions in (b). The effective lateral support is given by transverse reinforcement either in the form of circular rings capable of taking up circumferential tension or by polygonal links (lateral ties) with internal angles not exceedin 135. The ends of the transverse reinforcement shall be properly anchored [*See* 25.2.2.4 (b)].

(*b*) *Arrangement of transverse reinforcement*.

(1) If the longitudinal bars are not spaced more than 75 mm on either side, transverse reinforcement need only to go round corner and alternate bars for the purpose of providing effective lateral supports (*see* Fig. 7).

(2) If the longitudical bars spaced at a distance of not exceedin 48 times the diameter of the tie are effectively tied in two directions, additional longitudinal bars in between these bars need to be tied in one direction by open ties (*see* Fig. 8).

(3) Where the longitudinal reinforcing bars in a compressio member are placed in more than one row, effective lateral support to the longitudinal bars in the inner rows may be assumed to have been provided if ;

(i) transverse reinforcement is provided for the outer-most row in accordance with 25.5.3.2., and

(ii) no bar of the inner row is closer to the nearest compression face than three times the diameter of the largest bar in the inner row (*see* Fig. 9).

(4) Where the longitudinal bars in a compresssion member are grouped (not in contact) and each group adequately tied with transerverse reinforcement in accordance with 25.5.3.2., the transverse reinforcement for the compression member as a whole may be provided on the assumption that each group is a single longitudinal bar for purpose of determining the pitch and diameter of the transverse reinforcement in accordance with 25.5.3.2. The diameter of such transverse reinforcement need not, however, exceed 20 mm (*see* Fig. 10).

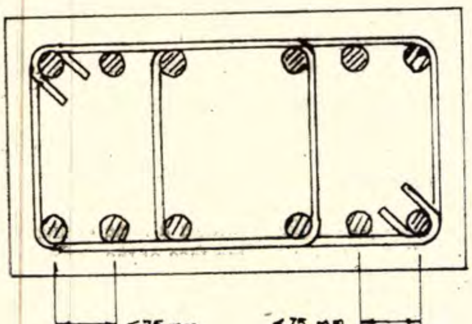


FIG. 7.

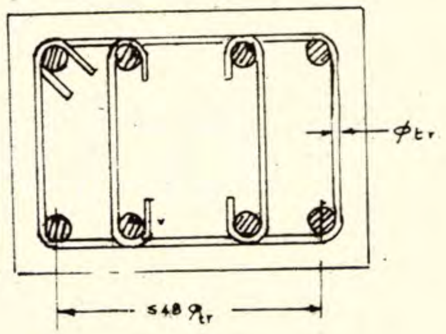


FIG. 8

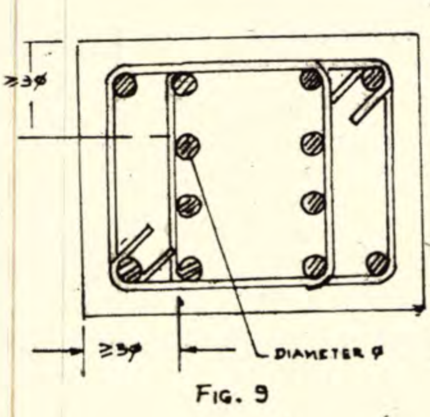


FIG. 9

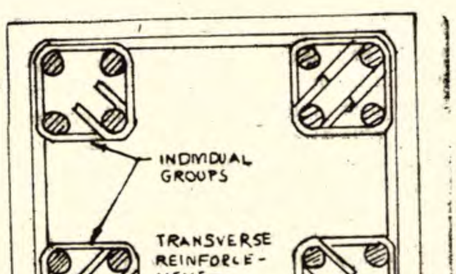


FIG. 10

(c) *Pitch and diameter of lateral ties.*

(1) *Pitch*—The pitch of transverse reinforcement shall be not more than the least of the following distances :

(i) The least lateral dimension of the compression member;

(ii) Sixteen times the smallest diameter of the longitudinal reinforcement bar to be tied;

(iii) Forty-eight times the diameter of the transverse reinforcement.

(2) *Diameter*—The diameter of the polygonal links or lateral ties shall be not less than one-fourth of the diameter of the largest longitudinal bar, and in no case less than 5 mm.

(d) *Helical reinforcement.*

(1) *Pitch*—Helical reinforcement shall be of regular formation with the turns of the helix spaced evenly and its ends shall be anchored properly by providing one and a half extra turns of the spiral bar. Where an increased load on the column on the strength of the helical reinforcement is allowed for, the pitch of helical turns shall be not more than 75 mm, nor more than one-sixth of the core—diameter of the column, nor less than 25 mm, nor less than three times the diameter of the steel bar forming the helix. In other cases, the requirements of 25.5.3.2. shall be complied with.

(2) *Diameter*—The diameter of the helical reinforcement shall be in accordance with 25.5.3.2. (c)(2).

25.5.3.3 In columns where longitudinal bars are offset at a splice the slope of the inclined portion of the bar with the axis of the column shall not exceed 1 in 6, and the portions of the bar above and below the offset shall be parallel to the axis of the column. Adequate horizonal support at the offset bends shall be treated as a matter of design, and shall be provided by metal ties, spirals, or parts of the floor construction. Metal ties or spirals so designed shall be placed near (not more than eight-bar diameters from) the point of bend. The horizontal thrust to be resisted shall be assumed as $1\frac{1}{2}$ times the horizontal components of the nominal strees in the inclined portion of the bar. Offset bars shall be bent before they are placed in the forms. Where column faces are offset 75 mm or more, splices of vertical bars adjacent to the offset face shall be made by separate dowels overlapped as specified in 25.2.5.1.

26. *Expansion Joints.*

26·1 In view of the large number of factors involved in deciding the location, spacing and nature of expansion joints, the provision of expansion joint in reinforced cement concrete structures should be left to the discretion of the designer.

26.2 Structures in which marked changes in plain dimensions take place abruptly shall be provided with expansion joints at the section where such changes occur. Expansion joints shall be so provided that the necessary movement occurs with a minimum resistance at the joint. The structures adjacent to the joint should preferably be supported on separate columns or walls but not necessarily on—separate foundations. Reinforcement shall not extend across an expansion joint and the break between the sections shall be complete.

26·3 The details as to the length of a structure where expansion joints have to be provided can be determined after taking into consideration various factors, such as temperature, exposure to weather, the time, and season of the laying of the concrete, etc. For the purpose of general guidance, how-ever, it is recommended that structures exceeding 45 m in length shall be divided by one or more expansion joints.

27. *General.*

27.1 This part covers special design requirements for some structural members and systems in addition to those given in Sections 3,5 and 6, except where modified.

28. *Deep Beams.*

28.1 *General.*

(a) A beam shall be deemed to be a deep beam when the ratio of effective span to overall depth, l/D is less than :

(1) 2.0 for a simply supported beam ; and

(2) 2.5 for a continuous beam.

(b) A deep beam complying with the requirements of 28.2 and 28.3 shall be deemed to satisfy the provisions for shear.

28.2 *Lever Arm*—The lever arm z for a deep beam shall be determined as below :

(a) For simply supported beams :

$$z=0.2\,(l+2D) \text{ when } 1 \leq \frac{l}{D} \leq 2$$

or

$$z=0.6\,l \qquad \text{when } \frac{l}{D} < 1$$

(b) For continuous beams :

$$Z=0.2\,(l+1.5D) \text{ when } 1 \leq \frac{l}{D} \leq 2.5$$

or

$$Z=0.5\,l \qquad \text{when } \frac{l}{D} < 1$$

Where l is the effective span taken as centre to centre distance between supports or 1.15 times the clear span, whichever is smaller and D is the overall depth.

28.3. *Reinforcement.*

28.3.1 *Positive reinforcement.*—The tensile reinforcement required to resist positive bending moment in any span of deep beam shall :

(a) extend without curtailment between supports ;

(b) be embedded beyond the face of each support, so that at the face of the support it shall have a development length not less than 0.8 Ld ; where Ld is the development length (*see 25.2.1*), for the design strees in the reinforcement ;

(c) be placed within a zone of depth equal to $0.25\,D-0.05\,l$ adjacent to the tension face of the beam where D is the overall depth and l is the effective span.

28.3.2 *Negative reinforcement.*

(a) *Termination of reinforcement.*—For tensile reinforcement required to resist negative bending moment over a support of a deep beam :

(1) It shall be permissible to terminate not more than half of the reinforcement at a distance of 0.5 D from the face ofthe support where D is as defined in 28.2 ; and

(2) The remainder shall extend over the full span.

(b) *Distribution.*—When ratio of clear span to overall depth is in the range 1.0 to 2.5, tensile reinforcement over a support of a deep beam shall be placed in two zones comprising :

(1) a zone of depth 0.2 D, adjacent to the tension face, which shall contain a proportion of the tension steel given by

$$0.5\left(\frac{l}{D}-0.5\right)$$

where

l —clear span, and

D—overall depth ; and

(2) a zone measuring 0.3 D on either side of the mid-depth of the beam, which shall contain the remainder of the tension steel, evenly distributed.

For span to depth ratios less than unity, the steel shall be evenly distributed over a depth of 0.8 D measured from the tension face.

28.3.3 *Vertical reinforcement*.—If forces are applied to a deep beam in such a way that hanging action is required bars or suspension stirrups shall be provided to carry all the forces concerned.

28.3.4 *Side face reinforcement*.—Side face reinforcement shall comply with requirements of minimum reinforcement of walls (*see 31.4*

30. *Flat Slabs*.

30.1 *General*.—The term flat slab means a reinforced concrete slab with or without drops, supported generally without beams, by columns with or without flared column heads. A flat slab may be solid slab or may have recesses formed on the soffit so that the soffit comprises a series of ribs in two directions. The recesses may be formed by removable or permanent filler blocks.

(For design refer to I.S. 456-1978)

31. *Walls*.

31.1 *General*.—Where reinforced concrete walls are intended to carry vertical loads, they should be designed generally in accordance with the recommendations given for columns. The provisions with regard to transverse reinforcement to restrain the vertical bars against buckling need not be applied to walls in which the vertical bars are not assumed to assist in resisting compression. The minimum reinforcement shall be as per *31.4*. The minimum thickness of wall should not be less than 100 mm.

31.2 *Load Carrying Capacity*.—The load carrying capacity of the walls shall be calculated as for columns given in Section 5 or 6; however the strength of the wall may be increased by the values given below :

Ratio of storey height to length of wall	1.5 or more	1.0	0.5 less
percentage increase in strength	0	10	20

NOTE.—The length of the wall is the overall length or, where openings occur, the length between adjacent openings.

31.3 *Slenderness Effects*.—When the effective height of the wall exceeds 12 times the wall thickness, the slenderness effects shall be considered as in columns. Where the wall is stiffened by cross walls, the slenderness ratios may be determined as in IS : 1905 1969*

31·4 *Reinforcement*.—The reinforcement for walls shall be provided as below :

(*a*) the minimum ratio of vertical reinforcement to gross concrete area shall be :

(1) 0.0012 for deformed bars not larger than 16 mm in diameter and with a characteristic strength of 415 N/mm² or greater.

(2) 0.0015 for other types of bars.

(3) 0.0012 for welded wire fabric not larger than 16 mm in diameter.

* Code of practice for structural safetyo fb uildings : Masonry walls (*first revision*).

(*b*) Vertical reinforcement shall be spaced not further apart than three times the wall thickness nor 450 mm.

(*c*) The minimum ratio of horizontal reinforecement to gross concrete area shall be :—

(1) 0.0020 for deformed bars not larger than 16 mm. in diameter and with a characteristic strength of 415 N/mm or greater.

(2) 0.002 5 for other types of bars.

(3) 0.002 0 for welded wire fabric not larger than 16 mm. in diameter.

(*d*) Horizontal reinforcement shall be spaced not farther apart than three times the wall thickness nor 4.50 mm.

NOTE.—The minimum reinforcement may not always be sufficient to provide adequate resistance to the effects of shrinkage and temperature.

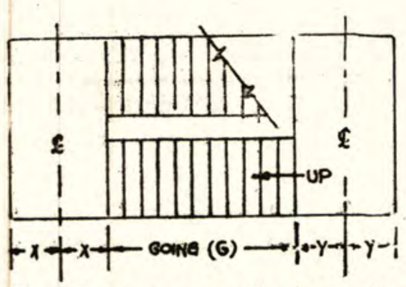
32 *Stairs*.

32·1 *Effective Span of Stairs*—The effective span of stairs without stringer beams shall be taken as the following horizontal distances :

(*a*) Where supported at top and bottom risers by beams spanning parallel with the risers, the distance centre-to-centre of beams ;

(*b*) Where spanning on to the edge of a landing slab, which spans parallel, with the risers (*see* Fig. 16), a distance equal to the going of the stairs plus at each end either half the width of the landing or one metre, whichever is smaller ; and

(*c*) Where the landing slab spans in the same directs as the stairs, they shall be considered as acting together to form a single slab and the span determined as the distance centre-to-centre of the supporting beams or walls, the going being measured horizontally.



X	Y	SPAN IN METRES
<1m	<1 m	G+X+Y
<1 m	≥1 m	G+X+1
≥1 m	<1 m	G+Y+1
≥1m	≥1m	G+1+1

FIG 16 EFFECTIVE SPAN FOR STAIRS SUPPORTED AT EACH END BY LANDINGS SPANNING PARALLEL WITH THE RISERS

32.2. *Distribution of loading on stairs.*—In the case of stairs with open wells, where spans partly crossing at right angles occur, the load on areas common to any two such spans Partly may be taken as one-half in each direction as shown in Fig. 17. Where flights or landing are embedded into walls for a length of not less than 110 mm. and are designed to span in the direction of the flight, a 150 mm. strip maybe deducted from the loaded area and the effective breadh of the section increased by 75 mm. for purposes of designs (*see* Fig. 18)

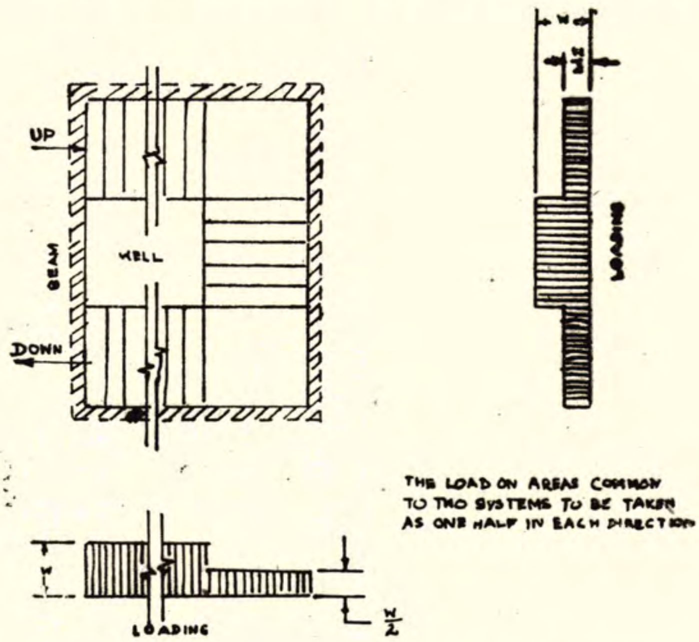


FIG 17 LOADING ON STAIRS WITH OPEN WELLS

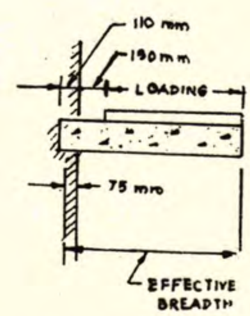


FIG 18 LOADING ON STAIRS BUILT INTO WALLS

32.3. *Depth of section.*—The depth of section shall be taken as the minimum thickness perpendicular to the soffit of the staircase.

33. *Footings.*—

33·1 *General.*—Footings shall be designed to sustain the applied loads, moments and forces and the induced reactions and to ensure that any settlement which may occur shall be as nearly uniform' as possible, and the safe bearing capacity of the soil is not exceeded (*see* IS : 1904-1978*).

33·1·1. In sloped or stepped footings the effective cross section in compression shall be limited by the area above the neutral plane and the angle of slope or depth and location of steps shall be such that the design requirements are satisfied at every section. Slopped and stepped footings that are designed as a unit shall be constructed to assure action as a unit.

33·1·2. *Thickness at the edge of footing.*—In reinforcement and plain concrete footings, the thickness at the edge shall be not less than 15 cm. for footings on soils, nor less than 30 cm. above the tops of piles for footings on piles.

33·1·3. In the case of plain concrete pedestals, the angle α between the plane passing through the bottom edge of the pedestal and the corresponding junction edge of the column with pedestal and the horizontal plane (*see* Fig. 19) shall be goverened by the expression :

$$\tan\alpha \not< 0{\cdot}9\sqrt{\frac{100\,q_0}{f_{ck}}+1}$$

where

= q_0 calculated maximum bearing pressure at the base of the pedestal in N/mm², and

= f_{ck} characteristic strength of concrete at 28 days in N/mm²

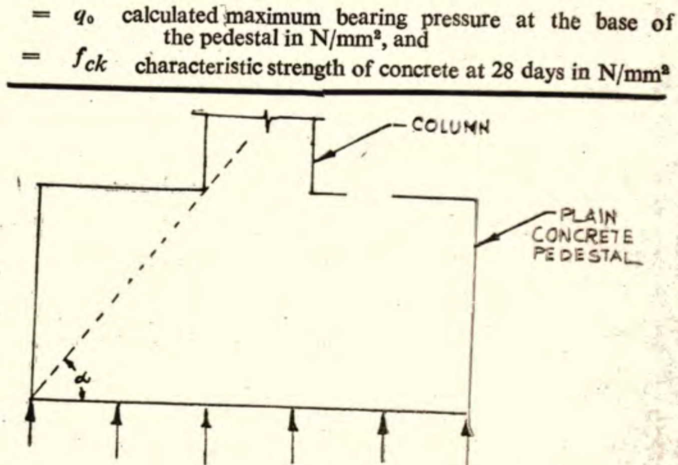


FIG. 19

33.2. *Moments and Forces*—

33.2.1. In the case of footings on piles, computation for moments and shears may be based on the assumption that the reaction from any pile is concentrated at the centre of the pile.

33.2.2. For the purpose of computing stresess in footings which support a round or octagonal concrete column or pedestal, the face of the column or pedestal shall be taken as the side of a square inscribed within the perimeter of the round or octagonal column or pedestal.

33.2.3. *Bending moment*—

33.2.3.1. The bending moment at any section shall be determined by passing through the section a vertical plane which extends completely across the footing, and computing the moment of the forces acting over the entire area of the footing on one side of the said plane.

33.2.3.2. The greatest bending moment to be used in the design of an isolated concrete footing which supports a column, pedestal or wall, shall be the moment computed in the manner prescribed in 33.2.3.1. at sections located as follows :—

(*a*) At the face of the column, pedestal or wall, for footings supporting a concrete column, pedestal or wall ;

(*b*) Halfway between the centre line and the edge of the wall, for footings under masonry walls ; and

(*c*) Halfway between the face of the column or pedestal and the edge of the gussetted base, for footings under gussetted bases.

33.2.4. *Shear and bond*—

33.2.4.1. The shear strength of footings is goverend by the more severe of the following two conditions:—

(*a*) The footing acting essentially as a wide beam, with a potential diagonal crack extending in a plane across the entire width : the critical section for this condition shall be assumed as a vertical section located from the face of the column, pedestal or wall at a distance equal to the effective depth of the footing in case of footings on soil and a distance equal to half the effective depth of footing for footing on piles.

(*b*) Two-way action of the footing, with potential diagonal cracking along the surface of truncated cone or pyramid around the concentrated load ; in this case, the footing shall be designed for shear in accordance with appropriate provisions specified in 30.6.

33.2.4.2. In computing the external shear on any section through a footing supported on piles, the entire reaction from any pile of diameter *Dp* whose centre is located *Dp*/2 or more outside the section shall be assumed as producing shear on the section, the reaction from any pile whose centre is located *Dp*/2 or more inside the section shall be assumed as producing no shear on the section. For intermediate positions of the pile centre, the portion of the pile reaction to be assumed as producing shear on the section shall be based on straight line interpolation between full value at *Dp*/2 outside the section and zero value at ;*Dp*/2 inside the section.

33.2.4.3. The critical section for checking the development length in a footing shall be assumed at the same planes as those described for bending moment in 33.2.3. and also at all other vertical planes where abrupt changes of section occur. If reinforcement is curtailed the anchorage requirements shall be checked in accordance with 25.2.3.

33.3. *Tensile Reinforcement*—The total tensile reinforcement of any section shall provide a moment of resistance at least equal to the bending moment on the section calculated in accordance with 33.2.3.

33.3.1. Total tensil reinforcement shall be distributed across the corresponding resisting section as given below :—

(*a*) In one-way reinforced footing, the reinforcement shall be distributed uniformly across the full width of the footing ;

(*b*) In two-way reinforced square footing, the reinforcement extending in each direction shall be distributed uniformly across the full width of the footing ; and

(*c*) In two-way reinforced rectangular footing, the reinforcement in the long direction shall be distributed uniformly across the full width of the footing. For reinforcement in the short direction, a central band equal to the width of the footing shall be marked along the length of the footing and portion of the reinforcement determined in accordance with the equation given below shall be uniformly distributed across the central band :

$$\frac{\text{Reinforcement in central band width}}{\text{Total reinforcement in short direction}} = \frac{2}{\beta + 1}$$

33.4. *Transfer of Load at the Base of Column*.—The compressive stress in concrete at the base of a column or pedestal shall be considered as being transferred by being to the top of the supporting pedestal or footing. The bearing pressure on the loaded area shall not exceed the permissible bearing stress in direct compression multiplied by

a value equal $\sqrt{\frac{A_1}{A_2}}$ but not greater than 2 ;

where

A_1 —supporting area for bearing of footing, which is sloped or stepped footing may be taken as the area of the lower base of the largest frustrum of a pyramid or cone contained wholly within the footing and having for its upper base, the area actually loaded and having side slope of one vertical to two horizontal ; and

A_2 —loaded area at the column base.

For working stress method of design the permissible bearing stress on full area of concrete shall be taken as 0.25 *fck*. for limit state method of design the permissible bearing stress shall be 0.45 *fck*.

33.4.1. Where the permissible bearing stress on the concrete in the supporting or supported member would be exceeded, reinforcement shall be provided for developing the excess force, either by extending the longitudinal bars into the supporting member, or by dowels (*see* 33.4.3.).

33.4.2. Where transfer of force is accomplished by reinforcement, the development length of the reinforcement shall be sufficient to transfer the compression or tension to the supporting member in accordance with 25.2.

33.4.3. Extended longitudinal reinforcement or dowels of at least 0.5 per cent of the cross sectional area of the supported column or pedestal and a minimum of four bars shall be provided. Where dowels are used, their diameter shall not exceed the diameter of the column bars by more than 3 mm.

33.4.4. Column bars of diameters larger than 36 mm. in compression only can be dowelled at the footings with bars of smaller size of the necessary area. The dowel shall extend into the column, a distance equal to the development length of the column bar and into the footing, a distance equal to the development length of the dowel.

34. *Safety and Serviceability Requirements—*

34.1. *General.*—In the method of design based on limit state concept the structure shall be designed to withstand safely all loads liable to act on it throughout its life ; it shall also satisfy the serviceability requirements, such as limitations on deflection and cracking. The acceptable limit for the safety and serviceability requirements before failure occurs is called a 'Limit State'. The aim of design is to achieve acceptable probabilities that the structure will not become unfit for the use for which it is intended, that is, that it will not reach a limit state.

34.1.1. All relavant limit states shall be considered in design to ensure an adequate degree of safety and serviceability. In general, the structure shall be designed on the basis of the most critical limit state and shall be checked for other limit states.

34.1.2. For ensuring the above objective, the design should be based on characteristic values for material strengths and applied loads, which take into account the variations in the material strengths and in the loads to be supported. The characteristic values should be based on statistical data if available ; where such data are not available they should be a based on experience. The 'design values' are derived from the characteristic values through the use of partial safety factors, one for material strengths and the other for loads. In the absence of special considerations these factors should have the values given in 35 according to the material, the type of loading and the limit state being considered.

34.2. *Limit State of Collapse.*—The limit state of collapse of the structure or part of the sturcture could be assessed from rupture of one or more critical sections and from buckling due to elastic or plastic instability (including the effects of sway where appropriate) or overturning. The resistance to bending, shear, torsion and axial loads at every section shall not be less than the appropriate value at that section produced by the probable most unfavourable combination of loads on the structure using the appropriate partial safety factors.

34.3. *Limit States of Serviceability—*

34.3.1. *Deflections.*—Limiting values of deflections are given in 22.2.

34.3.2. *Cracking.*—Cracking of concrete should not adversely affect the appearance or durability of the structure ; the acceptable limits of cracking would vary with the type of structure and environment. The actual widths of cracks will vary between wide limits and the prediction of obsolute maximum which is not possible.

NOTE.—As a guide, the following may be regarded as reasonable limits :—

The surface width of cracks should not, in general exceed 0.3 mm. For particularly aggressive environment, such as the severe category in Table 19, the assessed surface width of cracks at points nearest to the main reinforcement should not, in general, exceed 0.004 times the nominal cover to the main reinforcement. The possibility of some cracks being wider may be taken into account, if necessary.

34.4. *Other Limit States.*—Structures designed for unusual or special functions shall comply with any relevant additional limit state considered appropriate to that structure.

35. *Characteristic and Design Values and Partial Safety Factors—*

35.1. *Characteristic strength of materials.*—The term 'characteristic strength' means that value of the strength of the material below which not more than 5 per cent of the test results are excepted to fall. The characteristic strength for concrete shall be in accordance with Table 2 modified by 5.2.1. regarding increase in concrete strength with age. Until the relavant Indian Standard Specifications for reinforcing, steel are modified to include the concept of charateristic strength, the characteristic value shall be assumed as the minimum yield /0.2 per cent proof stress specified in the relevant Indian Standard specifications.

35.2. *Characteristic Loads.*—The term 'characteristic load' means that value of load which has a 95 per cent probability of not being exceeded during the life of the structure. Since data are not available to express loads in statistical terms, for the purpose of this code, the dead loads worked out on the basis of IS : 1911-1967, live and wind loads given in I.S. : 1875-1964 and seismic forces given in IS : 1893-1975 shall be assumed as the characteristic loads.

35.3. *Design Values—*

35.3.1. *Materials.*—The design strength of the materials, *fd* is given by :

$$fd = \frac{f}{\gamma\ m}$$

where

f = characteristic strength of the material (*see* 35.1) and

$\gamma\ m$ = partial safety factor appropriate to the material and the limit state being considered.

35.3.2. *Loads.*—The design load, *Fd* is given by

$$Fd = F\gamma t.$$

where

F = characteristic load (*see* 35.2) and

γf = partial safety factor appropriate to the nature of loading and the limit state being considered.

35.3.3. *Consequences of attaining limit state.*—Where the consequances of a structure attaining a limit state are of a serious nature such as huge loss of life and disruption of the economy, higher values for *r m* and than those given under 35.4.1. and 35.4.2. may be applied.

35.4. *Partial Safety Factor—*

35.4.1. *Partial safety for loads.*—The values of $\gamma\ t$ given in Table 2 shall normally be used.

TABLE 12—VALUES OF PARTIAL SAFETY FACTOR $\gamma\ t$ FOR LOADS.

(*Classes* 18.3 *and* 35.4.1.)

Load combination.	*Limit state of collapse.*			*Limit States of Serviceability.*		
	DL.	*LL.*	*WL.*	*DL.*	*LL.*	*WL.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
$DL+LL$ ..	..	1.5	..	1.0	1.0	..
$DL+WL$ ..	1.5 or 0.9*	..	1.5	1.0	..	1.0
$DL+LL+WL$.		1.2		1.0	0.8	0.8

NOTE 1.—While considering earthquake effects, substitute *EL* for *WL*.

NOTE 2.—For the limit states of serviceability, the values of γt given in this table are applicable for short term effects. While assessing the long term effects due to creep, the dead load and that part of the live load likely to be permanent may only be considered.

*This value is to be considered when stability against overturning of stress reversal is critical.

35.4.2 *Partial safety factor* γm *for material strength.*

35·4.2·1 When assessing the strength of a structure or structural member for the limit state of collapse the values of partial safety factor, γm should be taken as 1.5 for concrete and 1.15 for steel.

NOTE.—γm values are already incorporated in the equations table given in this code for limit state design.

36.4.2.2 When assessing the deflection, the material properties such as modulus of elasticity should be taken as those associated with the characteristic strength of the material.

36. *Analysis.*

36.1 *Analysis of Structure.*—Methods of analysis as in 21 shall be used. The material strength to be assumed shall be characteristic values in the determination of elastic properties of members irrespective of the limit state being considered. Redistribution of the calculated moment may be made as given in 36.1.1.

36.1.1 *Redistribution of members in continuous beams and frames.*—The redistribution of moments may be carried out satisfying the following conditions :—

(*a*) Equilibrium between the internal forces and the external loads is maintained.

(*b*) The ultimate moment of resistance provided at any section of a member is not less than 70 per cent of the moment at that section obtained from an elastic maximum moment diagram covering all appropriate combinations of loads.

(*c*) The elastic moment at any section in a member due to a particular combination of loads shall not be reduced by more than 30 per cent of the numerically largest moment given anywhere by the elastic maximum moments diagram for the particular member, covering all appropriate combination of loads.

(*d*) At sections where the moment capacity after redistribution is less than that from the elastic maximum moment diagram, the following relationship shall be satisfied :—

$$\frac{\delta M}{d} + \frac{Xu}{100} \leq 0.6$$

where

Xu=depth of neutral axis,

d=effective depth, and

δM=percentage reduction in moment.

(*e*) In structures in which the structural frame provides the lateral stability, the reductions in moment allowed by condition 36.1.1 (*c*) shall be restricted to 10 per cent for structures over 4 storeys in height.

36.1.2. *Analysis of slabs spanning in two directions at Right angles.*—Yield line theory or any other acceptable method may be used. Alternatively the provisions given in Appendix C may be followed.

37. *Limit state of collapse: Flexure.*

37.1. *Assumptions*—Design for the limit state of collapse n flexure shall be based on the assumptions given below :—

(*a*) Plane sections normal to the axis remain plane after bending.

(*b*) The maximum strain in concrete at the outermost compression fibre is taken as 0.0035 in bending.

(*c*) The relationship between the compressive stress distribution in concrete and the strain in concrete may be assumed to be rectangle, trapexiod, parabola or any other shape which results in prediction of strength in substantial agreement with the results of tests. An acceptable stress-strain curve is given in Figure 20. For design purposes, the compressive strength of concrete in the structure shall be assumed to be 0.67 times the characteristic strength. The partial safety factor γm =1.5 shall be applied in addition to this.

NOTE.—For the stress-strain curve in Figure 20 the design stress block parametres are as follows (*see* Fig. 21):—

Area of stress block	0.36 fck xu
Depth of centre of compressive force from the extreme fibre in compression.	0.42 xu

where

fck—characteristic compressive strength of concrete, and

xu—depth of neutral axis.

(*d*) The tensile strength of the concrete is ignored.

(*e*) The stresses in the reinforcement are derived from representative stress-strain curve for the type of steel used. Typical curves are given in Figure 22. For design purposes the partial safety factor γm, equal to 1.15 shall be applied.

(*f*) The maximum strain in the tension reinforcement in the section at failure shall not be less than :—

$$\frac{fy}{1.15Es} + 0.002$$

where

fy — characteristic strength of steel, and

Es —modulus of elasticity of steel.

NOTE.—The limiting values of the depth of neutral axis for different grades of steel based on the assumptions in 37.1 are as follows :—

fy	Xu,max/d
250	0.53
415	0.48
500	0.46

The expressions for obtaining the moments of resistance for rectangular and T-Sections, based on the assumptions of 37.1 are given in Appendix E.

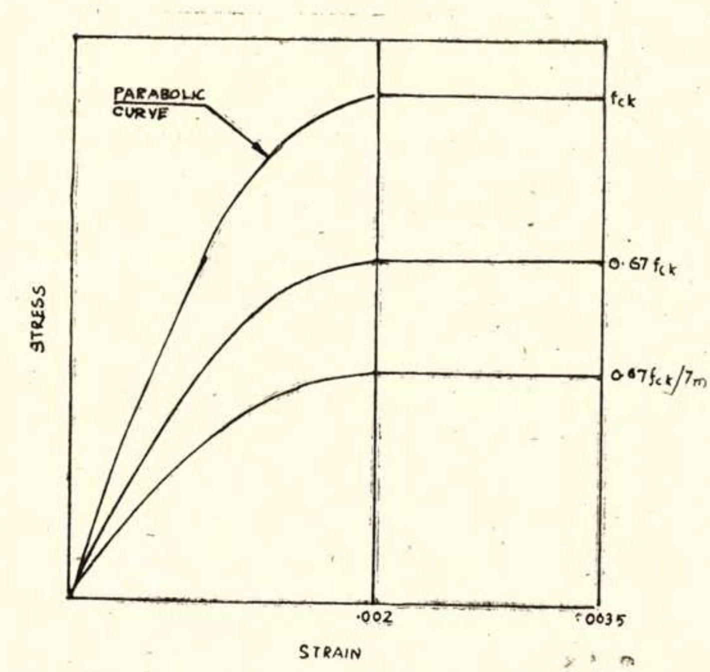


FIG. 20 STRESS STRAIN CURVE FOR CONCRETE

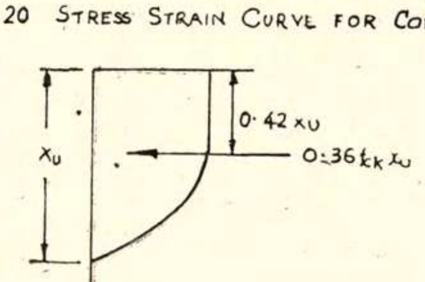
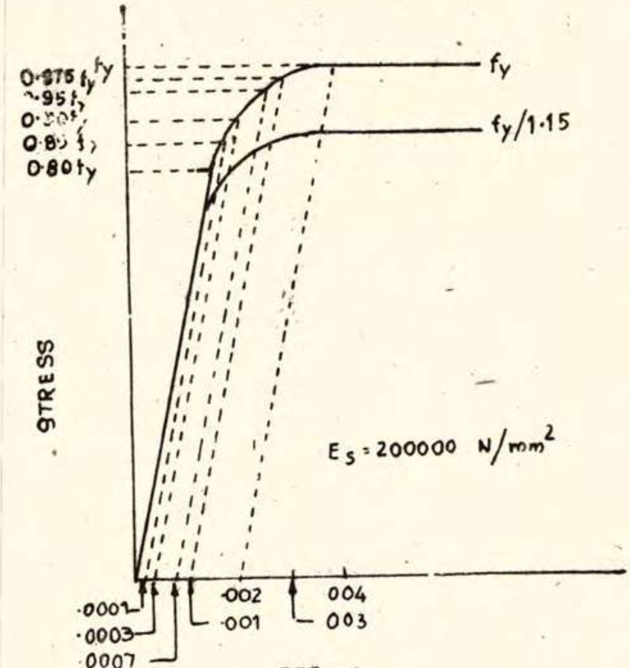
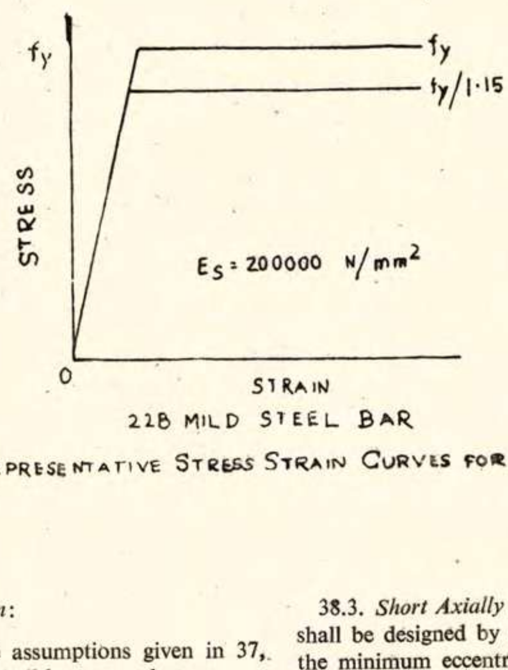


FIG: 21 STRESS BLOCK PARAMETERS



22A COLD WORKED DEFORMED BAR



22B MILD STEEL BAR

FIG. 22 REPRESENTATIVE STRESS STRAIN CURVES FOR REINFORCEMENT

38. *Limit state of collapse Compression*:

38.1. *Assumptions.*—In addition to the assumptions given in 37, 1(*a*) to 37·1 (*e*) for flexure, the following shall be assumed :

(*a*) The maximum compressive strain in concrete in axial compression is taken as 0.002.

(*b*) The maximum compressive strain at the highly compressed extreme fibre in concrete subjected to axial compression and bending and when there is no tension on the section shall be 0.003 5 minus 0.75 times the strain at the least compressed extreme fibre.

38.2. Minimum Eccentricity—All members in compression shall be designed for the minimum eccentricity in accordance with 24.4. Where calculated eccentricity is larger, the minimum eccentricity should be ignored.

38.3. *Short Axially Loaded Members in Compression.*—The member shall be designed by considering the assumptions given in 38.1 and the minimum eccentricity. When the minimum eccentricity as per 24.4 does not exceed 0.05 times the lateral dimension, the members may be designed by the following equation :

$$Pu. = 0.4 fck \cdot Ac. + 0.67 fy. \ Asc$$

Where

Pu—axial load on the member,

fck—characteristic compressive strength of the concrete,

Ac—area of concrete,

fy—characteristic strength of the compression reinforcement, and

Asc—area of longitudinal reinforcement for columns.

38.4. *Compression members with helical reinforcement.*— The strength of compression members with helical reinforcement satisfying the requirement of 38·4.1 shall be taken as 1.05 times the strength of similar member with lateral ties.

38.4.1. The ratio of the volume of helical reinforcement to the volume of the core shall not be less than $0.36\left\{\frac{Ag}{Ac}-1\right\}\frac{fck}{fy}$

where

Ag—gross area of the section,

Ac—area of the core of the helically reinforced column measured to the outside diameter of the helix,

fck—characteristic compressive strength of the concrete, and

fy—characteristic strength of the helical reinforcement but not exceeding 415 N/mm².

38.5. *Members subject to combined axial load and uniaxial bending.*— A member subjected to axial force and uniaxial bending shall be designed on the basis of 38.1 and 38.2.

NOTE.—The design of member subject to combined axial load and uniaxial bending will involve lengthy calculation by trial and error in order to overcome these difficulties intraction diagrams may be used. These have been prepared and published by ISI in SP:16 Design aids for reinforced concrete to IS : 456-1978.

38.6. *Members subject to combined axial load and biaxial bending.*— The resistance of a member subjected to axial force and biaxial bending shall be obtained on the basis of assumptions given in 38.1 and 38.2 with neutral axis so chosen as to satisfy the equilibrium of load and moments about two axes. Alternatively such members may be designed by the following equation :

$$\left\{\frac{Mux}{Mux_1}\right\}^{\alpha n}+\left\{\frac{Muy}{Muy_1}\right\}^{\alpha n}\leq 1{\cdot}0$$

where

Mux, Muy—moments about *x* and *y* axes due to design loads.

Mux_1, Muy_1—maximum uniaxial moment capacity for an axial load of *Pu* bending about *x* and *y* axes respectively, and

αn is related to *Pu/Puz*

where $Puz = 0.45\, fck\, Ac + 0{\cdot}75\, fy/Asc$

For values of $Pu/Puz = 0.2$ to 0.8 the values of αn vary linearly from 1.0 to 2.0. For values less than 0.2, αn *is* 1.0 ; for values greater than 0.8, αn is 2·0

38.7. *Slender compression members.*—The design of slender compression members (*see* 24.1.1) shall be based on the forces and the moments determined from an analysis of the structure, including the effect of deflections on moments and forces. When the effect of deflections are not taken into account in the analysis additional moment given in 38.7.1 shall be taken into account in the appropriate direction.

38.7.1 The additional moments *Max* and *May* shall be calculated by the following formulae :

$$Max=\left\{\frac{PuD}{2000}\right\}\left\{\frac{lex}{D}\right\}^2$$

$$May=\left\{\frac{Pub}{2000}\right\}\left\{\frac{ley}{b}\right\}^2$$

where

Pu — axial load on the member,

lex — effective length in respect of the major axis,

ley — effective length in respect of the minor axis,

D — depth of the cross section at right angles to the major axis, and

b — width of the members.

For design of section 38.5 or 38.6 as appropriate shall apply.

NOTE.—1. In the case of a braced column without any transverse loads occurring in its height, the additional moment shall be added to an initial moment equal to sum of $0{\cdot}4\, Mu_1$ and $0.6\, Mu_2$ where Mu_2 is the larger end moment and Mu_1 is the smaller end moment (assumed negative if the column is bent in double curvatue). In no case shall the initial moment be less than $0.4\, Mu_2$ nor the total moment including the initial moment be less than Mu_2. For unbraced columns, the additional moment shall be added to the end moments.

NOTE 2.—Unbraced compression members at any given level or store, subject to lateral load are usually constrained to deflect equally. In such cases slenderness ratio for each column may be taken as the average for all columns acting in the same direction.

38.7.1.1. The values given by equation 38·7.1 may be multiplied by the following factor :

$$k=\frac{Puz-Pu}{Puz-Pb}\leq 1$$

where

Pu—axial load on compression member,

Puz—as defined in 38·6 and

Pb—axial load corresponding to the condition of maximum compressive strain of 0.003 5 in concrete and tensile strain of 0·002 in outermost layer of tension steel.

39. *Limit state of collapse—Shear*:

39.1. *Nominal shear stress.*—The nominal shear stress τv in beams of uniform depth shall be obtained by the following equation :

$$\tau v=\frac{Vu}{bd}$$

where

Vu —shear force due to design loads ;

b —breadth of the member, which for flanged sections shall be taken as the breadth of the web, *bw* and

d —effective depth.

39.1.1. *Beams of varying depth.*—In the case of beams of varying depth the equation shall be modified as :

$$\tau v=\frac{Vu\pm\frac{Mu}{d}\tan\beta}{bd}$$

where

τv, *Vu*, *b* and *d* are the same as in 39.1

Mu—bending moment at the section and

β—angle between the top and bottom edges of the beam.

The negative sign in the formula applies when the bending moment *Mu* increases numerically in the same direction as the effective depth *d* increases, and the positive sign when the moment decreases numerically in this direction.

39. 2. *Design shear strength of concrete.*

39.2.1. *Without shear reinforcement.*—The design shear strength of concrete in beams without shear reinforcement is given in Table 13.

39.2.1.1. For solid slabs, the design shear strength for concrete shall be $K\tau c$ where k has values given below :—

Overall Depth of Slab, mm.	300 or more	275	250	225	200	175	150 or
k.	1.00	1.05	1.10	1.15	1.20	1.25	1.30

NOTE.—This provision shall not apply to flat slabs for which 30.6 shall apply.

39.2.2. *Shear strength of members under axial compression.*—For members subjected to axial compression Puw the design shear strength of concrete τc given in Table 13, shall be multiplied by the following factor δ :—

$$\delta = 1 + \frac{3Pu}{Ag\ fck}, \text{ but not exceeding } 1.5$$

where

Pu — axial compressive force in Newtons.

Ag — gross area of the concrete section in mm² and

fck— characteristic compressive strength of concrete.

39.2.3. *With shear reinforcement.*—Under no circumstances, even with shear reinforcement shall the nominal shear stress in beams τv exceed $\tau\ c\ max$ given in Table 14.

39.2.3.1. For solid slabs, the nominal shear stress shall not exceed half the appropriate values given in Table 14.

39.3. *Minimum shear reinforcement.*—When τv is less than τc given in Table 13, minimum shear reinforcement shall be provided in accordance with *25 5 16*.

39.4. *Design of shear reinforcement.*—When τv exceed τc given in Table 13, shear reinforcement shall be provided in any of the following forms :

(*a*) Vertical stirrups,
(*b*) Bent-up bars along with stirrups and
(*c*) Inclined stirrups.

Where bent up bars are provided their contribution towards shear resistance shall not be more than half that of the total shear reinforcement.

TABLE—13 DESIGN SHEAR STRENGTH OF CONCRETE.
τc, N/mm^2
(*Clauses* 39.2.1, 39.2.2, 39.3, 39.4, 40.3.2, 40.3.3 and 40.4.3.)

$100\frac{As}{bd}$	Concrete grade.					
	M 15	M 20	M25	M 30	M 35	M 40
(1)	(2)	(3)	(4)	(5)	(6)	(7)
0·25	0.35	0.36	0.36	0.37	0.37	0.38
0.50	0.46	0·48	0.49	0.50	0.50	0.51
0.75	0.54	0.56	0.57	0.59	0.59	0.60
1.00	0.60	0.62	0.64	10•66	0.67	0.68
1·25	0.64	0·67	0.70	0.71	0.73	0.74
1·50	0.68	0·72	0·74	0.76	0.78	0.79
1·75	0.71	0.75	0.78	0.80	0.82	0.84
2.00	0.71	0.79	0.82	0.84	0.86	0.88
2.25	0.71	0·81	0·85	0.88	0.90	0.92
2·50	0.71	0.82	0.88	0.91	0.93	0.95
2.75	0·71	82	0·90	0.94	0.96	0.98
3.00	0·71	0.82	0.92	0.96	0.99	1.01

NOTE.—The term As is the area of longitudinal tension reinforcement which continues at least one effective depth beyond the section being considered except at supports where the full area of tension reinforcement may be used provided the detailing conforms to 25.2.2. and 25.2.3.

TABLE—14 MAXIMUM SHEAR STRESS $\tau\ c\ max$, N/mm².

(*Clauses* 39.2.3., 39.2.3.1 *and* 40.3.1.)

Concrete Grade. ..	M15	M 20	M 25	M 30	M 35	M 40
$\tau\ c\ max$, N/mm²	2.5	2.8	3.1	3.5	3.7	4.0

Shear reinforcement shall be provided to carry a shear equal to $Vu - \tau c$ bd. The strength of shear reinforcement Vus shall be calculated as below :—

(*a*) For vertical stirrups :

$$Vus = \frac{0.87\,fy\,Asv\,d}{Sv}$$

(*b*) For inclined stirrups or a series of bars bent-up at different cross-sections :

$$Vus = \frac{0.87\,fy\,Asv\,d}{Sv}(\sin\alpha + \cos\alpha)$$

(*c*) For single bar or single group of parallel bars, all bent-up at the same cross-section :

$$Vsv = 0.87\,fy\,Aus\ \mathrm{Sin}\ \alpha$$

were

Asv —total cross sectional area of stirrup legs or bent-up bars within a distance Sv.

Sv — spacing of the stirrups or bent-up bars along the lengths of the member.

τv — nominal shear stress.

τc — design shear strength of the concrete.

b— breadth of the member which for flanged beams, shall be taken as the breadth of the web bw.

fy —characteristic strength of the stirrup or bent-up reinforcement which shall not be taken greater than 415 N/mm².

α —angle between the inclined stirrup or bent-up bar and the axis of the member, not less than 45°, and

d —defective depth.

NOTE 1.—Where more than one type of shear reinforcement is used to reinforce the same portion of the beam, the total shear resistance shall be computed as the sum of the resistances for the various types eparately.

NOTE 2.—The area of the stirrups shall not be less than the minimum specified in 25.5.1.6.

40. *Limit state of collapse* : *Torsion.*

40.1 *General.*—In general, where the torsional resistance or stiffness of members has not been taken into account in the analysis of structure no specific calculations for torsion will be necessary ; adequate control of any torsional cracking being provided by the required nominal shear reinforcement. Where the torsional resistance or stiffness of members is taken into account in the analysis the members shall be designed for torsion.

NOTE.—The approach to design in this clause for torsion is as follows.

Torsional reinforcement is not calculated separately from that required for bending and shear. Instead the total longitudinal reinforcement is determined for a fictitious bending moment which is a function of actual bending moment and torsion. Similarly web reinforcement is determined for a fictitious shear which is a function of actual shear and torsion.

40.1.1. The design rules laid down in 40.3 and 40.4 shall apply to beams of solid rectangular cross-section. However these clauses may also be applied to flanged beams, by substituting *bw* for *b* in which case they are generally conservative therefore specialist literature may be referred to.

40.2. *Critical Section.*— Section located less than a distance *d* from the face of the support may be designed for the same torsion as computed at a distance *d*, where *d* is the effective depth.

40.3. *Shear and Torsion.*

40.3.1. *Equivalent Shear.*— Equivalent shear, V_e, shall be calculated from the formula :

$$V_e = V_u + 1.6\frac{T_u}{b}$$

where

V_e – equivalent shear ;
V_u– ashear ;
T_u — torsional moment; and
b—breadth of beam.

The equivalent nominal shear stress, T_{ve}, in this case shall be calculated as given in 39.1, except for substituting V_u by V_e. The values of T_{ve} shall not exceed the values of $T_{c\,max}$ given in Table 14.

40.3.2. If the equivalent nominal shear stress, T_{ve} does not exceed T_c, given in Table 13, minimum shear reinforcement shall be provided as per 25.5.1.6. T_c

40.3.3 If T_{re} exceeds T_c given in Table 13, both longitudinal and transverse reinforcement shall be provided in accordance with 40.4.

40.4. *Reinforcement in Members Subjected to Torsion.*

40.4.1. Reinforcement for torsion, when required, shall consist of longitudinal and transverse reinforcement.

40.4.2. *Longitudinal Reinforcement.*— The longitudinal reinforcement shall be designed to resist an equivalent bending moment, M_{e1} given by $M_e = M_u + M_t$.

where

M_u– bending moment at the cross section ; and

$$M_t = T_u\left(\frac{1 + D/b}{1.7}\right)$$

where

T_u– is the torsional moment, D is the overall depth of the beam and b is the breadth of the beam.

40.4.2.1. If the numerical value of M_t as defined in 40.4.2. exceeds the numerial value of the moment M_u, longitudinal reinforcement shall be provided on the flexural compression face, such that the beam can also withstand an equivalent M_{e2} given by $M_{e2} = M_t - M_u$, the moment M_{e2} being taken as acting in the opposite sense to the moment M_u.

40.4.3. *Transverse reinforcement.*— Two legged closed hoops enclosing the corner longitudinal bars shall have an area of cross Section A_{sv}, given by

$$A_{sv} = \frac{T_u\, s_v}{b_1 d_1 (0.87 f_y)} + \frac{V_u\, s_v}{2.5\, d_1 (0.87 f_y)}$$, but the total transverse reinforcement shall not be less than

$$\frac{(T_{ve} - T_c)\, b.\, s_v}{0.87 f_y}$$

where

T_u—torsional moment ;
V_u—shear force ;
s_v —spacing of the stirrup reinforcement ;
b_1 —centre to centre distance between corner bars in the direction of the width ;
d_1 —centre to centre distance between corner bars in the direction of the depth ;
b —breadth of the member ;
f_y —characteristic strength of the stirrup reinforcement ;
T_{ve} —equivalent shear stress as specified in 40.3.1 ; and
T_c —shear strength of the concrete as per Table 13.

41. *Limit State of Serviceability : Deflection.*

41·1· *Flexural Members.*—In all normal cases, the deflection of a flexural member will not be excessive if the ratio of its span to effective depth is not greater than the appropriate ratios given in 22.3. When deflections are calculated according to Appendix B, they shall not exceed the permissible values given in 22.2.

42. *Limit State of Serviceability : Cracking.*

42.1. *Flexural Members.*— In general, compliance with the spacing requirements of reinforcement given in 25.3.2. should be sufficient to control flexural cracking.

42.2. *Compression Members.*—Cracks due to bending in a compression member subjected to a design axial load greater than $0.2 f_{ck}\ A_c$, where f_{ck} is the characteristic compressive strength of concrete and A_c is the area of the gross section of the member, need not be checked. A member subjected to lesser load than $0.2 f_{ck}\ A_c$ may be considered as a flexural member for the purpose of crack control (*see* 42.1.).

APPENDIX A.

(*Clauses* 7.2. *and* 13.4.1.)

REQUIREMENTS FOR DURABILITY.

A-1 Minimum cement contents for different exposures and sulphat attack are given in Tables 19 and 20, for general guidance.

TABLE–19.

MINIMUM CEMENT CONTENT REQUIRED IN CEMENT CONCRETE TO ENSURE DURABILITY UNDER SPECIFIED CONDITIONS OF EXPOSURE.

(*Clause* 34.3.2. *and A*-1.)

Exposure.	*Plain concrete.*		*Reinforced concrete*	
	Minimum cement content.	*Maximum water cement ratio.*	*Minimum cement content.*	*Maximum water cement ratio.*
(1)	(2) ($Kg./m^3$)	(3)	(4) ($Kg./m^3$)	(5)
Mild.—For example, completely protected against weather, or aggressive conditions, except for a brief period of exposure to normal weather conditions during construction.	220	0.7	250	0.65
Moderate.—For example, sheltered from heavy and wind driven rain and against freezing, whilst saturated with water ; buried concrete in soil and concrete continuously under water.	250	0.6	290	0.55
Severe.—For example, exposed to sea water, alternate, wetting and drying and to freezing whilst wet, subject to heavy condensation or corrosive fumes.	310	0.5	360	0.45

NOTE 1.—When the maximum water-cement ratio can be strictly controlled the cement content in the above Table may be reduced by 10 per cent.

NOTE 2.—The minimum cement content is based on 20 mm. aggregate. For 40 mm. aggregate, it should be reduced by about 10 per cent, for 12.5 mm. aggregate, it should be increased by about 10 per cent.

TABLE 20. REQUIREMENTS FOR CONCRETE EXPOSED TO SULPHATE ATTACK.

(*Clause* A-1)

Class.	Concentration of sulphates expressed as SO_3: In Soil: Total SO_3 (Persent)	In Soil: SO_3 in 2:1 Water extract g/l	In Ground Water (Parts per 100 000)	Type of cement.	Requirements for dense, fully compacted concrete made with aggregates complying with IS : 383-1970*: Minimum Cement Content.	Maximum Free Water Cement Ratio.
(1)	(2)	(3)	(4)	(5)	(6) kg/m³	(7)
1.	Less than 0.2	..	Less than 30	Ordinary Portland cement or Portland slag cement or Portland pozzolana cement.	280	0.55
2.	0.2 to 0.5	..	30 to 120	Ordinary Portland cement or Portland slag cement or Portland pozzolana cement.	330	0.50
				Supersulphated cement	310	0.50
3.	0.5 to 1.0	1.9 to 3.1	120 to 250	Supersulphated Cement	330	0.50

NOTE 1.—This table applies only to concrete made with 20 mm aggregates complying with the requirements of IS : 383-1970* placed in near-neutral groundwaters of pH 6 to pH 9, containing naturally occurring sulphates but not contaminants such as ammonium salts. For 40 mm aggregate the value may be reduced by about 15 percent and for 12.5 mm aggregate the value may be increased by about 15 percent. Concrete prepared from ordinary Portland cement would not be recommended in acidic conditions (pH 6 or less). Supersulphated cement gives an acceptable life provided that the concrete is dense and prepared with a water:cement ratio of 0.4 or less, in mineral acids, down to pH 3.5.

NOTE 2.—The cement contents given in Class 2 are the minimum recommended. For SO_3 contents near the upper limit of Class 2, cement contents above these minimum are advised.

NOTE 3.—Where the total SO_3 in column 2 exceeds 0.5 percent, then a 2 : 1 water extract may result in a lower site classification if much of the sulphate is present as low solubility calcium sulphate.

NOTE 4.—For severe conditions such as thin sections under hydrostatic pressure on one side only and sections partly immersed, considerations should be given to a further reduction of water cement ratio. and if necessary an increase in the cement content to ensure the degree of workability needed for full compaction and thus minimum permeability.

NOTE 5.—Portland slag cement conforming to IS : 455-1976† with slag content more than 50 percent exhibits better sulphate resisting properties.

NOTE 6.—Ordinary Portland cement with the additional requirement that C_3A content be not more than 5 percent and $2C_3A + C_4AF$ (or its solid solution 4 CaO, Al_2O_3, Fe_2O_3 +2CaO, Fe_2O_3) be not more than 20 percent may be used in place of supersulphated cement

*Specification for coarse and fine aggregates from natural sources or concrete (*second revision*).

†Specification for Portland slag cement (*third revision*).

A-2. To minimize the chances of deterioration of concrete from harmful chemical salts, the levels of such harmful salts in concrete coming from the concrete materials, that is cement, aggregates, water and admixtures, as well as by diffusion from the environments should be limited. Generally, the total amount of chlorides (as Cl) and the total amount of soluble sulphates (as SO_3) in the concrete at the time of placing should be limited to 0.15 percent by mass of cement and 4 percent by mass of cement respectively.

APPENDIX C.

(*Clauses* 23.4 *and* 36.1.2)

SLABS SPANNING IN TWO DIRECTIONS.

C-1. *Restrained Slabs.*

C-1.0 When the corners of a slab are prevented from lifting, the slab may be designed as specified in **C-1.1** to **C-1.11**.

C-1.1 The maximum bending moments per unit width in a slab are given by the following equations :

$$M_x = \alpha_x W l_x^2$$

$$M_y = \alpha_y W l_x^2$$

where

α_x and α_y are conffiicients given in Table 22,

W—total design load per unit area,

M_x, M_y—moments on strips of unit width spanning l_x an l_y respectively, and

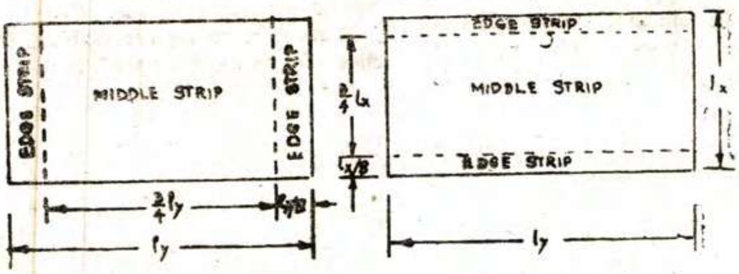
l_x and l_y—lengths of the shorter span and longer span respectively.

TABLE. 22—BENDING MOMENT COEFFICIENTS FOR RECTANGULAR PANELS SUPPORTED ON FOUR SIDES WITH PROVISION FOR TORSION AT CORNERS.

(*Clause* C-1.1)

Case number.	*Type of Panel and moments considered.*	*Short Span Coefficients* $>$ x. (*Values of* ly/lx).								*Long Span Coefficients* $>$ y *for all Values of* ly/lx
		1.0	1.1	1.2	1.3	1.4	1.5	1.75	2.0	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1	*Interior/Panels* :									
	Negative moment at continuous edge ..	0.032	0.037	0.043	0,047	0,051	0.053	0.060	0.065	0.032
	Positive moment at mid-span	0.024	0.028	0.032	0.036	0.039	0.041	0.045	0.049	0.024
2	*One Short Edge Discontinous* :									
	Negative moment at continuous edge ..	0.037	0.043	0.048	0.051	0.055	0.057	0.064	0.068	0.037
	Positive moment at mid-span	0.028	0.032	0.036	0.039	0.041	0.044	0.048	0.052	0.028
3	*One Long Edge Discontinuos* :									
	Negative moment at continuous edge ..	0.037	0.044	0.052	0.057	0.063	0.067	0.077	0.085	0.037
	Positive moment at mid-span	0.028	0.033	0.039	0.044	0.047	0.051	0.059	0.065	0.028
4	*Two Adjacent Edges Discontinuous* :									
	Negative moment at continous edge	0.047	0.053	0.060	0.065	0.071	0.075	0.084	0.091	0.047
	Positive moment at mid-span	0.035	0.040	0.045	0.049	0.053	0056	0.063	0.069	0.035
5	*Two Short Eges Discontinuous* :									
	Negative moment at continuous edge ..	0.045	0.049	0.052	0.056	0.059	0.060	0.65	0.069	..
	Positive monent at mid-span	0.035	0.037	0.040	0.043	0.044	0.045	0.049	0.052	0.035
6	*Two Long Edges Discontinus* :									
	Negative moment at continous edge	..	..	..	..	..	..	..	..	0.045
	Positive moment at mid-span	0.035	0.043	0.051	0.057	0.063	0.068	0.080	0.088	0.035
7	*Three Edges Discontinous (One Long Edge Continous)* :									
	Negative moment at continuous edge ..	0.057	0.064	0.071	0.076	0.080	0.084	0.091	0.097	..
	Positive moment at mid-span	0.043	0.048	0.053	0.057	0.060	0.064	0.069	0.073	0.043
8	*Three Edges Discontinuous (One Short Edge Discontinuous)* :									
	Negative moment at continuous edge ..		..	..	..	..	..	..	..	0.057
	Positive moment at mid-span	0.043	0.051	0.059	0.065	0.071	0.076	0.087	0.096	0.043
9	*Four Edges Discontinuous* :									
	Positive moment at mid-span	0.056	0.064	0.072	0.079	0.085	0.089	0.100	0.107	0.056

C-1.2 Slabs are considered as divided in each direction into middle strips and edge strips as shown in Fig. 23, the middle strip being three-quarters of the width andeach edge strip one-eighth of the width.



23A For Span l_x 23B For Span l_y

FIG. 23 DIVISION OF SLAB INTO MIDDLE AND EDGE STRIPS

C-1.3 The maximum moments calculated as in C-1.1 apply only to the middle strips and no redistribution shall be made.

C-1.4 Tension reinforcement provided at mid-span in the middle strip shall extend in the lower part of the slab to within 0.25*l* of a continuous edge, or 0.15*l* of a discontinuous edge.

C-1.5 Over the continous edges of a middle strip, the tension reinforcement shall extend in the upper part of the slab a distance of 0.15 *l* from the support, and at least 50 per cent shall extend a distanc of 0.3*l*.

C-1.6 At a discontinuous edge, negative moments may arise They depend on the degree of fixity at the edge of the salb but, in general, tension reinforcement equal to 50 per cent of that provided at mid-span extending 0.1 *l* into the span will be sufficient.

C-1.7 Reinforcement in edge trip, parallel to that edge, shall comply with the minimum given in Section 3 and the requirements for torsion given in **C-1·8, C-1·9** and **C-1·10**.

C-1.8 Torsion reinforcement shall be provided at any corner where the slab is simply supported on both edges meeting at that corner. It shall consist of top and bottom reinforcement, each with layers of bars placed parallel to the sides of the slab and extending from the edges a minmum distance of one-fifth of the shorter spaa The area of reinforcement in each of these four layer shall be three quarters of the area required for the maximum mid-span moment in the slab.

C-1.9 Torsion reinforcemtn equal to half that described in C-1.8 shall be provided at a corner contained by edges over only one of. which the slab is continous.

C-1.10 Torsion reinforcements need not be provided at any corner contianed by edges over both of which the slab is contineous.

C-1.11 Where lx/ly is greater than 2, the slabs shall be designe spanning one way.

C-2, Simply supported slabs.

C-2.1 When simply supported slabs do not have adequate provision to resist torsion at corners and to prevent the corners from lifting, the maxiumum moments per unit width are given by the following equation :

$$Lx = 0(x\ wlx^2$$

$$Ly = 0(y\ wlx^2$$

where

Mx, My, w, lx, ly are same as those in C-1.1, and

Lx and *L y* are moment coefficients given in Table 23.

TABLE-23 BENDING MOMENT COEFFICIENTS FOR SALE.

Spanning in two directions at right angles simply Supported on four sides.

lx/ly	..	1.0	1.1	1.2	1.3	1.4
0(*x*	..	0.062	0.074	0.084	0.093	0.099
0(*y*	..	0.062	0.061	0.059	0.055	0.051
		1.5	1.75	2.0	2.5	3.0
		0.104	0.113	0.118	0.122	0.124
		0.046	0.037	0.029	0.020	0.014

C-2.1.1 Atleast 50 percent of the tension reinforcemnt provided at midspan should extend to the supports. The remaining 50 percent should extend to wihtin 0.1 *lx* or 0.1 *ly* of the support, as appropriate

APPENDIX D.

(*Clause* 24.2).

EFFECTIVE LENGTH OF COLUMNS.

D-1 In the absence of more exact analysis, the effective length of columns in framed structures may be obtained from the ratio of effecitve length to unsupported length *lef/l* given in Fig. 24 when relative displacement of the ends of the column is prevented and in Fig. 25 when relative lateral displacement of the ends is not prevented in the latter case, it is recommended that the effective length ratio *lef/l* may not be taken to be less than 1.2.

NOTE 1—Figures 24 and 25 are reproduced from the Structural Engieers, No. 7, Volume 52, July 1974 by the permission of Council of the Institution of Structural Engineers, U.K.

NOTE 2—In Fig. 24 and 25, β_1 and β_2 are euqal to $\frac{\Sigma Kc}{\Sigma Kc + \Sigma Kb}$ where the summation is to be done for the members framing into a joint at top and bottom respectively; *Kc*, and *Kb*, being the flexural stiffiness for column and beam respectively.

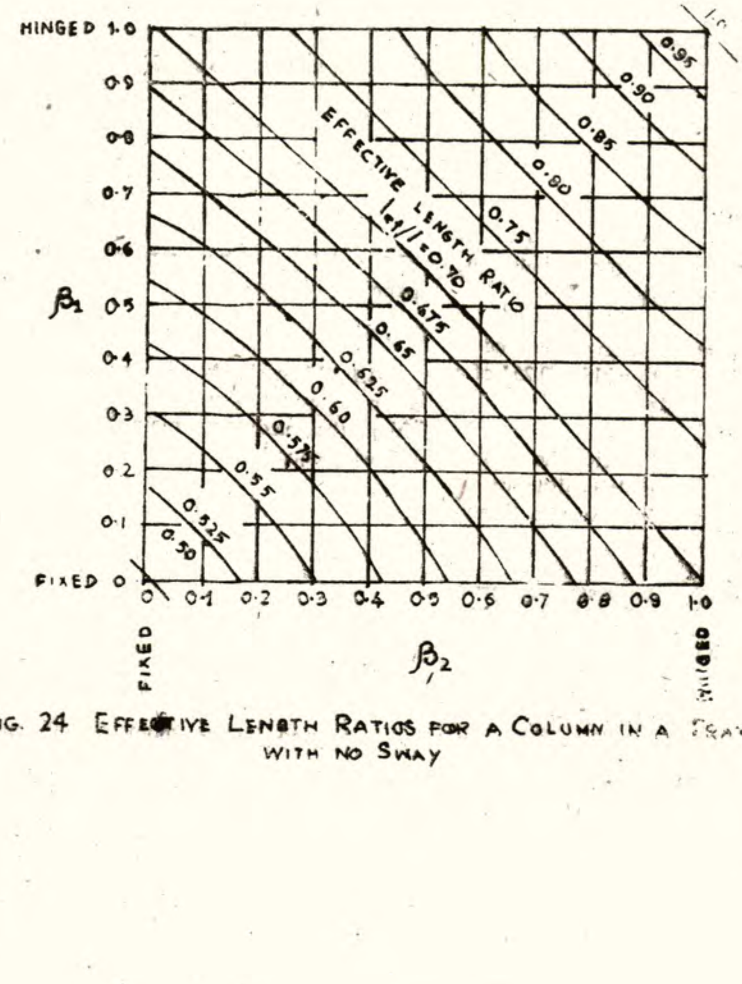


FIG. 24 EFFECTIVE LENGTH RATIOS FOR A COLUMN IN A FRAME WITH NO SWAY

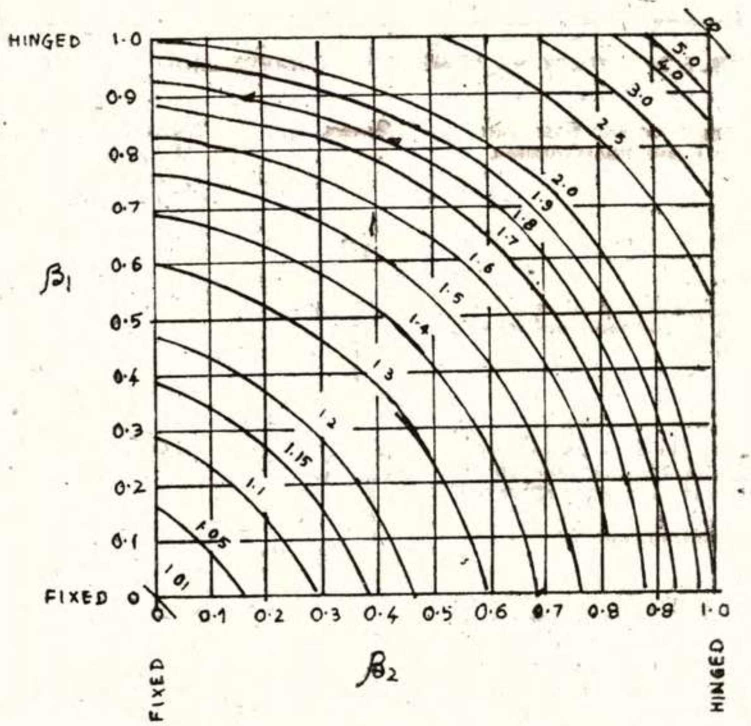


FIG 25 EFFECTIVE LENGTH RATIO FOR A COLUMN IN A FRAME WITHOUT RESTRAINT AGAINST SWAY

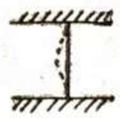
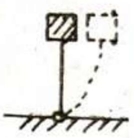
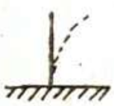
D-2 For normal usage assuming idealized conditions, the effective length l_{ef} in a given plane may be assessed on the basis of Table 24.

TABLE 24 EFFECTIVE LENGTH OF COMPRESSION MEMBERS

DEGREE OF END RESTRAINT OF COMPRESSION MEMBER	SYMBOL	THEORETICAL VALUE OF EFFECTIVE LENGTH	RECOMMENDED VALUE OF EFFECTIVE LENGTH
(1)	(2)	(3)	(4)
Effectively held in position and restrained against rotation at both ends		0·5l	0·65l
Effectively held in position at both ends, restrained against rotation at one end		0·7l	0·80l

(Continued)

TABLE 24 EFFECTIVE LENGTH OF COMPRESSION MEMBERS - Contd.

DEGREE OF END RESTRAINT OF COMPRESSION MEMBER	SYMBOL	THEORETICAL VALUE OF EFFECTIVE LENGTH	RECOMMENDED VALUE OF EFFECTIVE LENGTH
(1)	(2)	(3)	(4)
Effectively held in position at both ends, but not restrained against rotation		1·00 ℓ	1·00 ℓ
Effectively held in position and restrained against rotation at one end, and at the other restrained against rotation but not held in position		1·00 ℓ	1·20 ℓ
Effectively held in position and restrained against rotation at one end, and at the other partially restrained against rotation but not held in position		—	1·50 ℓ
Effectively held in position at one end but not restrained against rotation, and at the other end restrained against rotation but not held in position		2·00 ℓ	2·00 ℓ
Effectively held in position and restrained against rotation at one end but not held in position nor restrained against rotation at the other end		2·00 ℓ	2·00 ℓ

NOTE – ℓ is the unsupported length of compression member

EXTRACT FROM I.S. 5525—1969.

Recommendations for detailing of reinforcement in reinforced concrete works.

2. *Symbols and abbreviations.*

2.1. For the purpose of this standard and unless otherwise defined in the test, the symbols and abbreviations given in 2.1.1. to 2.1.4. may be used. All reinforcement bars used in the structures shall be suitably designated and numbered both in drawing and schedule.

2.1.1. Symbols relating to cross sectional shape and size of Reinforcement bars :

Ø Plain round bar

(or)

Diameter of plain round bar

Plain square bar

□ (or)

Side of plain square bar

Deformed bar (including square twisted bar)

(or)

Nominal size (equivalent diameter or side) of the deformed bar (*see* Note).

NOTE.—In accordance with I.S. 1139—1966* and I.S. 1766—1966+ the nominal size of the deformed bar is equivalent to the diameter or side of a plain bar having the same weight per metre run as the deformed bar.

2.1.2. Symbols relating to shape of the bar along its length :

Bt. = Bent Bar.

St. = Sraight bar.

Stp. = Stirrup.

Sp. = Spiral

Ct. = Column tie.

2.1.3. Symbols relating to position and direction :

EW. Each way

spacing centre to centre.

Limit of area covered by bars.

Direction in which bars extend.

2.1.4. Symbols relating to various structural members :—

Bm = Beam(s)

Col = Column(s)

FG = Footing(s)

GR = Girder(s)

JT = Joist(s)

LL = Lintel(s)

LB = Lintel Beam(s)

Sb = Slab(s)

WL = Longitudinal wall

WX = Cross wall.

5.11. *Schedules.*

5.11.1. The reinforcement of slabs, beams and many other parts of structures may be effectively shown on working drawings or in a tabular form, known as a schedule. The schedule is a compact summary of the dimensions of the concerned structural part, all the bars complete with the number of pieces, shape and size, lengths and bending details from which fabrication details may be easlly worked out. Bar lengths for straight bars should preferably be detailed in increments of 75 mm.

5.11.1.1. A schedule shall be supplemented with diagrams and sketches wherever necessary, where bars of different dimensions are used, the exact arrangements of the reinforcement shall be shown by means of clear diagrams. No abbreviation or symbol shall be used in a schedule without proper explanation.

5.11.1.2. For small structures detailed on a single sheet, the schedule may be placed in the upper left corner of the drawing. For larger structures requiring more than one drawing the complete schedule may appear on the last sheet of the details, or if the size of the structure warrents, separate schedules may be prepared for each unit (foundation, abutments, piers, etc.) on the drawing covering that specific unit of the structure.

5.11.2. *Beams, girders and joists.*—Details of reinforcement for beams, girders and joists are usually shown in schedules. The schedules should show the number, mark and size of number ; number; size, position and length of straight bars; number, size, position bending details and total length of bent bars and stirrups; size, shape and spacing of bar supports ; and any other special information necessary for proper fabrication and placement of the reinforcement (*see* Figure 3). Care shall be taken not to omit any controlling dimension such as over—all length of the bar and height of the bent bar and location of bar with respect to supporting members where the bar is not placed symmetrically. The schedule should also include special notes on bending and any special information, such as the requirement of laps, two layers of steel.

5.11.3. *Slabs.*—The reinforcement for slabs is generally indicated on the plan, with details for the various types of bend bars shown in a schedule (*see* Figures 3 and 4). The schedule shall be similar to that for bars in beams, except that the number of bars may also be obtained from the Plan. Panels exactly alike shall be given an identifying mark or so specified in the schedule.

* Specification for hot rolled mild steel and medium tensile steel deformed bars for concrete reinforcement (revised).

\+ Specification for cold twisted steel bars for concrete reinforcement.

Mark and location of member. (1)	Drawing reference. (2)	Number of member. (3)	Bar type. (4)	Bar number. (5)	Bar size. (6)	Detailed (Dimensioned) sketch X1. X2. X3. X4. etc. (7)	Cutting bar length. (8)	Number of Bars per member. (9)	Total number of bars. (10)	Total weight of bars. (11)	Remarks. (12)
Sb 4 Floor and 1 Sb 6.	Drg. No. etc.	2	StØ	43	25	..	40cm	10	20	..	..
Bm6 Floor Bm 7 1 Bm 8 and Bm1 0	Drg. No. etc.	4	Bt	75	16	40 20 20 10 20	200cm	8	32	..	..

and so on.:

St = Straight bars without hooks.
Bt = bent bar with hooks at both ends.

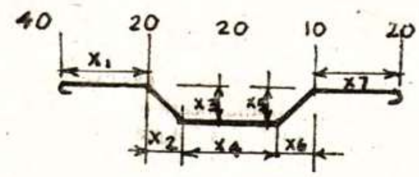


FIG. 3 TYPICAL SCHEDULE FOR BEAMS, SLABS AND COLUMNS

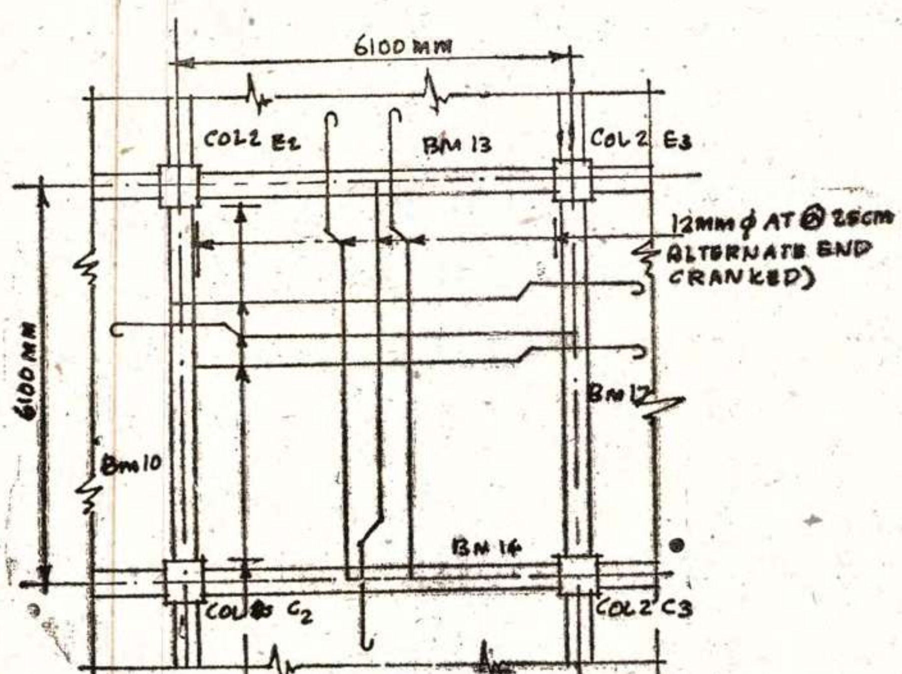
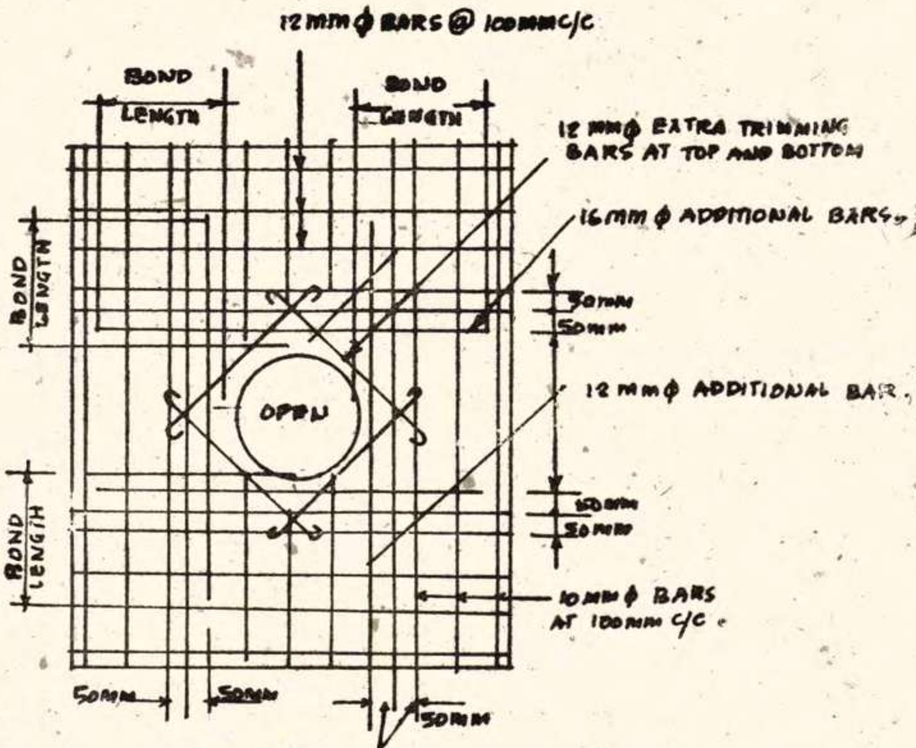
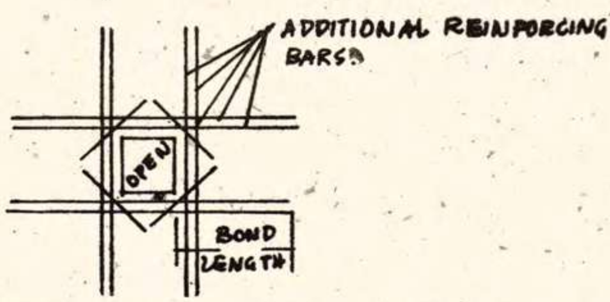


FIG. 4. TYPICAL DETAILS OF SLAB REINFORCEMENT IN STRUCTURAL DRAWING



5A



NOTE.—CROSS SECTIONAL AREA OF THE EXTRA BARS PLACED PARALLEL TO PRINCIPAL REINFORCEMENT SHOULD BE ATLEAST EQUAL TO THE AREA OF PRINCIPAL REINFORCEMENT DISTRIBUTED BY THE OPENING.

FIG.5.—TYPICAL REINFORCEMENT DETAILS FOR OPENING IN SLAB.

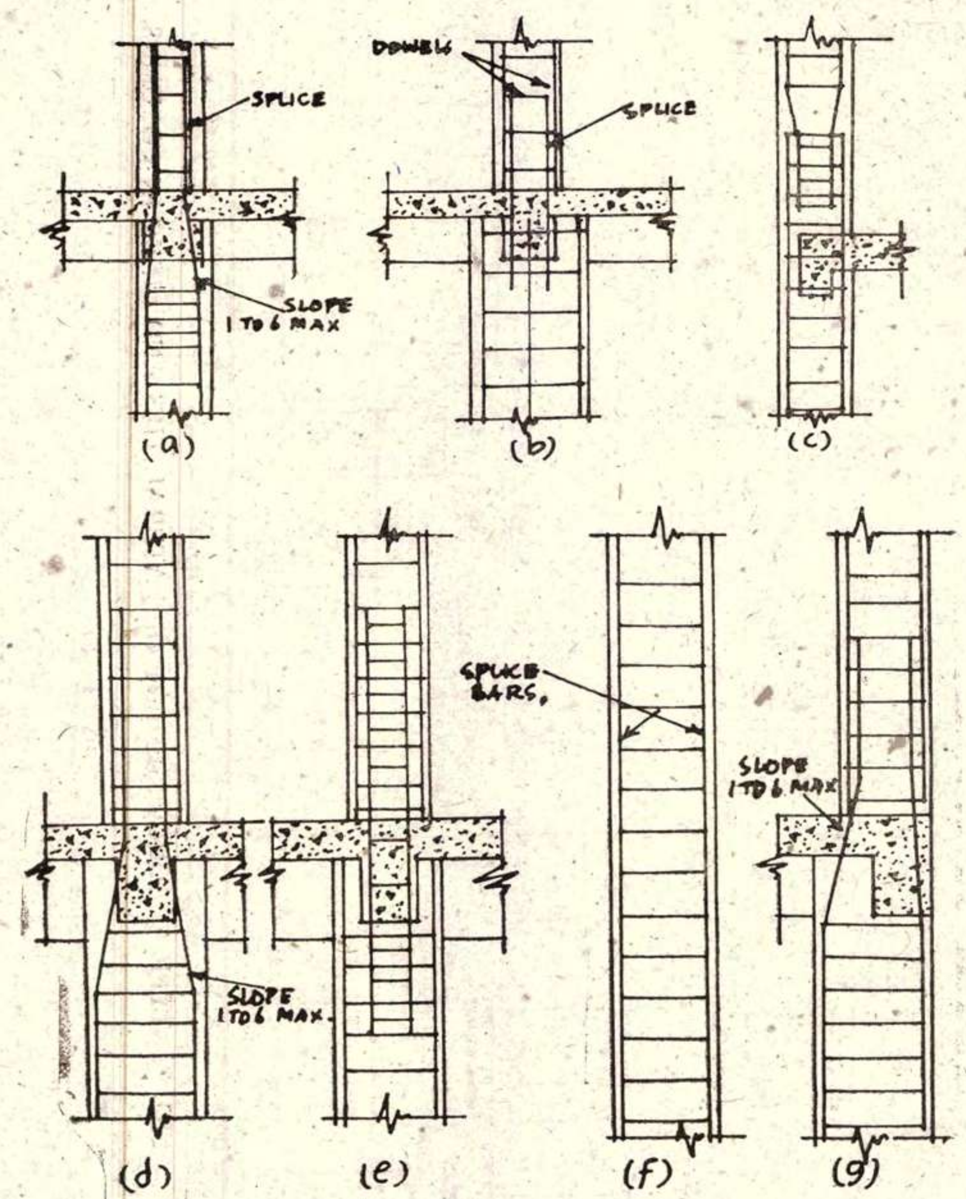


FIG 6. TYPICAL DETAILS OF COLUMN SIZES

466-3—24A

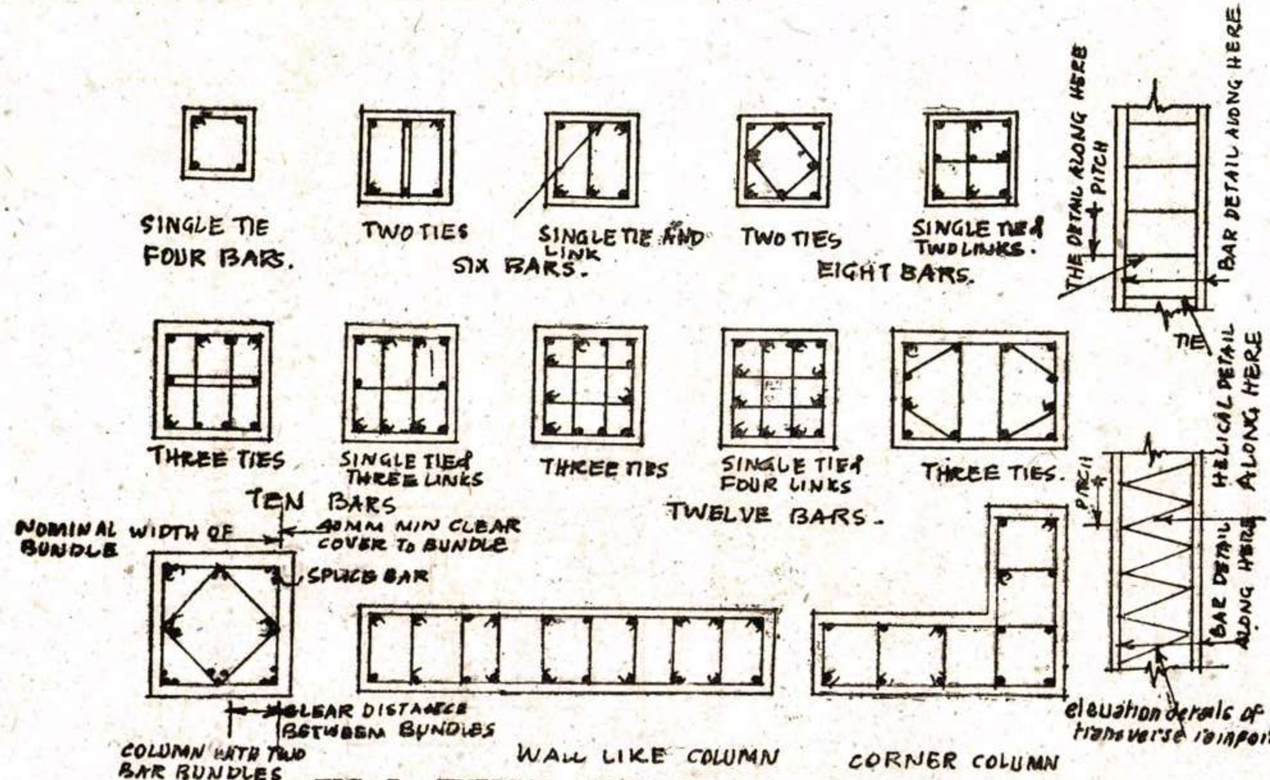
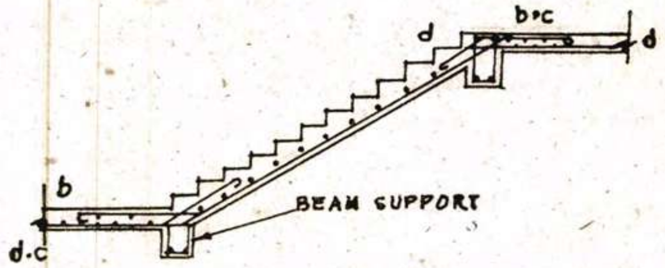
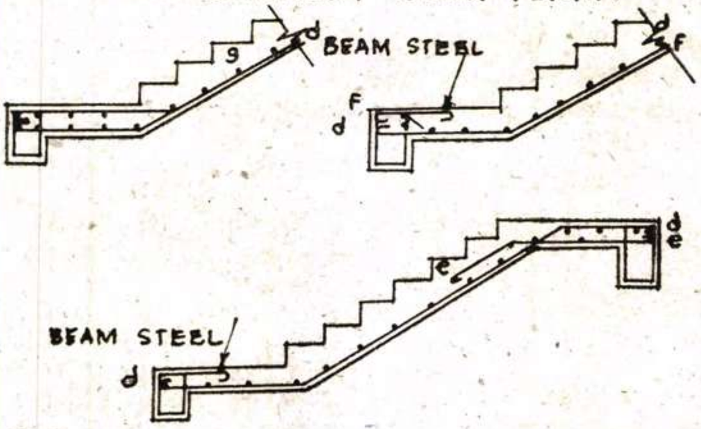


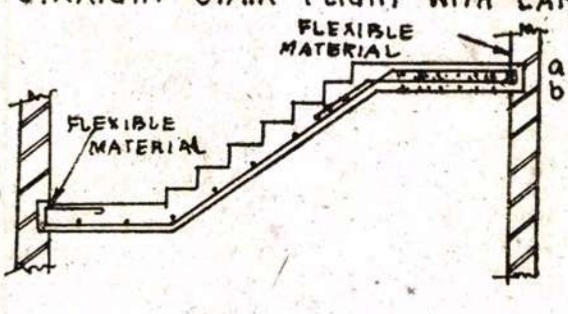
FIG. 7.—TYPICAL ARRANGEMENT OF LATERAL TIES AND LINKS IN COLUMNS.



8 A. STRAIGHT STAIR FLIGHT

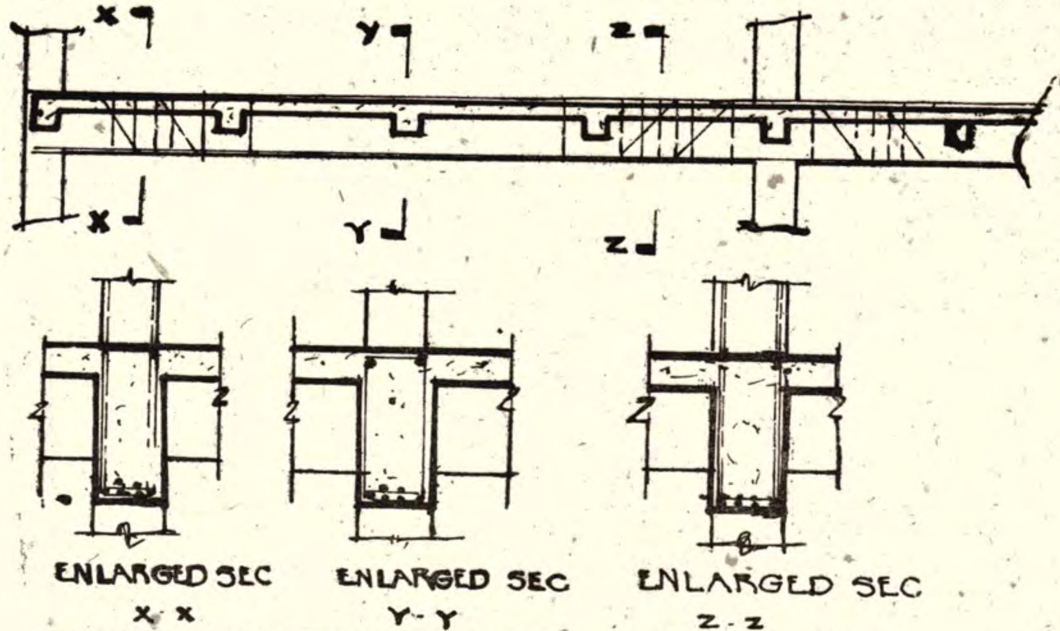


8.B. STRAIGHT STAIR FLIGHT WITH LANDING



8 C. STRAIGHT STAIR FLIGHT SUPPORTED ON BRICKWORK

FIG. 8 TYPICAL DETAILS OF REINFORCEMENT IN STAIR FLIGHT



TYPICAL REINFORCEMENT DETAILS AT JUNCTION OF COLUMN AND BEAM FIG: 9

5.11.3.1. In skewed panels, bars shall be fanned to maintain given spacing in the mid span. Additional bars for reinforcing the openings shall be as shown on plan (*see* Figure 5).

5.11.4. *Walls.*—The reinforcement for walls shall be indicated on the plan elevation and section with the details for various types of bent bars shown in schedule in a manner similar to that for beams and slabs.

5.11.5. *Columns.*—The reinforcement for columns may be shown in column schedule (*see* Figure 3) When pedestals are used, they should be included in the column schedule. Piles and pile caps should be treated as separate units and separate details or schedule or both may be provided. The main schedule may be supplemented with a smaller schedule for ties and bent bars, diagrams showing the arrangement and bending of the ties, and any special feature of the construction pertinent to the fabrication and placing of the column reinforcement (*see* Figures 6 and 7). In case of rectangular column the reinforcement details may be indicated with reference to framing pan. In case of square columns designed for building and axial load with unequal reinforcement in two directions, detailed plan should be given showing the reinforcement, the beams framing into the column, and other salient reference lines, so that the bars are placed in correct places in the plane of bending.

5.11.6. *Dowels and bar supports.*—Dowels and bar supports, spacer bars, bar chairs, etc, should be specifically listed on the structural drawing and should be scheduled in that portion of the structure in which they are first required so that they can be delivered with the reinforcement and are available for placement at proper time. Footing dowels shall be scheduled with footing rather than in column schedules.

5.11.7. *Other structures.*—On some types of structures, such as bridges, tanks, sewers and conduits, and certain components of buildings, such as stairs, special procedures may be used and adopted to the particular structure (*see* figure 8). The principal object is to show the reinforcement in a simple clear and easy manner. This may be accomplished by a small detailed sketch of each bar or type of bar with a table of dimensions.

6. *Miscellaneous.*

6.1. Congestion of steel should be avoided at points where members intersect. It should be ensured that all reinforcement shown can be properly placed. For example, at the intersection of a beam and girder, the beam bars should be placed at a diffrent elevation than those in the girder so as to avoid interference when the steel is being placed. Another very troublesome point is the intersection of columns with beams and griders and a large scale layout detail should be shown on the drawing for guidance of steel setter (*See* Figure 9).

6.2. It should be ensured that hooked and bent bars can be placed in the form work and have adequate concrete cover.

6.3. It should be ensured that the unusual bends shown in the drawing can be made with bending equipment normally available. (*See* I.S. 2502—1963*).

* Code of practice for bending and fixing of bars for concrete reinforcement.

4.6. When a member has a break in its direction so that the reinforce-ment in tension tends to separate from the body of the concrete, special anchorage shall be provided and shown in detail. Examples are the junction of stairs and landings (*see* Fig. 8) the soffit of a beam forming an angle, inside corners of walls, and inside corners of rigid frames.

6.4.1. Where slabs frame flush with the bottom of upstand beams, adequate reinforcement shall be provided to take care of extra tension.

6.5. Where the legnths of bars are not specifically fixed, such as for temperature steel, slabs on ground and tie bars in floors culverts and retaining walls, stock lengths or lengths which can be cut from stock length with a minimum of waste should be used.

6.6. When larger diameter bars are required in columns or in beams and to avoid congestion they have to be welded rather than lapped for splicing, the method of welding should be specified as well as the location of the staggered welds at heights or position convenient for welding.

6.7. *Splices.*— Where beams or girders require bars longer then, carried in stock, the splices in the bars shall be made where the stress in the bar is minimum, that is, at the point of inflection. Splices in bent bars can sometimes be avoided by using straight top and bottom bars though bent bars aid in carrying diagonal tension.

Splices shall be staggered and shall be made by lapping, welding or other positive connections, Lap splices should, however, not be used for 45 mm. and 50 mm. deformed bars in tension. Splices shall be avoided where the critical design stress is tensile. Lapped bars, if used. may be either in contact or separated.

6.7.1. *Lap splices.*—Since the strength of a lap splice does not increase directly with the length of lap, but varies with bar diameter, concrete strength, position of the bar, distance from other bars, and type of stress (compression or tension), it is necessary for the designer to show length and location of all lap splices.

6.7.1.1. At splice points, sufficient bars (or dowels) from the lower column shall extend into the upper column to provide not less than the sectional area of the bars in the upper column. These bars shall extend at least the minimum distance required for column spices. The remaining bars in the lower column shall extend to within 75 mm of the top of the floor, or to within 75 mm. of the top of other member transmitting the additional load to the column.

6.7.1.2. Where the tops of cloumn bars are less than 1·8 m. above the top of footings or pedestals, the bars shall extend in to the footing or pedestal, and dowels shall not be used unless specifically indicated by the designer.

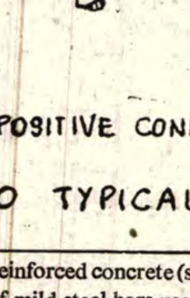
6.7.1.3. Dowels shall have a cross-sectional area at least equal to that of the bars above and they shall extend both above and below the points splice the minimum distance required for splices. The minimum length of lap shall be based on the size of the largest bar in the column above the splices.

6.7.1.4. Where the depth of the footing, or footing and pedestal combined, is less than the minimum length of embedment required for dowels of the desired size, the size of number of dowels shall be increased and shown on desgin drawings. In exceptional cases, hooks at the bottom of the bars may be desirable to resist tension, but the length of bars in any such hook shall not be considered in determining the bond area provided for compression.

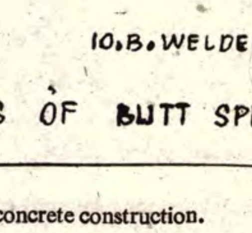
6.7.1.5. The use of a tier of columns one above the other is rare in bridge construction, but when used, the practice described above should apply.

6.7.2. *Butt splices.*— Reinforcing bar butt splices may be made by arc welding, fusion welding, or using positive connection (mechanical connections). The properties of these connectors, and the reinforcing bar and preparation requirements vary with the type of connection used. It is important that the designer should specify the type of connection which will meet the design requirements (*see* I.S. 456-1964* and I.S. 2715-1966)†.

6.7.2.1. Details of the more commonly used types of butt joint splices are shown in Fig. 10. On the drawings and on orders to the fabricating shop, the designer shall clearly show the reinforcing bar and preparation, the method of welding and details of positive connections, when used. In cases where material is ordered cut to length from the mill, considerations should be given while ordering length to allow for recutting by the fabricating shop.



10.A. POSITIVE CONNECTION



10.B. WELDED SPLICE

FIG. 10 TYPICAL DETAILS OF BUTT SPLICES

*Code of practice for plain and reinforced concrete (second revision).

†Code of practice for welding of mild steel bars used for reinforced concrete construction.

6.8. *Dowels.*—Dowels may be necessary for splicing column bars or where the concreting for part of the structure is delayed or between various units of structures. Dowels should always be detailed first so that they will be delivered to the job at the proper time. Except for special cases in columns, dowels shall be of the same number, size, and grade as the bars joined and shall be of sufficient length to splice with the main bars.

6.9. *Longitudinal reinforcement for column.*—Where a column at a partiuclar floor is small (in cross section) than the column immediately below it, the vertical bars from the lower column shall be offset to come within the upper column, or dowels shall be used. The slope of the inclined portion shall not exceed 1 in 6 (*see* Fig. 6). In detailing offset column bars, a bar diameter should be added to the desired offset and in the corners of square columns, the bars should be offset on the diagonal.

6.9.1. Longitudinal reinforcement bars in square or rectangular columns should be offset bent into the column above. Longitudinal reinforcing bars in round columns where columns size is not changed should be offset bent if maximum number of bars are desired in the column above. General practice is to sketch the offset for the corner bars which should be bent diagonally and make this the typical offset dimension for all the bars in the column.

6.9.2. For any offset between column faces up to a maximum of 75 mm. the longitudinal bars should be offset bent. When the offset exceeds 75 mm. the longitudinal bars in the column below should be terminated at the floor slab and separate dowels used.

6.9.2.1. Where upstand beam is not provided, the height of the column euqal to75 mm. above the floor level should be cast along with the lower column.

6.9.3. When the bar arrangement changes between floors, bars may extend through, stop off, or require separate dowles. Each situation requires its own solution, Steel equal in area and bond capacity to that in the column above shall be extended.

6.9.3.1. Column bars shall be spliced at the top of unstand beams rather than at floor level.

6.9.4. Where column verticals are offset bent, additional ties shall be provided and placed not more than eight bar diameters from the point of bend. For practical purposes, three closely spaced ties are usually used, one of which may be part of the regularly spaced ties plus two extra ties. The designer should indicate the general arrangements of vertical bars and all tie requirements.

6.9.5. Welded splices or other positive connections may be used as butt splices for vertical column bars instead of lapped splices. For bars of size 32 mm. and above such splices or connections may be used to avoid overcrowding of the bars due to the extremely long laps which would otherwise be required. Speical preparation of the ends of the vertical bars is usually required. Where bars are welded, the most common practice is to provide a sqaure-cut end at the top and a double bevelled end on the bottom of the upper bar to rest on the square-cut end. This permits filling the resulting space with weld metal to develop the splice (*See* Fig.10). Where a welded sleeve or mechnaical devise is used both ends of the bar may be either square cut or standard-shear cut, depending on the type of connection used. Since the points of splice are usually staggered between alternate vertical bars and the splice location will depend upon the design requirements, the designer should indicate the types of splices permissible and their location (*see* I.S. 456-1964* and I.S. 2751-1966†).

6.10. *Lateral reinforcement for columns.*—The arrangement of lateral ties and spirals shall conform to the requirements of I.S. 456-1964* and shall be adequately illustrated and detailed. Typical arrangement of ties for various numbers of longitudinal bars are shown in Fig. 7. If access to the interior of a column or pier is necessary some pattern of ties may be substituted provided the tie arrangement conforms to the requirements of I.S.456-1964!. The arrangement should preferably be such as to leave the inside core area of the column free from maze of interseting ties.

6.10.1. Bundled bars shall be tied, wired, or otherwise fastened to ensure, that they remain in position. End bearing compression splices will be held concentric, all bundles of column verticals will be held by additional ties at each side of end bearing splices, and any short splice bars added for tension should be tied as part of the bundle within the limit of four bars to a bundle, a corner of a tie should be provided at each bundle.

6.11. *Special reinforcement* —

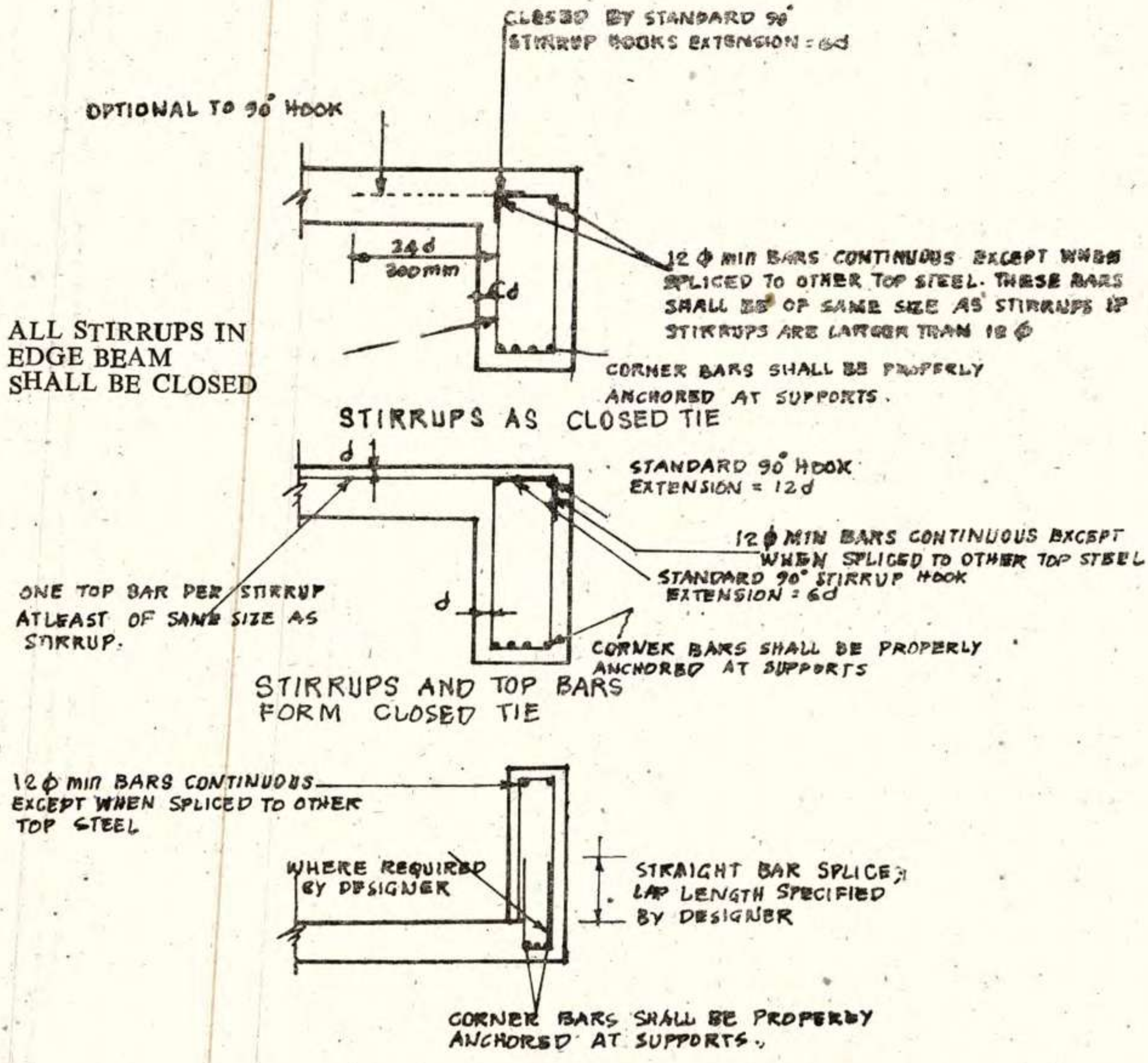
6.11.1. *General.*—Spirals, whether in building or in bridges shall be provided with one and one half extra turns at both top and bottom. Where necessary to splice the spiral it shall be done by shop welding or by a lap of one and one-half turns. Where a spiral cannot be furnished in one piece it may be furnished in two or more sections by providing one and one-half turns at each of the ends of each section to be lapped in the field. The sections shall be properly indentified by mark numbers, to ensure proper assembly.

6.11.1.1. The height (or length) of a spiral is defined as the distance out to out of coils including the finishing turns at top and bottom with a tolerance of $\pm$ 40 mm. The maximum length of spacers shall be that of the spiral plus one pitch.

6.11.2. *Columns.*—Unless otherwise specially provided, spirals shall be detailed as extending from the floor level or top of footing or pedestal to the level of the lowest horizontal reinforcement in the slab, drop panel, or beam above. In a column with a cpaital, it shall extend to the plane at which the diameter or width of the capital is twice that of the column. If the design main spiral and the floor level above, it shall be provided by a stub sprial (short section of spiral) by circular column ties. This is necessary to permit placing of the reinforcement in the floor system. Where stub sprials are used, they should be attached to the main spiral for transportation or carefully identified by bar type numbers.

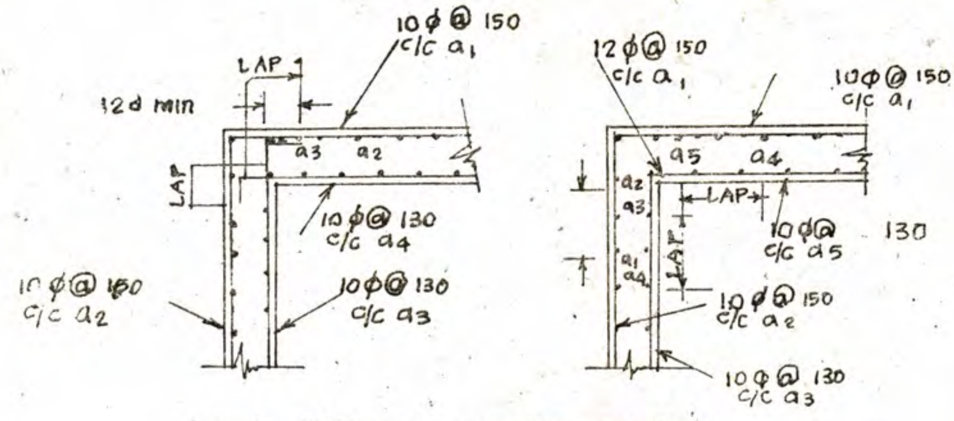
* Code of practice for plain and reinfored concrete (second revision).

† Code of practice for welding of mild steel bars used for reinforced concrete construction.

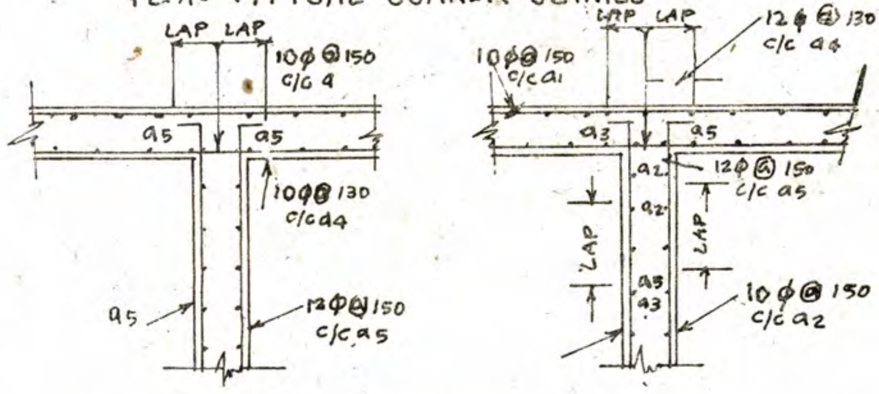


TWO-PIECE STIRRUPS FORM CLOSED TIE
(ALL DIMENSIONS IN MILLIMETRES)

FIG. 11. TYPICAL DETAILS OF REINFORCEMENT IN EDGE AND SPANDREL BEAM.



12. A. TYPICAL CORNER DETAILS



12. B. TYPICAL INTERSECTION DETAILS

FIG. 12. TYPICAL CORNER AND INTERSECTION DETAILS FOR WALLS

6.11.3. *Piles.*—The most common use of spirals is in reinforced concrete piles. They restrain the longitudinal bars during driving of the pile and support the structural loads. Piling spirals are geneally furnished formed to the required diameter and with the proper number of turns, but unmounted, that is without rigid spacers to hold the spirals to a designated pitch. The spiral is tied and transported in a compact bundle. On the job it is untied and pulled out over the longitudinal piling bars for the proper specified distance. It is then tied to the longitudinal bars at the required pitch. The diameter varies with each turn. Two types of spiral are fabricated the circular spiral for round or octagonal piles and the square spiral for square piles. Spirals may be supplied in two or more pieces. The tapered spiral is always furnished separately and the constant shaped spiral may be furnished in more than one piece to suit the length of spiral stock available or the fabricator's equipment. Unless the separate pieces contain the same number of turns, they should be carefully marked to ensure proper placing. At least one and one half extra turns of spiral should be provided at the ends of each section of spiral and the extra turns from one section lapped into that of the adjoining section.

6·11.3.1. Spirals are also used in circular caissons, columns of continuous bents for viaducts, columns over arches, and other special cases. When thus used, they are generally mounted on spaces to hold the spiral firmly in place at the desired pitch during placing of the concrete.

6.12. *Edge beams.*—Where the designer shows stirrups in any edge or spandrel beam, these strirrups shall be closed and at least one longitudinal bar shall be located in each corner of the beam section, the size of this bar to be at least equal to the diameter of the stirrup but not less than 12 mmØ. These details shall be clearly indicated by the designer. Typical details are shown in Fig. 11 for normal and upturned edge or spendrel beams. For easier placing of the longitudinal bars in the beam. details for two piece closed stirrups are also shown. For the same reason, the 90°stirrup hook is preferred (*see* fig. 11). The designer should show the general arrangement of all such bars and stirrups.

6.13. *Wall intersections and corners.*— Horizontal wall reinforcement may be required by the designer to resist moment, shear, or merely changes in length due to temperature or shrinkage. In any case unless the designer indicates a shrinkage control joint at this point, all the horizontal bars in one or sometimes both faces of a wall should be sufficiently extended past a corner or intersection to be fully developed. (*see* Fig. 12) Nevertheless it is necessary for the designer to indicate which, if any, hori zontal reinforcement should be extended for full development at intersections and corners of walls and footings. Typical details are shown in Fig. 12 for resistance against moment inward, outward, or both, with the reinforcement from the appropriate face or faces anchored.

EXTRACT FROM I. S. 2751—1966.

Code of practice for welding of mild steel bars used for reinforced concrete construction.

10. *Procedure*.

10·0. Steel bars shall be either butt welded or lap welded.

10.1. *Butt welding of mild steel bars.*

10.1.1.2. The edges shall be prepared by shearing, machining or any acetylene flame cutting. Bevelling may be done by chipping, machining, grinding, or oxygen cutting. The joint faces and the surrounding material shall be free from scale, dirt, grease, paint, rust and contaminants.

10.1.1.3. When it is not possible to rotate bars for welding in flat position, the axis of the bars shall be horizontal and the respective axes of welds shall be vertical, that is, the welds being carried out in the vertical position.

10.2. *Lap welding of mild steel bars.*

10.2.1. *Preparation of edges and set up of parts.*—Edge preparation is not necessary for lap welds. The joint faces and the surrounding material shall be free from scale, dirt, grease, paint, rust and contaminants.

11. *Initial Tests.*

11.1. *Butt welds.*—Test pieces containing butt welds at the centre n the 'as welded' condition shall be selected at the rate of one for tensile test and one for the nick break test for every 500 joints.

11.1.1. *Tensile test.*—The selected pieces when subjected to a tensile test shall have a tensile strength not less than 42 kg.f./mm^2.

11.1.2. *Nick break test.*—The test specimen shall be notched as given in Fig. 2 and shall be broken open along the weld, the fractured surface visually examined for fusion, root penetration, gas cavities and quality of weld metal. The surface should be reasonably free from cavities, inclusions etc. There shall be no lack of fusion. Small porosity may, however, be permitted.

11.2. *Lap joints.*—Test pieces containing lap joints at their centre shall be selected at the rate of 1 per 500 joints.

11.2.1. *Tensile test.*—The load required to shear the joint shall be at least equal to the tensile load required to fracture the bar.

NOTE.—When pulling lap weld specimens to determine the tensile strength a jig should be used to prevent distortion due to secondary stresses. Jig may be of design and detail preferred by the testing agency but should prevent change in geometric of the specimen as it is being pulled.

12·0 *Retests.*

12.1. If a sample selected for testing fails to meet the requirements given under 11.1. or 11.2. the purchaser or his representative shall select two further samples from the same lot. If on testing, either of the samples fails to meet the specified requirements, the whole lot shall be rejected.

NICK BREAK TEST SPECIMENS

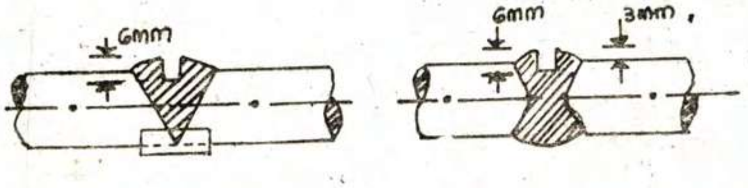


FIG. 2.

EXTRACT FROM I. S. 1199–1959.

Methods of sampling and analysis of concrete.

3. *Sampling of fresh concrete in the field.*

3.1. This method specifies the procedure to be followed in the field for obtaining representative samples of fresh concrete directly from the mixer or from concrete at the time and place of deposition.

3.2. *Sample.*—The composite sample shall be truly representative of the batch and shall be not less than 0·02 cu. m. in volume. It shall be composed of a mixture of portions taken from different points in the batch. When continuous mixers are used, a batch shall be regarded as the discharge from the mixure during one minute.

3.3. *Procedure.*

3.3.1. *From mixers.*—At least three approximately equal sample increments totalling 0·02 cu. m. shall be taken from a batch during its discharge and each sample increment shall be collected by passing a clean and dry receptable across the stream of concrete. This receptable shall be constructed of non-absorbent material, preferably of metal and shall be such that the sample retained is not segregated. A flat surface without retaining sides will not fulfil this purpose. Where three sample increments are taken they shall be taken at about the time when one quaters, one half and three-quarters of the concrete have been discharged from the mixer and if more than three are taken they shall be at correcspondingly shorter, but equally spaced intervals.

3.3.2. *From concrete at the time and place of deposition.*—The sample shall be taken while a batch of concrete is being, or immediately after it has been, discharged on the site. The sample shall be collected from not less than five well distributed positions, avoiding the edge of the mass where segregation may have occurred.

3.4. *Mixing the composite sample.*—The composite sample obtained by either of the methods described above, shall be mixed on a non-absorbent base either with a shovel or by other suitable implement in such a manner as to ensure uniformity. The sample thus obtained shall be used immediately for the purpose of carrying out the tests. Care shall be taken to protect the sample from the weather.

3.5. *Recording of samples.*—The following information regarding the samples shall be recorded:—

(*a*) Date and time of sampling.

(*b*) method of sampling used.

(*c*) mix proportions (proportions of ingredients including water, admixtures, etc.)

(*d*) mixture from which delivered (if more than one is used).

(*e*) the location of the sampled batch after placing, and

(*f*) temperature and weather conditions.

5. *Tests for workability.*

5.1. *Slump test.*

5.1.1. This method of test specifies the procedure to be adopted, either in the laboratory or during the progress of work in the field for determining, by the slump test, the consistancy of concrete where the nominal maximum size of the aggregate does not exceed 38 mm.

5.1.2. *Apparatus.*—(*a*) *mould.*—The mould for the test specimen shall be in the form of the frustum of a cone having the following dimensions:

Dimensions	*cm.*
Bottom diameter	20
Top diameter	10
Height	30

The mould shall be constructed of metal (brass or aluminium shall not be used) of at least 1·6 mm (or 15 BG) thickness and the top and bottom shall be open and at right angles to the axis of the cone. The mould shall have a smooth internal surface. It shall be provided with suitable foot pieces and also handles to facilitate lifting it from the moulded concrete test specimen in a vertical direction as required by the test. A mould provided with a suitable guide attachment may be used. A typical mould without the guide is shown in Fig. 1.

(*b*) *Tamping rod.*—The tamping rod shall be of steel or other suitable material, 16 mm in diameter, 0·6 m long and rounded at one end.

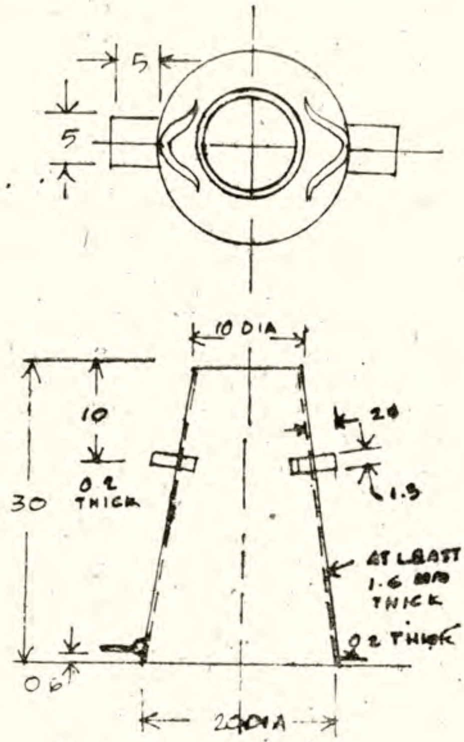


Fig. 1 : *Typical mould for slump test.*

NOTE.—To facilitate the lifting of the mould in a veritical direction it is recommended that suitable guide attachment be provided. Any rivets used in the construction of mould shall be countersunk flush on the inside of the cone. Attachments should preferably be welded to the mould.

All dimension in centimetres.

5·1·3. *Sampling.*—If this test is being carried out in the field, the sample of freshly mixed concrete shall be obtained as described in 3 In the case of concrete containing aggregate of maximum size more than 38mm, the concrete shall be wet sieved through 1½ inch screen exclude aggregate particles bigger than 38 mm.

5·1·4. *Procedure*:—The internal surface of the mould shall be thoroughly cleaned and freed from superfluous moisture and any set concrete before commencing the test. The mould shall be placed on a smooth, horizontal, rigid and non-absorbent surface, such as a carefully levelled metal plate the mould being firmly held in place while it is being filled. The mould shall be filled in four layers, each approximately one-quarter of the height of the mould. Each layer shall be tamped with twenty-five stroke of the rounded end of the tamping rod. The strokes shall be distributed in a uniform manner over the cross section of the mould and for the second and subsequent layers shall penetrate into the underlying layer. The bottom layer shall be tamped throughout its depth. After the top layer has been rodded, the concrete shall be struck off level with a trowel or the tamping rod, so that the mould is exactly filled. Any mortar which may have leaked out between the mould and the base plate shall be cleaned away. The mould shall be removed from the concrete immediately by raising it slowly and carefully in a vertical direction. This allows the concrete to subside and the slump shall be measured immediately by determining the difference between the height of the mould and that of the highest point of the specimen being tested. The above operations shall be carried out at a place free from vibration or shock, and within a period of two minutes after sampling.

5·1·5· *slump* —The slump measured shall be recorded in terms of millimetres of subsidence of the specimen during the test. Any slump specimen which collapses or shears off laterally gives incorrect result and if this occurs the test shall be repeated with another sample. If, in the repeat test also, the specimen should shear, the slump shall be measured and the fact that the specimen sheared, shall be recorded.

NOTE.—Some indication of the cohesiveness and workability of the mix can be obtained, if after the slump measurement has been completed, the side of the concrete is tapped gently with the tamping rod, a well proportioned concrete which has an appreciable slump will gradually slump further but if the mix has been badly proportioned, it is likely to fall apart.

EXTRACT FROM I. S. 2502-1963.

Code of practice for bending and fixing of bars for concrete reinforcement.

2. *Form of schedule.*

2·1. In conjunction with the requirements of this code, standard form of reinforcement schedule as shown in Table I shall be used for purposes of detailing reinforcement in concrete work.

3. *Bend dimensions and symbols.*

3·1· *General.*—The dimensions of bends shall be so given that a minimum amount of calculation is necessary for marking off bars and setting the machine and shops. The dimensioning procedure shown in Fig. 1 should be adopted as far as possible.

3·1·1. Where no indication is given to the contrary, the angle between the portions of a bar at a bend shall be assumed to be a right angle. Bending dimensions in which angles are expressed in degrees should be avoided as far as possible. When bending bars of large diameter, care should be taken to ensure that the overall length of the bent bar does not exceed the theoretical or calculated length.

3·1·2. When the shape of any bent bar is other than those coveredby Tables III to IX but is made up by combining two or more shapes, the bending dimensions shall be measured as shown for appropriate standard shapes. Where the shape of a bent bar is such that it cannot be obtained even by combining two or more standard shapes, the bars shall be fully dimensioned in the schedule and also the method of measuring the bending dimensions shall be indicated in the schedule ; but such special shapes should be avoided as far as possible.

TABLE—I. STANDARD FORM OF REINFORCEMENT SCHEDULED
(*Clause* 2·1) *Schedule number.*

Location	*Mark designation.*	*Size and type.*	*Number of sets.*	*Number per set.*	*Total number.*	*length*	*Shape (al. dimensions are in accordance with this standard unless otherwise stated).*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Column	C4 4R 25N	MS round 25 mm.	5	4	20	3,000 mm.	Straight.

NOTE 1–The recommended widths of the above columns are reading from left to right 25, 20, 15, 15, 15, 15, 15 and 75 mm. The 75 mm dimension may be reduced to 70 mm for paper sizes other than *A. 4. Adequate margin should be provided on either side the left hand margin being not less than 15 mm. The length of the form should not generally exceed that of *A4 size.

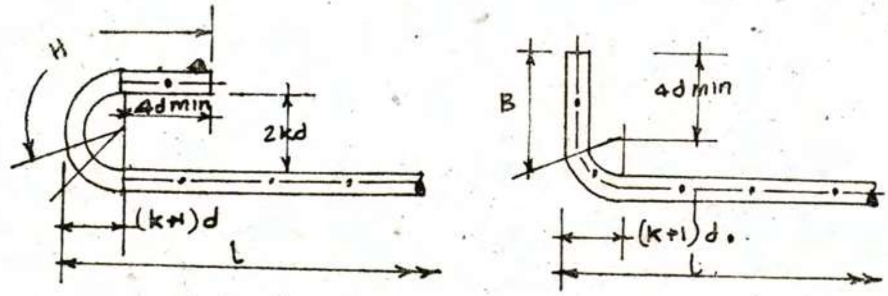
*A4 size is 210 X 297 mm.

NOTE 2—In col. 2 the bar identification that will be put on the labels attached to the bars shall appear. It should be simple. The first number in the mark designation refers to the number of identical bars in similar locations in the same section of a given member, and the letter Rerefers to round bars, the figure that follows the letter R represents the diameter or the nominal size of the bar in millimetres and N represents the identification number of the bar/bars given consecutively.

NOTE 3—In col. 3, the quality of basic shape of the reinforcement bar shall be specified.

3·2. *Bends and hooks forming and anchorages.*

3·2·1. Dimensions of Bends and Hooks :—Unless otherwise indicated in the schedule, a semicircular hook or a bend forming-anchorage to a bar shall be bent with an internal radius in accordance with Fig. 1–A and Fig. 1-B, respectively. The hook and bend allowances shall be in accordance with Table II.



1A HOOK.　　　　1B. BEND.

NOTE 1:- K HAS A VALUE OF 2, IN THE CASE OF MILD STEEL CONFORMING TO IS: 432-1960 SPECIFICATION FOR MILD STEEL AND MEDIUM TENSILE STEEL BARS AND HARD-DRAWN STEEL WIRE FOR CONCRETE REINFORCEMENT (REVISED) OR IS: 1139-1959 SPECIFICATION FOR HOT ROLLED MILD STEEL AND MEDIUM TENSILE STEEL DEFORMED BARS FOR CONCRETE REINFORCEMENT, 3, IN THE CASE OF MEDIUM TENSILE STEEL CONFORMING TO I.S:-132-1960 or I.S:-1139-1959 AND 4, IN THE CASE OF COLD WORKED STEEL CONFORMING TO I.S: 1786-1961 SPECIFICATION FOR COLD TWISTED STEEL BARS FOR CONCRETE REINFORCEMENT. IN THE CASE OF BARS ABOVE 25 mm however IT IS DESIRABLE TO INCREASE THE VALUE TO 3, 4, AND 6 RESPECTIVELY.

NOTE 2: H AND B REFER TO HOOK ALLOWANCE AND BEND ALLOWANCE RESPECTIVELY (SEE TABLE II)

FIG. 1. STANDARD HOOK AND BEND

TABLE II : HOOK AND BEND ALLOWANCES.

(*Clause* 3·1. *and* 3·2·1.)

Nominal size of Bar.	*Hook allowance (H).* *Mild steel conforming to *IS 432-1960 or to † IS 1139-1959.*		*Medium tensile steel conforming to *IS 432-1960 or to † IS 1139-1959.*		*Cold worked steel bars conforming to ‡IS 1786-1961.*		*Bend allowance (B).* *Mild steel conforming to *IS 432-1960 or to †IS 1139-1959.*		*Medium tensile steel conforming to IS 432-1960 or to †IS 1139-1959.*		*Cold worked Steel bars conforming to ‡ IS 1786-1961.*	
	Min.	*Re-commd.*	*Min.*	*Re-commd.*	*Min.*	*Re-commd.*	*Min.*	*Re-commd.*	*Min.*	*Re-commd.*	*Min-*	*Re-commd.*
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
5	75	..	75	..	75	..	75	..	75	..	75	..
6	75	..	75	..	75	..	75	..	75	..	75	..
8	75	..	90	..	105	..	75	..	75	..	75	..
10	90	..	110	..	130	..	75	..	75	..	75	..
12	110	..	130	..	155	..	75	..	75	..	75	..
16	145	..	175	..	210	..	80	..	90	..	95	..
20	180	..	220	..	260	..	100	..	110	..	120	..
22	200	..	240	..	285	..	110	..	120	..	130	..
25	225	..	275	..	325	..	125	..	140	..	150	..
28	250	310	310	365	365	475	146	155	155	170	170	195
32	290	350	350	415	415	545	160	175	175	190	190	225
36	325	395	395	470	470	610	180	200	200	215	215	250
40	360	440	440	520	520	680	200	220	220	240	240	280
45	405	495	495	585	585	765	225	250	250	270	270	315
50	450	550	550	650	650	850	275	275	275	300	300	350

H = Hook allowance taken as 9d, 11d, 13d, and 17d for k values, 2, 3, 4 and 6 respectively and rounded off to the nearest 5 mm, but not less than 75 mm.

B = Bend allowance taken as 5d, 5·5d, 6d and 7d for k values 2, 3, 4 and 6 respectively and rounded off to the nearest 5 mm. but not less than 75 mm.

*IS 432-1960 Specification for Mild Steel and Medium Tensile Steel Bars and Hard Drawn Steel Wire for Concrete Reinforcement (Revised):

† IS. 1139-1959 Specification for Hot Rolled Mild Steel and Medium Tensile Steel Deformed Bars for Concrete Reinforcement.

‡ IS 1786-1961 Specification for Cold Twisted Steel Bars for Concrete Reinforcement.

3.3. *Binders, stirrups, links and the like.*—In the case of binders stirrups, links, etc., the straight portion beyond end-of the curve at the end shall be not less than eight times the nominal size of the bar:

7. *Fixing reinforcement.*

7·1. *General.*—The economy of reinforced concrete design will be fully realised only when the reinforcements are maintained at their designed positions at all times. The important factors in fixing the reinforcement are provision and convenience.

7·1·1·. Reinforcements shall be placed in position as given on the detailed design drawing the shall be secured at that position. In case of delay occurring between fixing of reinforcement and concreting, the position of the reinforcement shall be checked Prior to concreting.

7·1·2. Lapping of bars shall be done in accordance with the relevant requirements specified in I.S. 456-1964 code of practice for Plain and reinforced concrete (second revision) Laps shall be staggered.

7·1·3. The precautions described in 7·2. to 7·5·. shall be taken to prevent displacement of reinforcement during shuttering and concreting.

7·2. *Tying of reinforcement bars* :—Bars crossing each other, where required, shall be secured by binding wire (annealed) of size not less than 0·90 mm and conforming to I.S. 280-1962 specification for Mild steel Wire (Revised) in such a manner that they will not slip over each other at the time of fixing and concreting.

7·2·1. Every compression bar shall be tied at least in two perpendicular directions.

7·2.2. Stirrups may be staggered, provided it is ensured that the corresponding stirrups form a uniform pattern in elevation.

7·2·3. Three methods of tying reinforcements bars are illustrated in Fig. 6. Of the three methods, the method illustrated in Fig. 6-A should be preferred to method given in Fig. 6 B and th .t given in Fig. 6-B to the one given in Fig. 6-C.

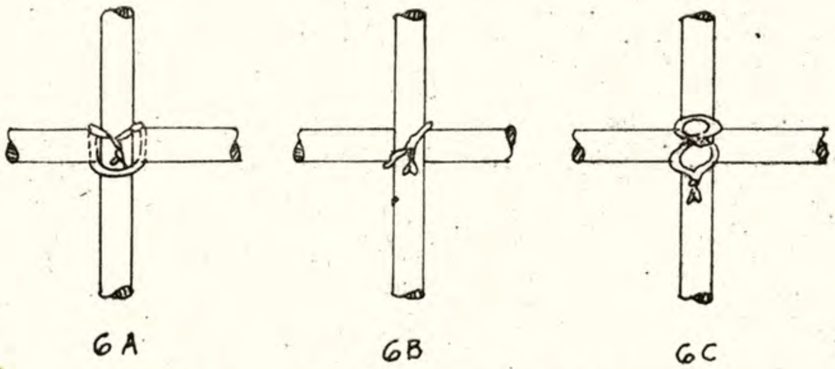


FIG. 6. THREE METHODS OF TYING REINFORCEMENT BARS

7·3. *Cover blocks.*

7·3·1. Cover blocks, which are generally of cement mortar, shall be used to ensure the required cover for reinforcement. Cover blocks are generally square or rectangular in plan with or without binding wire embedded in them which will be tied to the reinforcement at the time of placing (see Fig. 7). Rings with suitable hold at the centre may also be used.

7.3.2. The mortar or concrete used for the cover blocks or rings shall not be leaner than the mortar or concrete in which they will be embedded.

7.3.3. To provide necessary cover for reinforcement at any section only single cover blocks shall be used.

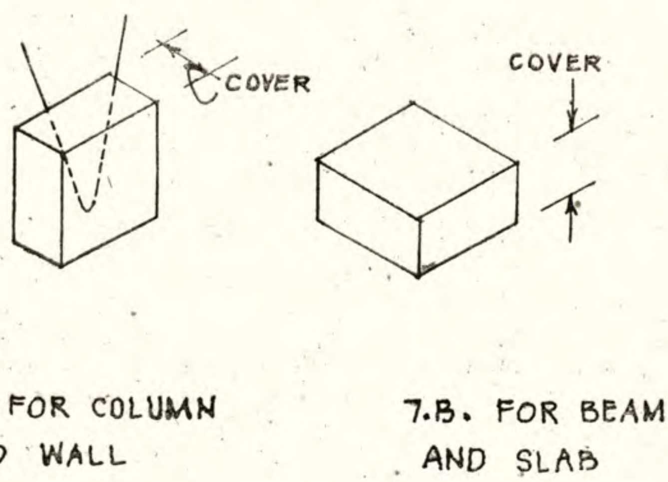
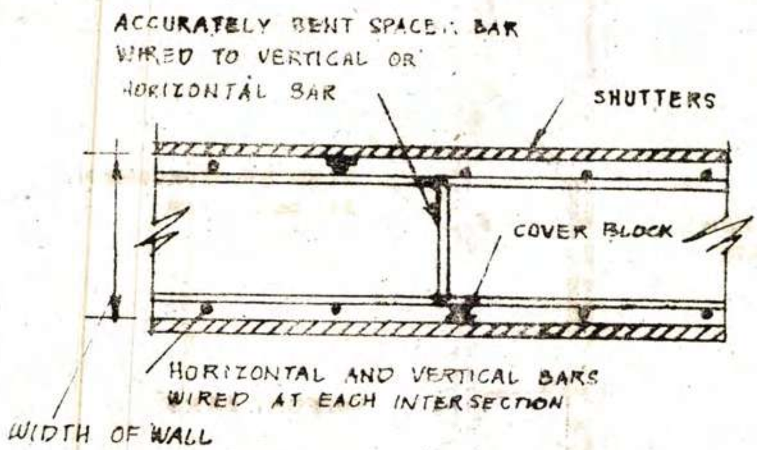


FIG. 7. COVER BLOCKS

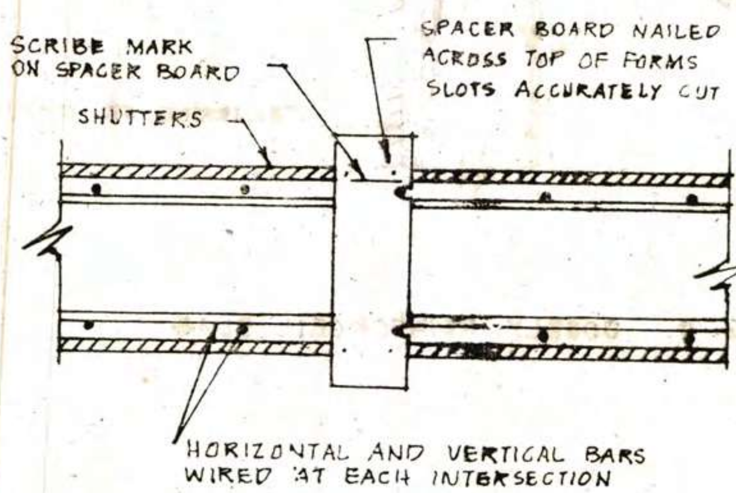
7.4 *Spacers.*

7.4.1. *Walls.*—In walls where multiple rows of reinforcements are provided, it is very important that the distances between successive rows are properly maintained while concreting; and this may be achieved by following one of the methods illustrated in Fig. 8.

7.4.1.1. In the method illustrated in .Fig. 8-A, two rows of reinforcement are separated and kept in their correct relative position by being attached to an accurate bent bar that acts as distance piece while in the method illustrated in Fig. 8-B the same effect is achieved by placing the vertical bars in slots accurately cut in a board with additional advantage of maintaining the correct cover. The slots may be placed by pairs of projecting nails and scribe marks on the board will indicate the correct alignment on the inside face of the hutters.



8A. USE OF WALL SPACER BAR



8B. USE OF SPACER BOARD

FIG. 8 MAINTAINING WALL BARS IN POSITION

466-3—26

7.4.1.2. In the first method, the bar remains permanently in position but in the second method the spacer board has to be removed before the shutters.

7.4.2. *Slabs.*—In slabs, whether double or multiple layers of reinforcement are provided, the distances between the layers may be maintained by the method illustrated in Fig. 9.

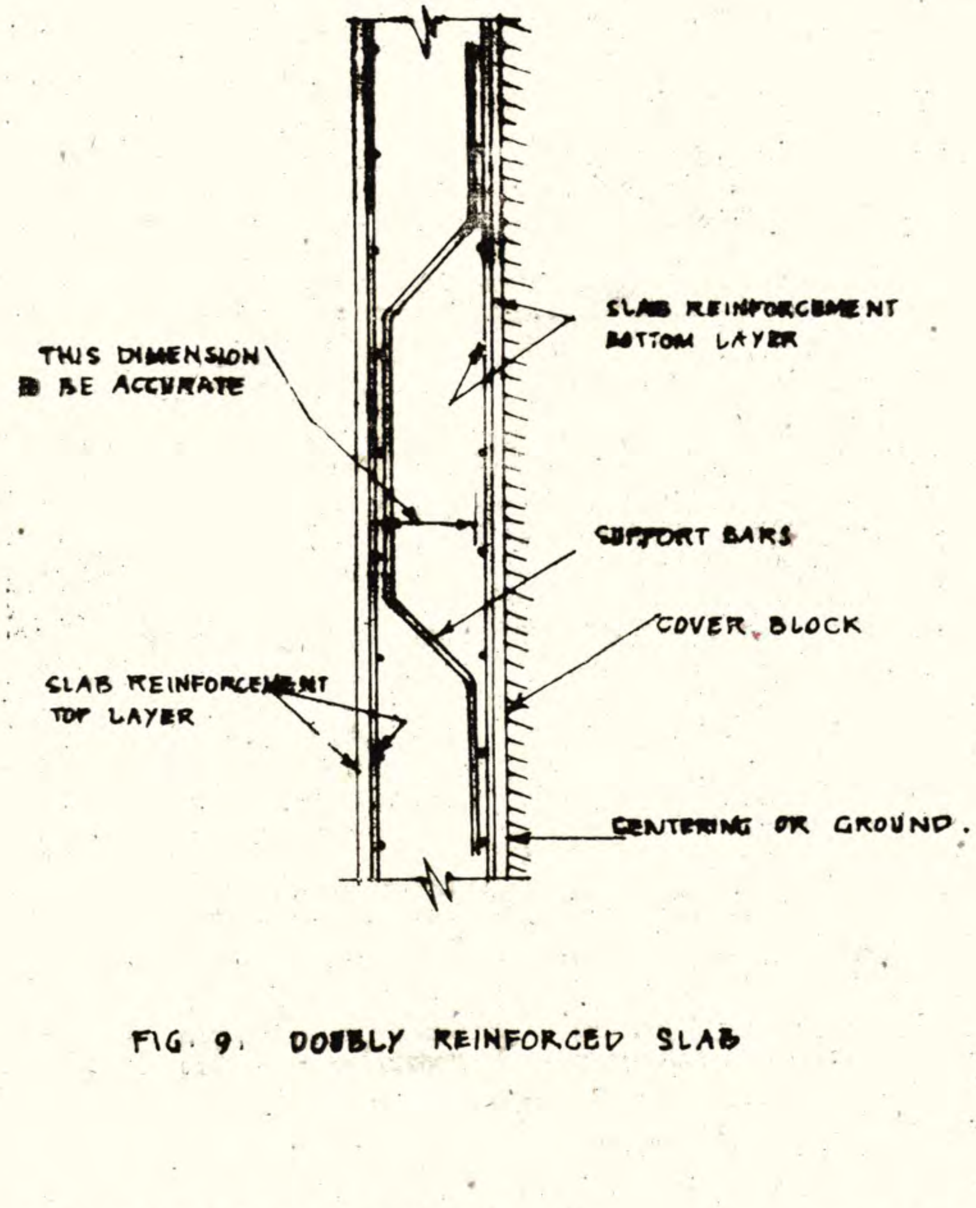
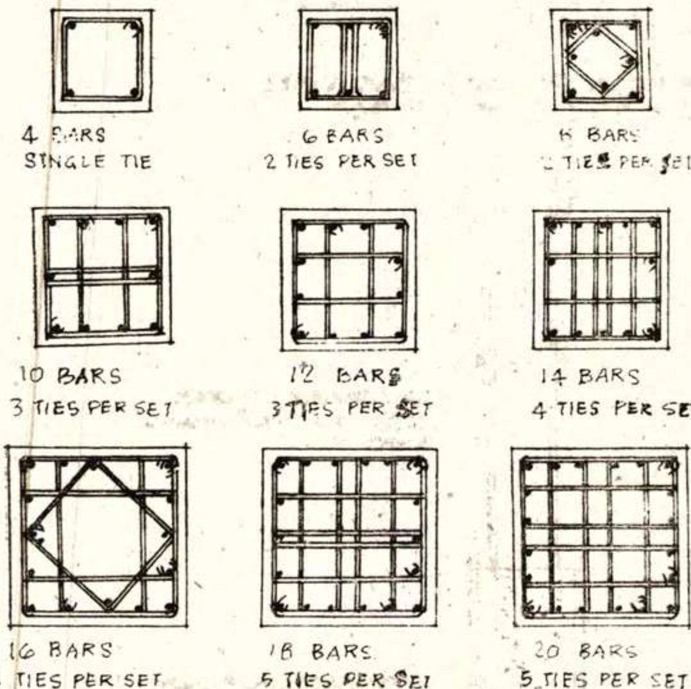


FIG. 9. DOUBLY REINFORCED SLAB

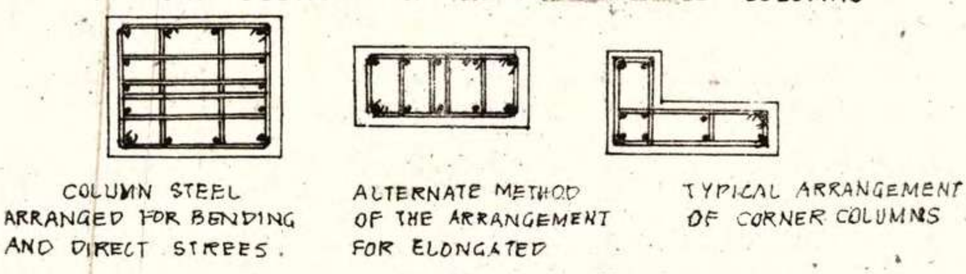
7.4.2.1. In the figure, additional support bars are shown inserted but in a good design, the provision of these extra bars would not be necessary as the designer would so arrange the reinforcement that the supporting bars would be a part of the principal reinforcement.

7.4.3. *Beams.*—In beams with top reinforcement, it is desirable to suspend the top reinforcement from the form work by suitable arrangement which may be removed on completion of concreting upto the appropriate level, unless such reinforcement is otherwise rigidly held in position by stirrups or other members.

7.5. *Column reinforcement.*—The column reinforcement, especially in heavily reinforced columns and in columns subjected to a combination of direct load and bending, should be properly tied, otherwise the strength of the column will be considerably affected. Some of the typical methods of tying the reinforcement are shown in Fig. 10. The ties may be staggered provided it is ensured that the corresponding ties form a uniform pattern in elevation and they shall be in closed loops.



TYPICAL SECTIONS OF GENERAL PURPOSE COLUMNS



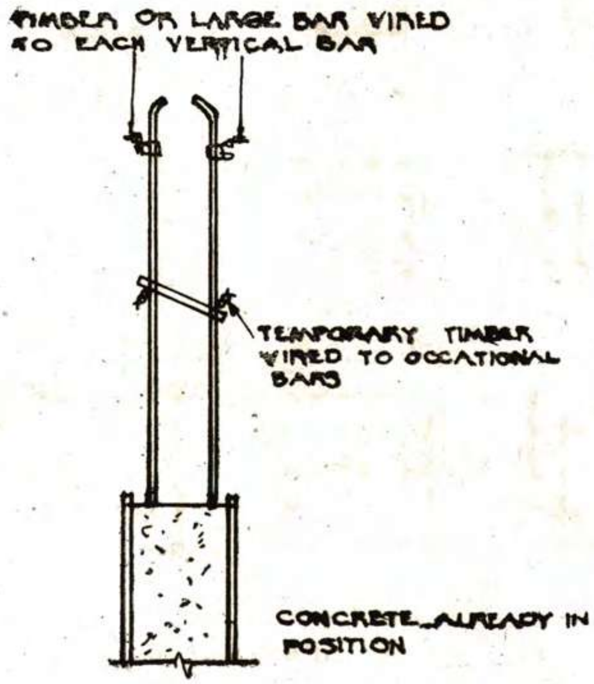
TYPICAL SECTIONS OF SPECIAL PURPOSE COLUMNS

NOTE 1: IF ACCESS TO THE INTERIOR OF A COLUMN IS NECESSARY A DIFFERENT PATTERN OF TIES MAY BE SUBSTITUTED PROVIDED TIES ARE SO DESIGNED THAT EACH VERTICAL BAR IS SECURELY BRACED AGAINST MOVEMENT

NOTE 2: THE TIES MAY BE STAGGERED PROVIDED IT IS ENSURED THAT THE CORRESPONDING TIES FORM A UNIFORM PATTERN IN THE ELEVATION

FIG 10: COLUMN TIES

7.6. Distortion of projecting vertical bars in double rows in walls may be preven'ed prior to complete assembly of horizontal reinforcement and erection of shutters by the arrangements illustrated in figure. This arrangement consists of a longitudinal timber or sarge bar placed along each row of vertical bar and tied to each bar Between every sixth bar of opposite rows a cross piece of wood or teel should be tied.



7.6.1. For single vertical row of large bars in walls, a timber frame as illustrated in Fig. 12 may be employed to prevent the distortion of bar. The diamensions, details and spacing of the frame shall be determined by the nature of the work.

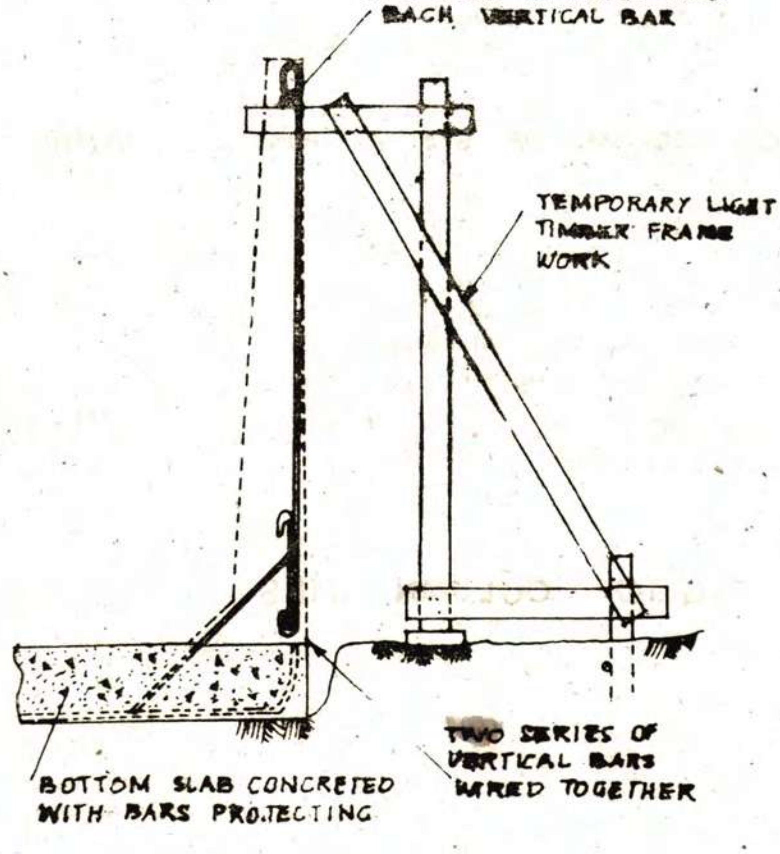


FIG 12 SUPPORTING VERTICAL WALL REINFORCEMENT

NOTE.—The frame could often be part of the shuttering.

8. *Transporting reinforcement.*

8.1. Reinforcement shall be transported to the site of work or to the place of storage by such means and in such a manner that the reinforcement is neither damaged nor deformed. The unloading of the reinforcement shall be done at the nearest convenient place where it is to be processed further. Particularly in cases where unloading is required to be done by hand, it is important that the vehicle should be brought as close as possible to the stacking or bending place in order to avoid carrying over long distances. As far as possible, at the time of unloading the bars should be separated by sizes and lengths.

9. *Storage of reinforcement.*

9.1. The actual location of the stacking place of reinforcement repends upon the site conditions, but it should be such that the reinforcement could be conveniently received and supplied to the operational centres in the site. On works covering large areas, in might be an advantage to stack the reinforcement at different places close to the areas where they are likely to be used most.

9.1.1. In order to ensure that the reinforcement bars are kept in good condition, they should not be left in direct contact with the ground but they should be stacked on top of an arrangement of timber sleepers or the like. Suitable racks may also be used for stacking reinforcement in tiers. Where space is extremely limited, bars may also be stacked vertically but the vertical stacking has the disadvantage that it is more difficult to get the bars in and out and in identifying bars of different sizes and lengths. Whatever method of stacking is adopted, the bars should be stacked in such a way that the various sizes and lengths can be quickly and easily identified.

9.1.2. After the reinforcement bars have been bent, they should be placed in the most convenient locations for transport to working points Flexible bends like stirrups and bends of small diameter bars should be grouped together and bundled for ease of handling. Each bundle of bars or group of bars should have labels affixed to it indicating the bar mark, bending schedule reference number and its position in laying.

9.1.3. In storing bars, attention shall be paid to avoiding distortion and to preventing deterioration and corrosion.

9.1.4. Whilst a certain amount of hard rust on the reinforcement is considered desirable in reinforced concrete work, care should be taken to ensure that undue rusting or loose scaling do not take place in storage and in such conditions of weather where the reinforcement is likely to get corroded, the stack of reinforcement shall be suitably sheltered.

EXTRACT FROM I.S. 3370 (PART I), 1965.

Code of practice for concrete structures for the storage of liquids. Part I—General requirements.

1. *Scope.*

1.1. This standard (Part I) lays down the general requirements for the design and construction of concrete structures, plain reinforced or prestressed concrete, intended for storage of liquids, mainly water.

The requirements applicable specifically to reinforced concrete liquid retaining structures are covered in Part II.

1.2. This code does not cover the requirements for reinforced and prestressed concrete structures for storage of hot liquids and liquids of low viscosity and high penetrating power like petrol, diesel oil set. Special problems of shrinkage arising in the storage of non adueous liquids and the measures necessary where chemical attack is possible, are also not dealt with. The recommendations, however may generally be applicable to the storage at normal temperature of aqueous liquids and solutions which have no detrimental action on concrete and steel or where sufficient precations are taken to ensure protection of concrete and steel from damage due to action of such liquids as in the case of sewage.

3. *Concrete mix.*

3.1. Provisions in 5 of I.S. 456-1965 and 4.2.5. of I.S. 1343-1960 shall apply for reinforced concrete and prestressed concrete members respectively subject to the following further requirements.

(*a*) Except in case of thick sections as described in 7 and parts of structure nei her in contact with the liquid on any face not enclosing the space above the liquid, concrete mix weaker than M 200 shall not be used.

(*b*) The minimum quantity of cement in the concrete mix shall not be less than 330 kg./m^3 in reinforced concrete work, 360 kg./m^3 in post tensioned prestressed work and 380kg / m^3 in pretensioned prestressed work. The maximum quantity of cement in the concrete mix shall preferably not exceed 530 kg/m^3 of concrete.

(*c*) The design of the mix shall be such that the resultant concrete is sufficiently impervious. The mix obtained in accordance with the above, if fully compacted, will generally give a degree of imperme-ability adequate for all ordinary purposes. In special circumstances the Engineer in charge should satisfy himself that an adequate permeability is obtained by percolation tests.

3·3. *Imperviousness of coucrete mix.*—In the construction of concrete structures for the storage of liquids, the imperviousness of concrete is an importent basic requirement. The permeability of any uniform and thoroughly compacted concrete of given mix proportions is very largely dependent on the water cement ratio. While an increase in this ratio leads to an increase in the inherent permeability, a very much reduced water cement ratio of a mix with a given cement content may cause compaction difficulties and thus may prove equally harmful. For a given mix made with particular materials, there is a lower limit to the water-cement ratio which can be used economically on any job. It is essential to select a richness of mix compatible with available aggregates, whose particle shape and grading have an important bearing on workability which must be suited to the means of compaction selected. Efficient compaction preferably by vibration is essential. In practice, it is usually convenient particularly when dealing with thin congested reinforced sections to specify a cement content sufficiently high to ensure that thorough compaction is obtainable while maintaining a sufficiently low water cement ratio. In thicker sections, where a reduction in cement content might be desirable to restrict the temperature rise due to cement hydration, a lower cement content is usually permissible, partly because the overall permeability of the section is reduced by the greater thickness and partly because less congested conditions may permit thorough compaction of a somewhat drier mix.

While proper attention must be paid in achieving a mix of inherently low permeability, it should be recognized that common and more serious causes of leakage in practice, other than cracking, are defects such assegregation and honey combing and in particular, all joints are potential source of leakage.

The mixes as specified in 3, if fully compacted, will give a degree of permeability adequate for all ordinary purposes. In speciae circumstances where necessary, the engineer should satisfy himselfl by a percolation test, that an adequate degree of impermeability is obtained.

5. *Protection against corrosion.*

5.1. The type of liquid to be retained should be considered in relation to the possibility of corrosion of steel or attack on concrete with corrosion waters (as in the case with certain natural waters), it is desirable to use richer and denser concrete and provide increased cover to steel. Considerations may also be given to the use of special cements, such as, sulphate-resisting cement or high alumina cement. Where attack is likely to be appreciable the provision of an impervious rotective lining should be considered.

7. *Thick sections.*

7.1. Thick sections shall be those parts of structure which have thickness greater than 450 mm. There is a likelihood of cracking in such sections as a consequence of temperature rise during hydration of the cement and subsequent cooling. Such cracking is not easy to control by reinforcement. The following are some of the measures that may be adopted for reducing the likelihood of cracking.

(*a*) Magnitude of the temperature rise should be restricted by limiting the cement content, or by using a type of cement with a low ate of heat of evolution or adopting suitable construction methods. Portland cements with lower rates or strength development generally give lower rates of heat evolution. In such cases the permissible stresses shall conform to requirements of 3.3. Temperature rise may also be restricted by casting the concrete in shallow lifts at intervals of a few days so as to allow the escape of part of heat from the exposed upper surface.

(*b*) Steep temperature grading will occur by sudden chilling of the concrete surface. This should be aovided, for instance, some protection may be required when removal of heavy timber form work coincides with onset of cold weather.

(*c*) Restraint to over all contraction may be limited by provision of movement joints and by provision of suitable sliding layer. Another cause of restraint which may lead to cracking occurs when a substantial lift of concrete is cast upon a cold foundation. A better procedure is to avoid excessive disparity in temperature between successive lifts and where paracticable to introduce shallow lifts when starting from or resuming work on a cold foundation.

7.2. While concreting in thick sections, the requirements of I.S. 456 -1964 shall apply as far as possible.

Code of practice for plain and reinforced concrete Secod revision)

EXTRACT FROM I.S. 3370 (PART II), 1965.

Code of practice for contract structure for the storage of liquids Part II Reinforced concrete structures.

1. *Scope.*

1.1. This standard (Part II) lays down the requirements applicable specifically to reinforced concrete structures for the storage of liquids, mainly water. These requirements are in addition to the general equirements laid down in I.S. 3370 (Part I), 1965.

1.2. This code does not cover the requirements for reinforced and prestressed concrete structures for storage of hot liquds and liquids of low viscosity and high penetrating power like petrol, diesel oil, etc. Special problems of shrinkage arising in the storage of non-aqueous liquids and the measures necessary where chemical attack is possible, are also not dealt with. The recommendations, however, may generally be applicable to the storage at normal temperatures of aqueous liquids and solutions which have no detrimental action on concrete and steel or where sufficient precautions are taken to ensure protection of concrete and steel from damage due to action of such liquids as in the case of sewage.

2. *General requirements.*

2.1. Design and construction of reinforced concrete liquid retiaining structures shall comply with the requirements of I.S. 3370 (Part I)—1965

3. *Design*

3.1. *General.*—Provisions shall be made for conditions of stresses that may occur in accordance with principles of mechanics,recognized methods of design and sound engineering practice. In particular, adequate consideration shall be given to the effects of monolithic-construction in the assessment of bending moment and shear.

3.1.1. Before taking up the detailed design, the designer should satisfy himself on the correct estimation of loads and on the adequate statical equilibrium of the structure,particularly in regard to safety against over turning of over hanging members ; in the latter case the general arrangement should be such that statical equilibrium should be satisfied even when the overturning moment is doubled.

3.2. *Basis of design.*

3.2.1. General basis of design shall be in line with the recommendations of I.S. 456-1964 except where otherwise specified in this code. The parts of the structure neither in contact with the liquid on any face nor enclosing the space above the liquid,as in case of staging of a water tower, shall be designed in accordance with the requirements of I.S. 456-1964.

3.2.2. Design of members other than those excluded by 3.2.1. shall be based on consideration of adequate resistance to cracking as well as adequate strength. Calculation of stresses shall be based on the following assumptions in addition to the general assumptions of stresses shall be based on the following assumptions in addition to the general assumptions given in I.S. 456-1964.

(*a*) In calculations for both flexure and direct tension (or combination of both) relating to resistance to cracking, the concrete is capable of sustaining limited tensile stress, the whole section of concrete including the cover, together with the reinforcement being taken into account.

(*b*) **The total shear stress given by the following equation shall not exceed the value given in 3.3.1 whatever the reinforcement provided :—**

$$\text{Total shear stress} = \frac{Q}{b\,jd}$$

Where

Q=total shear.
b=breadth and
jd=lever arm.

(*c*) In strength calculations the concrete has no tensile strength

3.2.3. ***Plain concrete structures.***—Plain concrete members of rein forced concrete liquid retaining structures may be designed against structural failure by allowing tension in plain concrete as per the permissible limits for tension bending specified in I.S. 456-1964 This will automatically take care of failule due to cracking. However nominal reinforcement in accordance with the requirements of I.S. 456-1964 shall be provided or plain concrete structural members.

3.3. *Permissible stresses in concrete.*

3.3.1. For resistance to cracking : For calculations relating to the resistance of members to cracking, the permissible stresses in tension (direct and due to bending) and shear shall conform to the values specified in Table I. The permissible tensile stresses due to bending apply to the face of the member in contract with the liquid. In members less than 225 mm. thick and in contact with the liquid on one side, these permissible stresses in bending apply also to the face remote form the liquid.

TABLE 1 : PERMISSIBLE CONCRETE STRESSES IN CALCULATIONS RELATING TO RESISTANCE TO CRACKING.

Grade of concrete.	*Permissible stresses kg./cm.²*		*Shear.* (Q/*bjd*.)
	Direct tension.	*Tension due to bending.*	
(1)	(2)	(3)	(4)
M 150	11	15	15
M 200	12	17	17
M 250	13	18	19
M 300	15	20	22
M 350	16	22	25
M 400	17	24	27

3·3·2. For strength calculation.—In strength calculation, the permissible concrete stresses shall be in accordance with 8 of I.S 456-1964. Where the calculated shear strees in concrete alone exceeds the permissible value, reinforcement acting in conjunction with diagonal compression in the concrete shall be provided to take the whole of the shear.

3·4. *Permissible stresses in steel.*

3·4·1. *For resistance tocracking.*—When steel and concrete are assumed to act together for checking the tensile stress in concrete for avoidance of cracks, the tensil stress in the steel will be limited by the requirement that the permissible tensile strees in the concrete is not exceeded ; so the tensile stress in steel shall be equal to the product of modular ratio of steel and concrete, and the corresponding allowable tensile stress in concrete.

3·4·2. *For strength Calculation* :—In strength calculations the permissible stresses in steel reinforcement shall be as follows :—

(i) Tensile stress in members in direct tension.	1,000 kg./cm.²
(ii) Tensile stress in members in bending :—	
On liquid retaining face of members.. ..	1,000 kg./cm.²
On face away from liquid for members less than 225 mm. thick.	1,000 kg./cm.²
On face away from liquid for members 225 mm. or more in thickness.	1,250 kg./cm.²
(iii) Tensile stress in shear reinforcement :—	
For members less than 225 mm. in thickness.	1,000 kg./cm.²
For members 225 mm. or more in thickness.	1,250 kg./cm.²
(iv) Compressive stress in columns subject to direct load.	1,250 kg./cm.²

NOTE 1.—Stress limitations for liquid retaining faces shall also apply to the following :–

(*a*) Other faces within 225 mm. of the liquid retaining face

(*b*) Outside or external faces of structures away from the liquid but placed in water logged soils up to the level of highest subsoil water level.

NOTE 2.—The permissible stress of 1,000 kg /cm.² in (i), (ii) and (iii) may be increased to 1125 kg./cm.² in case of deformed bars and in case of plain mild steel bars when the cross reinforcement is spot welded to the main reinforcement.

3·5. *Stresses due to Drying Shrinkage of Temperature Change:* Stresses due to drying shrinkage or temperature may be ignored provided that :—

(*a*) the permissible stresses specified in 3.3 and 3.4 are not otherwise exceeded.

(*b*) adequate precautions are taken to avoid cracking of concrete during the construction period and until the reservoir is put into use.

(*c*) the recommendations of this code (*see* I.S. 3370 (Part I) 1965 as regard the provisions of joints and for suitable sliding layer beneath the reservoir are complied with, or the reservoir is to be used only for the storage of water or aqueous liquids at or near ambient tmperature and the circumstances are such that the concrete will never dry out.

3.5.1. Shrinkage stresses may, however, be required to be calculated in special cases, when a shrinkage confficient of 300×10^{-6} may be assumed.

3.5.2 When the shrinkage stresses are allowed, the permissible stresses, tensile stresses in concrete (direct and beding) as given in table 1 may be increased by 33-1/3 per cent

3.5.3. Where reservoirs are protected with an internal impermeable lining, consideration should be given to the possibility of concrete eventually drying out. Unless it is established on the basis of tests or experience that the lining has adequate crack bridging properties, allowance for the increased effect of drying shrinkage should be made in the design.

4. *Floors.*

4.1. Provisions of Movement Joints : Movement joints shall be provided in accordance with 8 of I.S. 3370 (Part I)—1965.

4·2. Floors of Tanks Resting on Ground.—If the tank is resting directly over ground floor may be constructed of concrete with nominal percentage of reinforcement (small than the minimum specfied in 7) provided it is certain that the ground will carry the load without appreciable subsidence in any part and that the concrete floor is cast in panels with sides not more than 4.5 metres with contraction or expansion joints between. In such cases a screed concrete layer not less than 75 mm. thick shall first be placed on the ground and covered with a sliding layer of bitumen paper or other suitable material to destroy the bond between the screed and floor concrete.

In normal circumstances the screed layer shall be of grade not weaker than M100 specified in I.S. 456-1964, where injurious soils or aggressive water are expected, the screed layer shall be of grade not weaker than M 150 specified in I.S. 456-1964 and if necessary a sulphate resisting or other special cement should be used.

4·3. *Floors of tanks resting on supports*:—If the tank is supported on walls or other similar supports, the floor slab shall be designed as floors in buildings for bending moments due to water load and self weight. The worst conditions of loadings may not be those given in 9·3 of I.S. 456-1964, since water level extends over all spans in normal construction except in the case of multi-cell tanks, these will have to be determined by the designer in each particular case.

4·3·1. When the floor is rigidly connected to the walls (as is generally the case) the bending moments at the junction between the walls and floor shall be taken into account in the design of floor together with any direct forces transferred to the floor from the walls or from the floor to the wall due to the suspension of the floor from the wall.

If the walls are non-monolithic with the floor slab, such as in case where movement joints have been provided between the floor slabs and walls, the floor shall be designed only for the vertical loads on the floor.

4·3·2. In continuous T-Beams or L-Beams with ribs on the side remote from the liquid, the tension in concrete on the liquid side at the face of the supports shall not exceed the permissible stresses for controlling cracks in concrete. The width of the slab given in 9·2·2· of I.S. 456-1964 shall be made the basis for calculation of the resistance to cracking of T-Beam, L-Beam sections at supports.

4·3·3. The floor slab may be suitably tied to the walls by reinforcement bars properly embedded in both the slab and the walls. In such cases no separate beam (curved or straight) is necessary under the wall, provided the wall of the tank itself is designed to act as a beam over the supports under it.

4·3·4. Some times it may be economical to provide the floors of circular tanks in the shape of dome. In such cases the dome shall be designed for the vertical load of the liquid over it and the ratio of its rise to its diameter shall be so adjusted that the stresses in the dome are, as far as possible, wholly compressive. The dome shall be supported at its bottom on the ring beam which shall be designed for resultant circumferential tension in addition to vertical loads.

5. *Walls.*

5·1. *Provision of Joints:*

5·1·1. *Sliding joints at the base of the wall* : Where it is desired to allow the walls to expand or contract separately from the floor or to prevent moments at the base of the wall owing to fixity to the floor sliding joints may be employed.

5·1·1·1. Considerations affecting the spacing of vertical movement joints are discussed in 8 of I.S. 3370 (Part I)-1965. While the majority of these joints may be of the partial or complete contraction type, sufficient joints of the expansion type should be provided to satisfy the requirements of 8 of I.S. 3370 (Part I)-1965.

5·2. *Pressure on walls* :

5·2·1. In liquid retaining structures with fixed or floating covers, the gas pressure developed above liquid surface shall be added to the liquid pressure.

5·2·2. When the wall of liquid retaining structure is built in ground or has earth embanked against it, the effect of earth pressure shall be taken into account as discussed in 4 of I.S. 3370 (Part I)—1965.

5·3. *Walls of tanks rectangular or polygonal in plan* : While designing the walls of rectangular or polygonal concrete tanks, the following points should be borne in mind :—

(*a*) In plane walls, the liquid pressure is resisted by both vertical and horizontal bending moments. An estimate should be made of the proportion of the pressure resisted by bending moments in the vertical and horizontal planes. The direct horizontal tension caused by the direct pull due to water pressure on end walls should be added to that resulting from horizontal bending moment. On liquid retaining faces, the tensile stresses due to the combination of direct horizontal tension and bending action shall satisfy the following ondition :—

$$\frac{t'}{t} + \frac{\sigma_{ct}'}{\sigma_{ct}} \leq 1$$

Where t' = Calculated direct tensile stress in concrete.

t = Permissible direct tensile stress in concrete (*see* Table 1).

σ_{ct}' = Calculated tensile stress due to bending in concrete, and

σ_{ct}' = Permissible tensile stress due to bending in concrete (*see* Table 1).

(*b*) At the vertical edges where the walls of a reservoir are rigidly joined, horizontal reinforcement and hanch bars should be provided to resist the horizontal bending moments, even if the walls are designed to withstand the whole load as vertical beams or cantilever without ateral supports.

(*c*) In the case of rectangular or polygonal tanks, the side walls act as two-way slabs, whereby the wall is continued or restrained in the horizontal direction, fixed or hinged at the bottom and hinged or free at the top. The walls thus act as thin plates subject to triangular loading. and with boundary conditions varying between full restraint and free edge. The analysis of moment and forces may be made on the basis of any recognized method, However, moment, co-efficients, for boundary conditions of wall panels for some comom or cases are given in I.S. 3370-(Part IV) of this code for general guidance.

5·4. *Walls of cylindrical tanks* : While designing walls of cylindrical tanks, the following points should be borne in mind :

(*a*) Walls of cylindrical tanks are either cast monolithically with the base or are set in grooves and key ways (movement joints). In either case deformation of the wall under the influence of liquid pressure is restricted at and above the base. Consequently, only part of the triangular hydrostatic load will be carried by ring tension and part of the load at the bottom will be supported by cantilever action.

(*b*) It is difficult to restrict rotation or settlement of the baseslab and it is advisable to provide vertical reinforcement as if the walls were fully fixed at the base, in addition to the reinforcement required to resist horizontal ring tension for hinged at base conditions of walls, unless the appropriate amount of fixity at the base is established by analysis with due consideration to the dimensions of the base slab, the type of joint between the wall and slab and, where applicable, the type of soil supporting the base slab.

5.4.1. Coeffients for ring tension and vertical moments for different conditions of the walls for some common cases are given in I.S. 3370 (Part IV) for general guidance.

6. *Roofs.*

6.1. *Provision of movement joints.*—To avoid the possibility of sympathetic cracking, it is important to ensure that movemens joints in the roof correspond with those in walls if roof and wall-are monolithic. If, however, provision is made by means of a sliding joint for movement between the roof and the wall, correspondence of joints is not so important.

6.2. *Loading*—Fixed covers of liquid retaining structures should be designed for gravity loads, such as the weight of roof slab, earth cover, if any live loads, and mechanical equipment. They should also be designed for upward load if the liquid retaining structure is subjected to internal gas pressure.

6.2.1. A superficial load sufficient to ensure safety with the equal intensity of loading which occurs during the placing of the earth cover should be allowed for in designing roofs. The engineer should specify a loading under these temporary conditions, which should not be exceeded. In designing the roof, allowance should be made for the temporary condition of some spans loaded and other spans unloaded. even though in the final state the load may be small and evenly distributed.

6.3. *Water-tightness.*—In case of tanks intended for the storage of water for domestic purposes, the roof must be made water-tight. This may be achieved by limiting the stresses as for the rest of the tank or by the use of the covering of water proof membrane of by providing slopes to ensure adequate drainage.

6.4. Protection against corrosion: Protective measures shall be provided to the under side of the roof to prevent it from corrosion due to condensation.

7. *Detailing.*

7.1. *Minimum Reinforcement.*

7.1.1. The minimum reinforcement in walls, floors and roofs in each of two directions at right angles shall have an area of 0·3 percent of the concrete section in that direction for sections upto 100 mm. thick. For sections of thickness greater than 100 mm. and less than 450 mm. the minimum reinforcement in each of the two directions shall be linearly reduced from 0·3 per cent for 100 mm. thick section to 0·2 percent for 450 mm. thick section. For sections of thickness greater than 450 mm. minimum reinforcement in each of the two directions shall be kept at 0·2 per cent. In concrete sections of thickness 225 mm. or greater, two layers of reinforcing steel shall be placed one near each face of the section to make up, the minimum reinforcement specified in this clause.

7.1.2. In special circumstances (*see* 4.2) floor slabs may be constructed with percentage of reinforcement less than that specified above. In no case the percentage of reinforcement in any member shall be less than that specified in I.S. 456-1964.*

7.2. *Minimum cover to reinforcement.*

7.2.1. For liquid faces of parts of members either in contact with the liquid or enclosing the space above the liquid (such as inner faces of roof slab), the minimum cover to all reinforcement should be 25 mm. or the diameter of the main bar, whichever is greater. In the presence of sea water and soils and water of corrosive character the cover should be increased by 12 mm. but this additional cover shall not be taken into account for design calculations.

7.2.2 For faces away from the liquid and for parts of the structure neither in contact with the liquid on any face no enclosing the space above the liquid, the cover shall conform t the requirements of I.S. 456—1964.*

7.3. *Size of Bars, Distance between Bars, Laps and Bends:*—Details regarding reinforcement such as size of bars, distance between bars, laps and bends in bars, and finding of bars shall comply with the provisions of I.S. 456—1964* and I.S. 2502—1963.

7.3.1. *Bends in Bars.*—In bends in reinforcing bars, the local stresses on concrete may be increased to three times the value permitted in 3-3-2 for concrete in direct compression.

7.3.2. *Laps in Bars.*—Bars should be lapped only when such practice is unavoidable. Where laps are used they should be designed in accordance with the relevant requirements of I.S. 456—1964.*

*Code of practice for plain and reinforced concrete (second verision)

EXTRACT FROM I.S. 1346–1966.

Code of practice for water proofing of roofs with bitumen felts

(First Revision.)

1. *Scope.*

1.1. This standard deals with the methods of application of bitumen felts to roofs of buildings designed to render them waterproof.

2. *Terminology.*

2.0. For the purpose of this standard, the following definition shall apply.

2.1. *Bonding material.*—Bitumen adhesives employed to stick the first layer of roofing felt to the roof surface (or to the underlay when used) or one layer of roofing felt to another and as a top dressing.

2.2. *Layer.*— A single thickness of bitumen felt or bitumen.

2.3. *Multiple layer.*—Two or more layers of bitumen felt laid with overlapping joints and bonded together with bitumen.

2.4. *Bitumen primer.*—A liqud bitumen of low viscosity which penetrates into a prepared surface upon application.

2.5. *Underlay.*— A layer of bitumen—saturated felt sometimes used additionally between the roof surface and the first layer of self-finished bitumen felt when the waterproofing treatment is to be isolated from the roof structure.

4. *Materials.*

4.1. *Materials for regarding of roof surface.*—Regrading shall be carried out with a suitable cement mortar incorporating a clean, medium coarse and or with a lime *SURKHI* mortar or any other suitable material.

4.2. *Bitumen Primer.*—Primer shall conform to the requirements laid down in I.S. 3384-1965.

4.3. *Bitumen felts.*—These shall comply with the requirements laid down in I.S. 1322-1965.

4.4. *Bonding materials.*— These shall consist of blown type bitumen conforming to I.S. 702-1961 or residual bitumen conforming to I.S. 73-1961 or a mixture thereof, selected to withstand local conditions of prevailing temperature and gradient of roof surface. The penetration of bitumen shall not be more than 40 when tested in accordance with I.S. 1203-1958.

4.5. *Nails.*—The nails for fixing roofing felts, with round extra large head with a diameter of 11mm and overall length of 20 mm shall be galvanized and shall conform to I. S. 723-1961.

5. *Water proofing treatment*:

5.1. In selecting the combinations of layers and grades of felt to be used, consideration shall be given to the type and construction of buildings, climatic and stmospheric conditions and the degree of permanence required.

5.2. *Concrete and masonry roofs, flat or sloping.*—The following treatments are recommended :

(*a*) *Normal treatment*: Four courses for moderate condition; Primer conforming to I.S. 3384—1965 to be applied to the roof surface:

(1) Hot applied bitumen at the rate of 1.2kg./m² min ;

(2) Hessian-base self-finished felt, type 3, grade 1 ;

(3) Hot applied bitumen at the rate of 1.2 kg/m², Min ; and.

(4) Pea-sized gravel or grit at the rate of 0.006 m³/m².

OR

Floting treatment :

(1) Fibre base bitumen saturated underlay, type 1 ;

(2) Hot applied bitumen at the rate of 1.2 kg./m², Min ;

(3) Fibre base self finished felt, type 2, Grade I or Grade 2 ;

(4) Hot applied bitumen at the rate of 1.2 kg/m² ; and

(5) Pea-sized gravel or grit at the rate of 0.008 m³/m².

(*b*) *Heavy treatment.*—Six courses for severe conditions ; Pimer conforming to I.S. 3384—1965 to be applied to the roof surface:

(1) Hot applied bitumen at the rate of 1.2. kg/m², Min ;

(2 Hessian-base self-finished felt, type 3, grade, 1 ;

(3) Hot applied bitumen at the rate of 1.2 kg/m², Min ;

(4) Hessian -base self-finished felt, type 3, Grade 1 ;

(5) Hot applied bitumen at the rate of 1.2 kg/m², Min ; and

(6) Pea sized gravel or grit at the rate of 0.006 m³/m².

OR

(1) Hot applied bitumen at the rate of 1.2 kg/m² Min ;

(2) Fibre-base self-finished felt, type 2, Grade 1 or grade 2.

(3) Hot applied bitumen at the rate of 1.2 kg/m² Min ;

(4) Fibre-base self-finished felt, type 2 Grade 1, or grade 2 ;

(5) Hot applied bitumen at the rate of 2.5 kg/m², Min; and

(6) Pea-sized gravel or grit at the rate of 0.008 m³/m².

Floating treatment—

(1) Fibre-base bitumen saturated underlay, type 1 ;

(2) Hot applied bitumen at the rate of 1.2. kg./m², Min ;

(3) Fibre-base self-finished felt, type 2, grade 1 or grade 2 ;

(4) Hot applied bitumen at the rate of 1.2 kg./m², Min ;

(5) Fibre-base self-finished felt, type 2, grade 1 or grade 2 ;

(6) Hot applied bitumen at the rate of 2.5 kg./m², Min. and

(7) Pea-sized grvel or girt at the rate of 0·008 m³/m².

(*c*) *Extra. heavy treatment* : Eight courses for very severe conditions ; Primer conforming to I.S. 3384-1965* to be applied to the roof surface ;

(1) Hot applied biutmen at the rate of 1.2 kg./m², Min.

(2) Hessian—base self-finsihed felt, type 3, grade 1 ;

(3) Hot applied bitumen at the rate of 1.2. kg./m², Min. ;

(4) Hessian-base self-finsihed felt, type 3, grade 1 ;

(5) Hot applied bitumen at the rate of 1.2. kg./m² Min ;

(6) Hessian-base self-finsihed felt, type 3, grade 1 ;

(7) Hot applied bitumen at the rate of 1.2. kg./m², Min.; and

(8) Pea sized gravel or grit at the rate of 0·006 m³/m².

OR

(1) Hot applied bitumen at the rate of 1.2. kg. / m², Min ;

(2) Fibre-base self-finished felt, type 2 grade 1 or grade 2;

(3) Hot applied bitumen at the rate of 1.2. kg./m², Min ;

(4) Fibre-base self-finished felt, type 2, grade 1 or grade 2 ;

(5) Hot applied bitumen at the rate of 1.2. kg./m², Min ;

(6) Fibre-base self-finished felt, type 2, grade 1 or grade 2.

(7) Hot applied bitumen at the rate of 2.5 kg./m², Min ; and

(8) Pea-sized gravel or grit at the rate of 0·008 m³/m².

NOTE (1).—The types and grades of felts refer to these given in I.S. 1322-1965.

NOTE (2).—Where pea-sized gravel or girt are not available, coarse may be used.

6.2.1.3. The felt shall be first cut to required lengths, brushed clean of dusting materials and laid out flat on the roof. This serves to eliminate curls and subsequent stretching. Each length of felt prepared for laying as described above shall be laid in position and rolled up for a distance of half of its length. The hot bonding material shall be poured on to the roof across the full width of the rolled felt as the latter is steadily rolled out and pressed down. The excess bonding material is squeezed out at the ends and is removed as the laying proceeds.

6.2.1.4. When the first half of the strip of felt has been bonded to the roof, the other half shall be rolled up and then unrolled on to the hot bonding material in the same way.

6.2.1.5. Miniumm overalps of 100 and 75 mm. shall be allowed at the end and the sides of strips of felt. All overlaps shall be firmly bonded with hot bitumen.

6.2.1.6. The laying of the second layer of felt shall be so arranged that the joints are staggered with those of the layer beneath it.

6.2.1.7. In case of pent roofs where the type of treatment consists of one layer of felt only, in normal treatment (*see* Fig. 5.2.), an additional layer of felt shall be provided at the ridge which shall cover a minimum length of the slope of 250 mm. on both sides of the ridge.

6.2.2. *Flashings.*—Felt shall be laid as flashings in widths wherever junctions of vertical and horizontal structures occur with minimum overlap of 100 mm. The lower edge of flashing shall overlap the felt laid on flat portion of the roof and the upper edge of the flashing shall be tucked into the groove made in the parapet on the vertical face of the wall. Each layer shall be so arranged that the joints are staggered with those of the layer beneath it.

6.2.2.1. After all the layers specified have been laid and the flashings properly bonded, the groove shall be filled up with cement mortar or cement concrete which when set will satisfactrily secure the treatment to the wall. The groove filling shall be cured by watering for at least 4 days after filling to ensure satisfactory strength and to avoid shrinkage cracks.

6.2.3. *Drain mouths.*—Drain mouths shall be widened and other items of worth completed. Felt shall be generally laid as on the other portion of the roof excepting that the treatment shall be carried inside the drain pipes overlapping at least 100 mm.

6.2.4. *Gutters.*—The treatment to be laid in the gutters shall provide for one layer of roofing felt more than is provided on the roof proper. Hence at least two layers of felt shall be laid in the gutters even when only one layer of felt has been specified for the roof as in normal treatment (*see* 5.2.) A priming coat shall first be applied. Over this, the first layer of felt shall be bonded with hot bitumen followed by successive layers of felt securely bonded together and finally painted with a coat of hot bitumen at not less than 1.5. kg./m².

6.2.4.1. The felt layers laid separately in the gutters shall be overlapped with the corresponding layers on the roof proper.

6.2.4.2. The felt treatment in the gutters shall be carried down into the outlet pipes to a minimum depth of 100 mm. Where there are walls, grooves shall be cut out at a reasonable height and the felt tucked in the groove which shall then be filled in with cement mortar.

6.2.4.3. For gutters in pent roofs, the flashings shall be laid separately at the sides and carried well under the caves of the pent roofs.

6.4. *Shell roofs*:

6.4.1. In the case of shell roofs, an additional layer of felt shall be provided for the valley gutter for normal treatment and for other types of treatment, the number of felts in the valley gutters shall be one layer extra. The treatment on the valley gutter shall be laid first and the height to which the felt is to be taken shall be at least 150 mm. above the anticipated standing water in the gutter. For normal treatment on pent roofs or shell roofs ; the felt shall be laid parallel to the direction of the run off gradient. The felts in case of shell roofs shall be laid from one edge of the valley gutter to the other, that is, round the curvature. In the case of northlight cylindrical shells, it can either start from the valley gutter or from the upper edge. The upper edge shall be securely anchored at the edge of the shell.

NOTE.—Where insulation has been specified, the insulating material shall be applied on the top of the shell surface and plastered, if necessary, with cement mortar to provide adequate base for application of the waterproofing treatment.

6.4.2. *Surface finishing*.—Instead of the normal bituminous grave finish the surface may be finished as follows :—

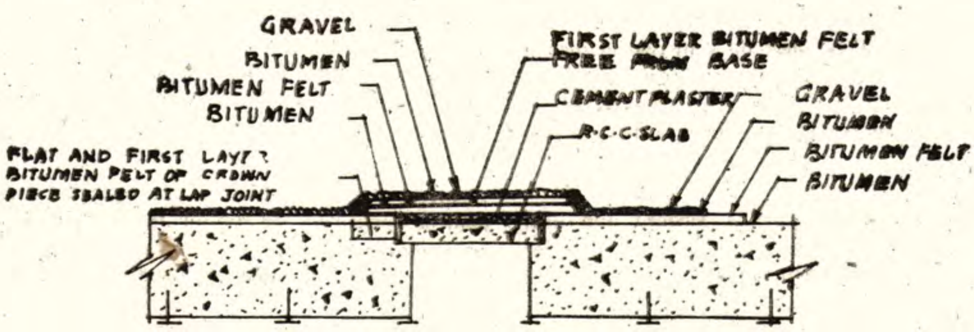
(*a*) With two coats of bituminous aluminum paint, or

(*b*) One layer of aluminium foil struck with hot bitumen, or

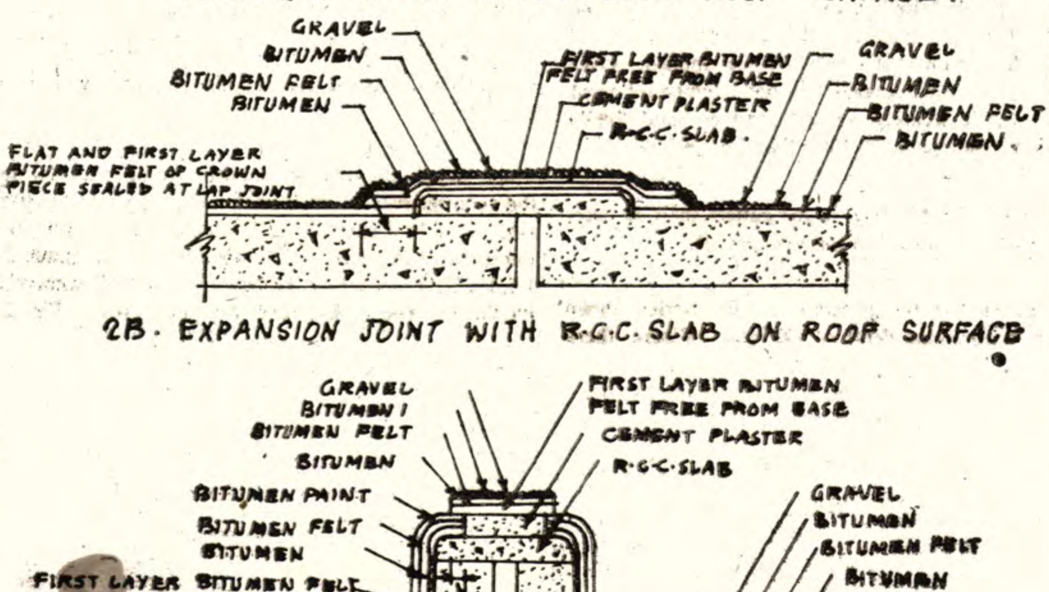
(*c*) One layer of cold applied bitumen with gravel or coarse sand.

6.5. *Expansion joints.*—Expansion joints shall be designed to suit the requirements of each roof. Expansion joint coverings may be zinc or of lead sheet or of bitumen felt. In case of the latter, a minimum of two layers of bitumen felt, type 2, grade 2 as specified in I.S. 1322-1965 shall be used with a top dressing gravel or other suitable finish. The typical cases are illustrated in Fig. 2.

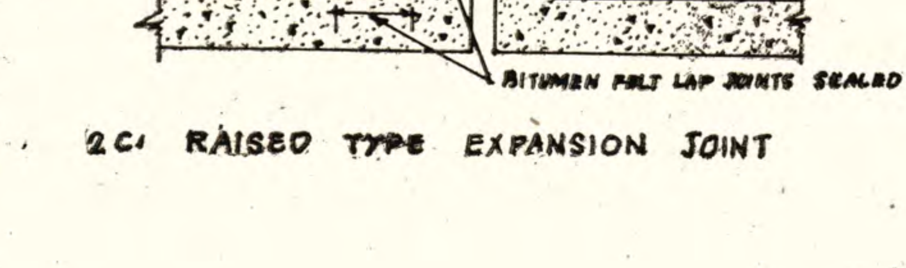
FIG. 2. EXPANSION JOINTS



2.A. EXPANSION JOINT WITH TEE IRON TILE AND TERRACE CONSTRUCTION IN LEVEL WITH ROOF SURFACE.



2B. EXPANSION JOINT WITH R.C.C. SLAB ON ROOF SURFACE



2C. RAISED TYPE EXPANSION JOINT

6.6. *Treatment of bubble formation*.—If ballooning occurs which does not in fact adversely affect the efficiency of the water-proofing treatment but is unsightly to look at, the defect may be rectified as given in 6.6.1.

6.6.1. Remove the gravel on the ballooned surface. Then cut open and squeeze out the trapped vapour by firm pressure applied by hand. Seal the bitumen felt so lifted, back on the surface by applying additional bitumen. Finally seal the cut with a piece of bitumen felt with bitumen application and reapply the gravel finish over it to make the surface look uniform with the rest.

7. *Inspection and maintenance*:

7.1. It is recommended that arrangements should be made for a detailed inspection of the water proofing treatment periodically preferably prior to the advent of the rainy season, with a view to repairing any apparent defects and to ensure complete water-proofing

EXTRACT FROM I.S. 4365-1967.

Code of practice for application of bitumen mastic for waterproofing of roofs.

1. *Scope.*

1.1. This standard lays down the procedure for applying bitumen mastic for water-proofing of roofs and its maintenance.

2. *Materials*:

2.1. *Bitumen mastic*.—This shall conform to I.S. 3037-1965.

2.2. *Bonding materials*—These shall consist of blow type bitumen conforming to I.S. 702-1961 or residual bitumen conforming to I.S. 73-1961 or a mixture thereof, selected to withstand local conditions of prevailing temperature and gradient of roof surface. The penetration of blown type bitumen shall be limited to 45 when tested in accordance with I.S. 1203-1958.

2.3. *Reinforcement*—Bitumen coated plain expanded metal lathing used for laying bitumen mastic to vertical or sloping surfaces.

2.4. *Underlay or isolating membrance*.—A layer of bitumen felt conforming to I.S. 1322-1965]

2.5. *Vapour barrier*.—The vapour barrier should consist of hessian based type 3 felt conforming to I.S. 1322-1965 with minimum overlaps of 100 and 75 mm. at the end and the sides of strips of felt This is used, where necessary as an isolating layer between the roof deck and the insulating materials to protect the insulation against the absorption and the effects of moisture from below.

3.3.1. All work above roof level should be completed befo bitumen mastic is laid. If work has to be carried out on or above the bitumen mastic after laying, provision shall be made for complete protection of the bitumen mastic by the main contractor.

4. *Design considerations*:

4.1. The primary function of bitumen mastic is to provide a water-proof covering to a roof. The different considerations given in 4.2. to 4.10 should be taken into account for the effectiveness of the water-proofing treatment.

4.2. *Weather resistance*.—The weather resistance of bitumen mastic as a roof covering depends on the following :—

(*a*) The design, condition and strength of the base including its suitability and the nature of surface to receive mastic roofing and

(*b*) The technique of laying and workmanship.

4.3. *Base to receive asphalt*. —The base shall be strong enough to carry its own weight, the weight of the covering, insulation materials, and any addtional surface finishes together with live load and wind load. the designer should study the needs for movement joints in the structure and it is essential that these be located at each part of the change of direction of the roof deck. The movement joints should be continuous through vertical upstands, walls and edges of buildings.

4.3.1. *Preparation of surface*.—The surface on which bitumen mastic is to be laid shall be true, plane and even, free from ridges, hollows and indentations. Where bitumen mastic is to be keyed to a surface the screed should be designed to remain free from cracks.

4·3.2. *Slopes to flat surface*.—Bitumen mastic shall be laid to an even thickness on flat surfaces. The slopes shall be previded in the base on which the roof covering is to be laid. To ensure adequate drainage, the slopes shall be formed to even gradients of not less than 1 in 60.

4.3.1.2. For concrete, hollow tile, precast hollow beam of similar construction with an irregular surface, all slopes except when provided as part of the structure shall be formed of a screeding which shall be floated to a plane, even surface free from ridges and indentations. Drainage holes shall be provided to prevent any water being trapped in the cavities of the hollow tiles or beams or in the substructure.

4.3.2.2. When the base of the roof is formed in timber the slopes may be formed by sloping the joints.

Isolating membrane or underlay.—On all flat roofs, it is essential that direct contact between the base and the bitumen mastic roofting is avoided by interposing an isolating membrane which shall be laid loose on a concrete roof and shall be nailed down on a timber roof with not less than 100 mm and 75 mm lapped joints at the ends and the sides respectively.

4.4.1. On vertical and steeply sloping timber surfaces (slope greater than 30°) an isolating memberane shall be interposed between the timber base and the bitumen mastic. The isolating membrane shall be fixed with galvanized round extra large heads nails with a diameter of 11 mm and overall length of 20 mm conforming to I.S. 723–1961 at not more than 150 mm centres.

4.5. *Thermal insulation.*—Where it is necessary to preevent fluctuation of temperature inside a building to conserve heat or to prevent an increase in temperature through the roof structure, additional thermal insulation is obtainable by placing a layer of insulating materials immediately below the bitumen mastic roofing. A vapour barrier as shown in Fig. 1 shall be laid between the base and the insulation layer.

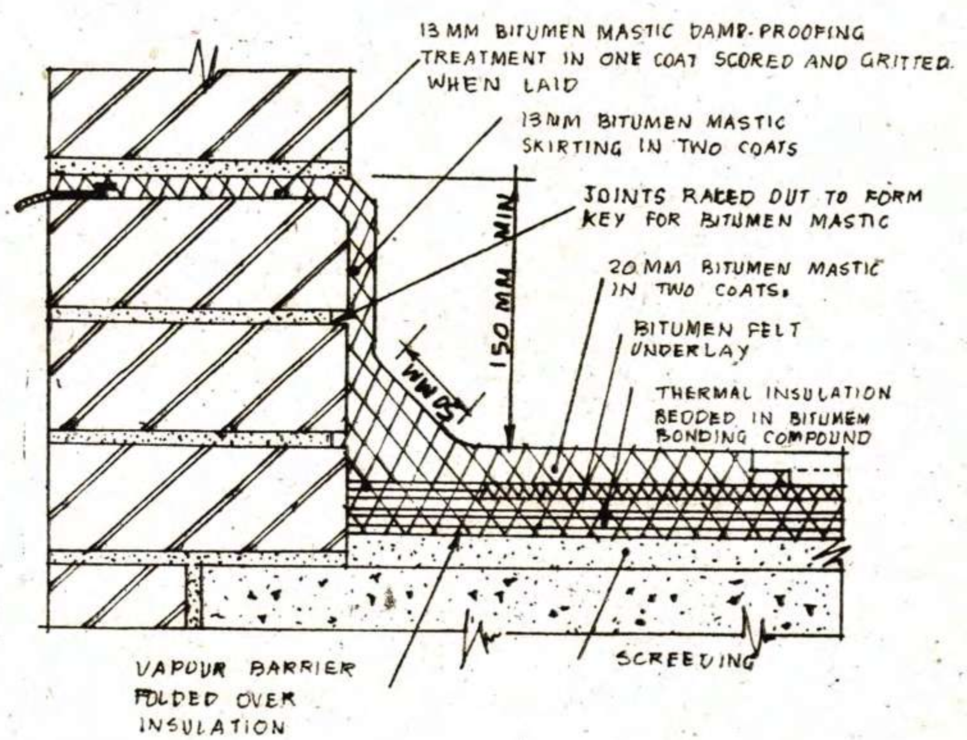


FIG. 1. BITUMEN MASTIC LAID ON THERMAL INSULATING MATERIAL

4.6· *Keying.*—Bitumen mastic will not adhere satisfactorily to vertical and steeply sloping surfaces unless such surfaces afford an adequate key. The following preparations shall be provided.

4.6.1. When bitumen mastic is applied to vertical surfaces including skirtings and upstands against brick work, stone or concrete, the top of the bitumen mastic shall be tucked into a continuous groove of not less than 25 x 25 mm formed in the structure and its exposed part shall be formed with a splay shed rain water.

4.6.2. *Brick work.*—Horizontal joints in the brickwork shal not be less than 10 mm wide, the motar shall be raked out and brushed clean to form a key to the bitumen mastic (see Fig. 2) When bricks have an extremely smooth face, an additional key shall be provided by hacking or similar treatment.

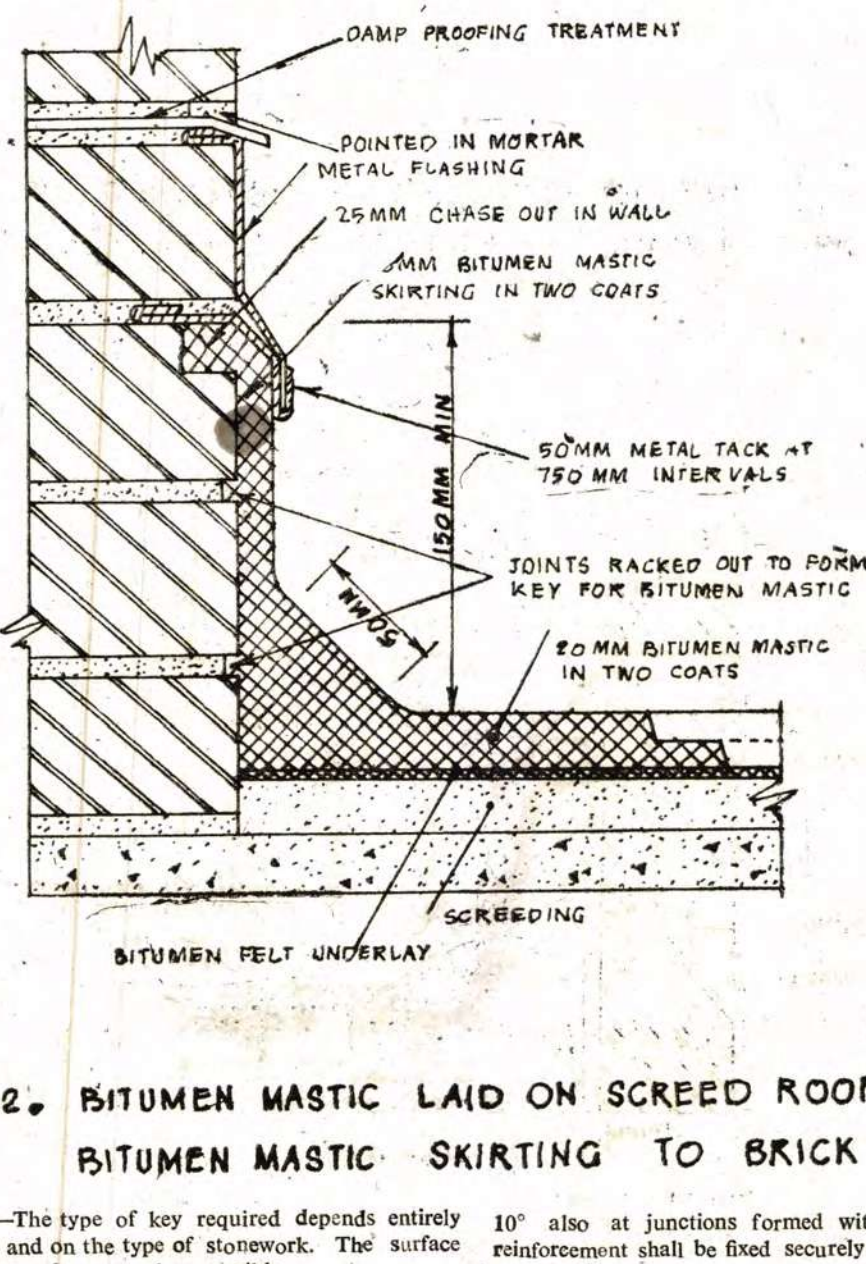


FIG 2. BITUMEN MASTIC LAID ON SCREED ROOF AND BITUMEN MASTIC SKIRTING TO BRICK WALL

4.6.3. *Stone work.*—The type of key required depends entirely on the kind of stone and on the type of stonework. The surface of the stone shall always be as rough as possible.

4.6.4. *Concrete.*—All vertical concrete surfaces and those with a slope greater than 30° shall be provided with continuous grooves 25 x 25 mm at approximately 600 mm centres and the surface of the areas between the grooves shall be hacked, if found smooth (*See* Fig 3) The screeding to sloping surfaces greater than 30° and vertical surfaces shall be formed with continuous grooves 25 x 25 mm at about 600 mm centres and the surface areas between the lines of grooves must be finished with a wooden float and then lightly scored in a horizontal direction.

4.6,5. *Timber.*—To provide an adequate key for bitumen mastic aid on vertical timber surfaces and those of slope greater than 10° also at junctions formed with such surfaces. a layer reinforcement shall be fixed securely by means of nails.

4.6.6. *Metal.*—All metal surfaces shall be primed with a rubbe bitumen emulsion before the bitumen mastic is applied.

4.6.7. *Other types of surfaces.*—Surfaces which are glazed shall be cleaned and hacked- Surface coatings, such as paint, distemper or lime was shall be removed and the base so exposed shall be hacked and wire burshed.

4.7. *Timber construction.*—When roofing is to be laid on timber boarding, the boards shall be well seasoned of not less than 25 mm nominal thickness and well and closely clamped together with nailed, tongued and grooved joints, or closely butter if plain edges; arris e to opon edges should be rounded. The whole structure should be rigid. The construction shall minimize the effects of shrinkage warping and displacement or relative movement of the timber and care should be taken to guard against any conditions which might allow decay, partly through the moisture already present in timber or resulting from the ingress of water from other parts of the structure. To avoid fungal attack, ventilation shall be provided between the roof boarding and the ceilling. Adjacent to vertical walls a free-standing wooden kerb shall be securely nailed to the roof deck and fixed so as to leave and air space between the wall and the base (*see* Fig. 4). The timber base shall be protected from rain water during construction. Before the under lay or the bitumen mastic is laid, any timber affected by dampness shall be allowed to dry. Therefore, the fixing of ceiling should be delayed as long as possible.

BITUMEN MASTIC LAID. ON TIMBER ROOF AND BITUMEN MASTIC SKIRTING ON FREE-STANDING KERB

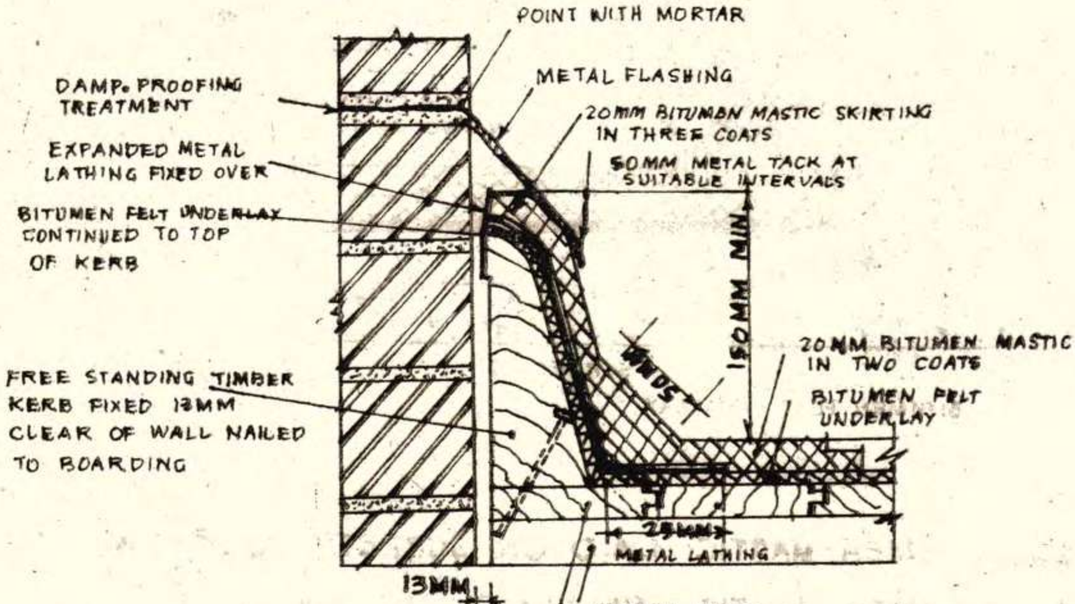


FIG. 4

4.8. *Number of coats and thickness.*—The number of coats for a particular position and for a given total thickness depends in each coat on the maximum thickness of bitumen mastic that is possible to apply while the material is in a warm plastic state. The requirements are as laid down in 4.8.1. to 4.8.5.

4.8.1. On horizontal surfaces and on slopes up to 300, but excluding horizontal damp-proof treatment in walls, two coats of equal thickness to a total thickness of not less than 20 mm shall be applied.

4.8.2. On a horizontal roof subject to foot traffic, such as a terrace or balcony, two coats of bitumen mastic shall be applied. The first coat shall be minimum 10 mm thick and the second coat minimum 15 mm thick.

4.8.3. On vertical surfaces other than timber including skiritings upstands and drips and on slopes over 30°, either two coats to a total thickness of not less than 13 mm or three coats to a total of not less than 20 mm shall be applied.

4.8.4. On slopes and on vertical surfaces of timber three coats of bitumen mastic shall be applied to the reinforcement to a total thickness of not less than 20 mm.

4.8.5. At the intersection of the two planes forming an internal angle and after the bitumen mastic has been laid on horizontal sloping and vertical surfaces, a solid angle fillet of bitumen mastic, not less than 50 mm wide on its face, shall be formed in two-coat work. (*See* Fig. 3).

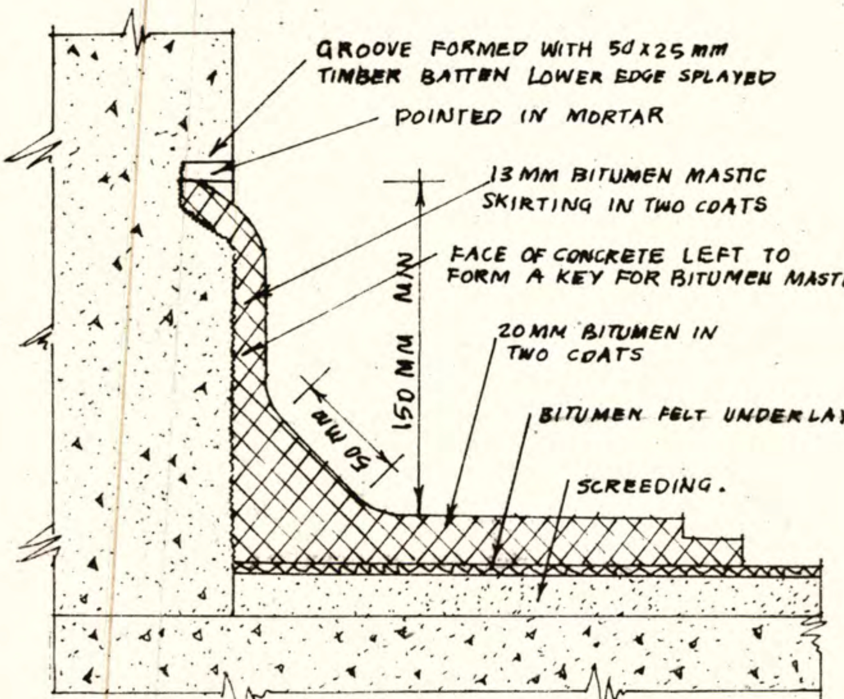


FIG. 3. BITUMEN MASTIC LAID ON SCREEDED ROOF AND BITUMEN MASTIC SKIRTING TO CONCRETE WALL

466-3—28

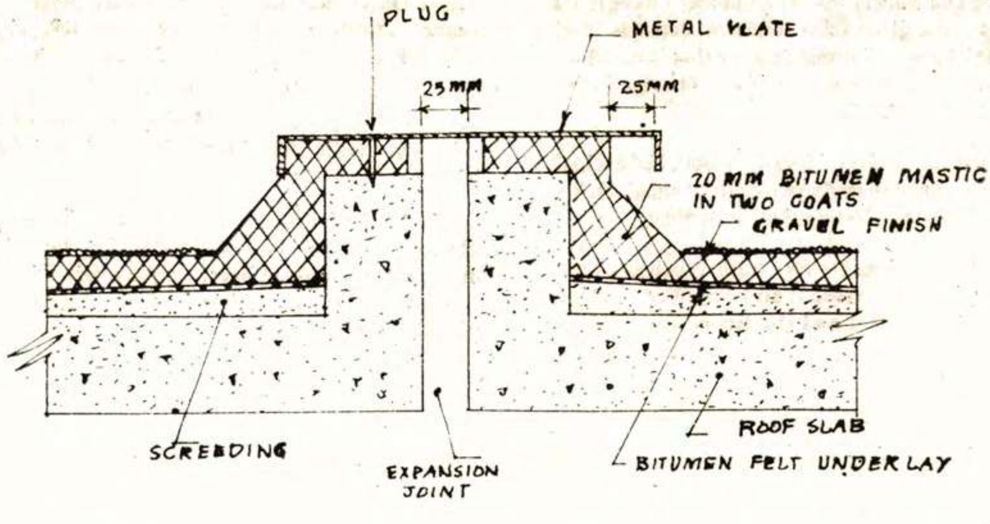


FIG. 5. EXPANSION JOINT IN FLAT ROOF
TWIN KERB TYPE

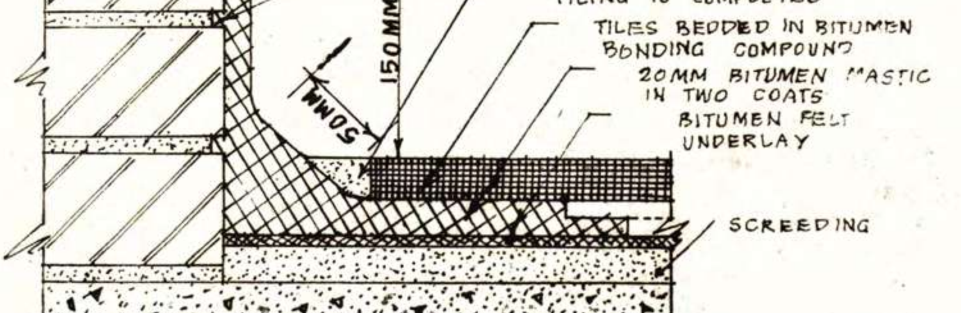


FIG. 6 - BITUMEN MASTIC LAID ON SCREEDED ROOF AND FINISHED WITH TILES

4.9. *Movement joints.*—Where it is considered necessary to provide movement joints in the roof structure, these should be of the twink kerb type with a suitable metal capping (*See* Fig. 5).

4.10. *Solar reflectivity.*—The absorption of solar heat may be substantially reduced by embedding light coloured mineral aggregate in bitumen dressing compound. The finished bitumen mastic roofing may also be covered with light coloured cement concrete titles or with a sand and cement screed out into paving squares (*see* Fig. 6).

5. *Methods of laying and workmanship.*—

5.1. *Protection and storage of materials.*—The mechanical mixer shall be as near as possible to the place where the bitumen mastic is to be laid,so as to avoid cooling of the material during the conveyance. The blocks of bitumen mastic and other materials required shall also be placed as near as possible to the area of roof to be treated.

5.1.1. Dry storage shall be provided for materials such as felt underlays, thermal insulating material, metal lathing, gauges and metal edgings. Normally the mechanical mixer and the blocks of mastic need no such protection. Bitumen mastic shall be delivered to the site either in the form of blocks for remelting in a mechanical mixer or in a molten condition delivered in a mobile mechanical mixer.

5.2. *Precautionary measures before laying.*—The operator shall not start laying the bitumen mastic until all preliminary work including laying of the underlay has been completed. The laying of bitumen mastic shall not be commenced until the surface of the base is sufficiently set to withstand. without damage, the traffic involved in laying operations. All other works which are liable to damage the bitumen mastic shall have been completed. When this is not possible, adequate protection of the bitumen mastic against damage shall be arranged prior to and during the course of subsequent building operations. For example, special care is necessary to avoid damage to the surface of the bitumen mastic laid on the roof by careless handling of scaffolding and other builder's accessories, by mixing or depositing cement and mortar upon its surfaces, by the storing of heavy material of any kind on the bitumen mastic surface Paint, distemper and solvents, even in small quantities, shall not be allowed to drop on the bitumen mastic. The following shall be ensured before actual laying of the mastte.

(*a*) The provision of scaffolding and hoisting facilities for the materials and plant ;

(*b*) The preparation of various surfaces of the base, including the provision of an adequate key to any veritical and steeply sloping surface, also protection of the surfaces of the base from the weather immediately prior to the laying of the bitumen mastic : and

(*c*) The fixing of all metal work. such as flashings drips and outlets.

5.3. *Setting out the work.*—The operator shall examine and check the gradients, the direction of the slopes and the condition of the surface on which the bitumen mastic is to be laid. The design of the roof and the number of operatives engaged determine the setting out and the size of the bays. The dimensions of each bay shall be such that easy control by the operator is ensured during the process of laying and rubbing.

5.4. *Remelting.*—Remelting shall be carried out at the site of works in a mechanical mixer. The type of remelting plant selected for use shall be governed by the site conditions and the area of the roof to be covered, Blocks of bitumen mastic conforming to I.S. 3037-1965 shall be sent to the site, broken to pieces and then staked in layesr, first round the sizes of the mixer and then inwards towards the centre. The charge in the mechanical mixer shall be gradually heated to about 200°C and when the bitumen mastic has attained a molten condition, it shall be agitated continuously to ensure a uniform consistency. Any course aggregate required shall then be added to the hot bitumen mastic until the consistency is uniform At no time during remelting shall the temperature of the bitumen mastic exceed 200° C. Whether the bitumen mastic is transferrd to the site in a molten condition or remelted on the site, the total duration of heating and the type of plant used shall be such that the properties of the bitumen mastic shall not be impaired. When the bitumen mastic is in a sufficiently molten state to be workable buckets shall be used for transporting the material, in small quantities from the mechanical mixer. The inside of the bucket shall be coated with a fine, inert dust. Ashes or oil shall not be used for this propose

5.5. *Technique of laying*—

5.5.1. *Spreading.*—(a) Each coat of ecah bay shall be spread and uniformly by means of a float to the recommended thickness, on to the previoulsy prepared surface, the isolating membrane or the preceding coat.

(b) Each coat of bitumen mastic shall be followed without delay by the succeeding coat, since exposure to contamination, for example by dust or dirt, might impair adhesion and cause blistering.

(c) The junction between two contiguous days of a coat of bitumne mastic shall not be less than 150 mm from corresponding junction in preceding coat.

(d) When bitumen mastic is laid horizontally, timber gauges o specified thickness shall be used during the laying of each coat.

(e) When bitumen mastic is laid on vertical or steeply sloping surfaces, the first coat is essentially an adhesive layer which acts as a base to ensure complete bonding of subsequent coats.

Any ' blows ' shall be pierced and the affected area be carefully made good while the bitumen mastic is still warm.

5.5.2. *Surface finish.*—Immediately after the completion of laying the required number of coats and while the bitumen mastic is still warm, horizontal surfaces and slight slopes shall be well rubbed with a wood float, using clean sharp sand passing 850 micron I.S. Sieve and retained on 300 micorn I.S. Sieve (See I.S. 460-1962). Special attention should be given to the junction between bays. When rubbing, care shall be taken to aviod sand spreading over exposed edges of a bay. If this occurs the edges shall be brushed clean before the next bay of bitmen mastic is laid.

5.5.3. *Final Finish.*—(*a*) To avoid absorbtion of solar heat, light coloured mineral aggregated or pea-size gravel may be evenly spread shoulder to shoulder over the entire surface. The aggregate shall be struck to the top surface with bituminous bonding materais.

(*b*) The bitumen mastic top may also be paved with cement concrete flooring tiles conforming to I.S. 1237-1959. The concrete tile finish is recommended where the roof surface is subjected to continuous foot traffic. The bitumen primer conforming to I.S. 3384-1965 shall be applied to the surface of the bitumen mastic flat roofing and allowed to dry. The concrete tiles shall be fixed to the primed surface of the bitumen mastic by pouring out from a can just sufficient quantity of hot bituminous bonding material. Care should be taken not to squeeze up the bituminous compund between the tiles, any compound is squeezed up, it should be allowed to get cold before removing from the surface of the tile. A space 75 mm. wide should be left at the angle fillet of all upstands and perimeter walls and an open joint 25 mm wide shall be formed at approximately 9 m^2 of the area laid and be subsequently filled with hot bitumen bonding material.

(c) Where decorative finish is necessary aluminum paint free from material deleterious to bitumen mastic or any other coloured bitumen emulsion paint may be used.

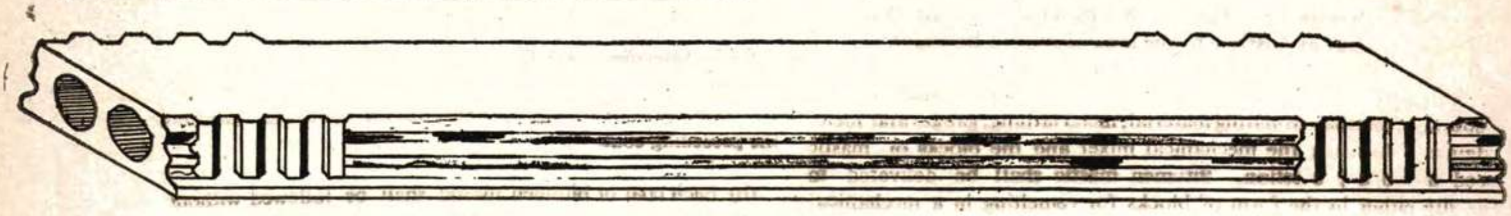
5.5.4. *Protection of surface.*—(a) The treatment laid should not be put into service until the bitumen mastic has cooled to the prevailin atmospheric temperature.

(b) Care shall be taken to aviod damage to the surface due to careless handling of builder·s tools.

EXTRACT FROM C.B.R.I.

Data Sheet No. 3.

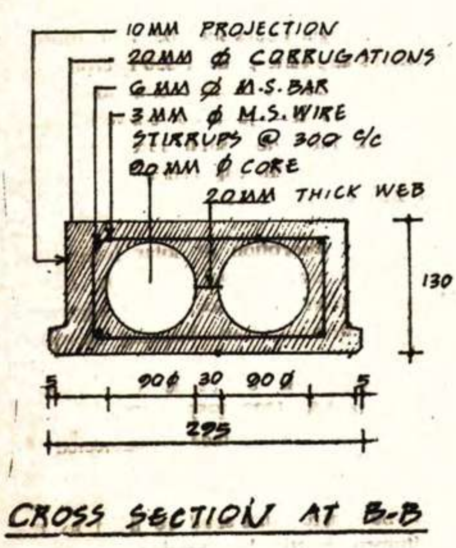
CORED UNIT FOR ROOF/FLOOR



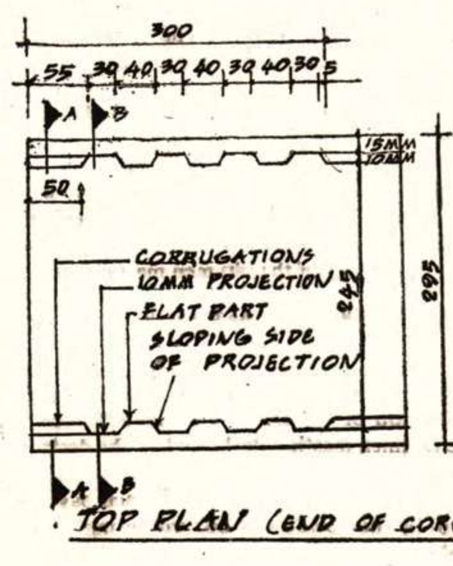
The unit is a precast R.C.C. structural component having two circular cores throughout its length (Fig.). The unit is structurally complete by itself and does not require any type of temporary support or propping during construction. It provides a flush ceiling. It can be used for floors and roofs in load bearing wall and framed structures· No deck concrete is required in this scheme.

Shape and Size :

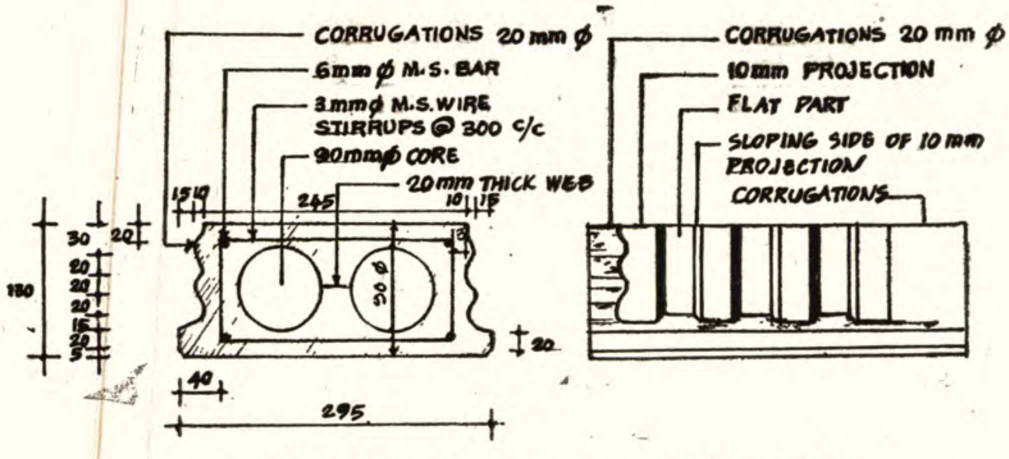
The nominal width of the unit is kept as 300 mm. with the actual width as 295 mm. Though the depth (thickness) of the unit will depend upon the spanand loading conditions, a depth of 130 mm. can be taken for normal situations. The weight of such a unit will be 46 kg. per running metre· These unit can be easily handled manually If mechanical handling facilities are available, units having nominal widths of 600 mm and 900 mm can be used. The minimum flange web thickness of the unit is kept as 20mm. The top and bottom of the units are flush while the side are corrugated with some distance towards the ends grooved as shown in Figs. The corrugations on the sides of the units, when filled with insitu concrete develop monolithicity and help in transferring the loads transversely and also provide space for negative reinforcement over supports. The units are suitable for spans 2·5 to 4·2· metres.



CROSS SECTION AT B-B



TOP PLAN (END OF CORED UNIT)



CROSS SECTION AT A-A

ELEVATION
(END OF CORED UNIT)

Structural DesIgn :

The cored unit may be designed either by working stress or ultimate load method. Depending upon the end condition of the unit, it may be designed as simply supported or continuous. The units are designed for the following two stages of loading :

(i) *Stage I-Loading*.—The unit shall be checked for handling stresses considering the permissible stress in concrete at the time of handling.

At the time of laying the units, the load comprises of self-weight of the unit and the weight of concrete in joints between two units and incidental live load of about 75 kg/m^2.

The unit shall be able to with stand this loading as simply supported beam.

(ii) *Stage II- Loading*.—Full load acting on the unit under the appropriate end conditions i.e., simply supported or continuous.

When the floor/roof is of three or more continuous bays of approximately equal span, in absence of exact calulations, the following values may be taken for bending moments and shear forces for the two stages of loading.

For first stage of loading :

1. B.M. at midspan$=(W_c+W_i)\times L^2/8$.

$S.F.=(W_c+W_i)\times 0.5\ L$.

Where, W_e=Dead weight of the unit including the in-situ concrete in joints between units for nominal width of one pre cast unit, uniformly distributed.

W_i=Incidental live load for one cored unit, uniformly distributed.

L=Effective span.

For the final stage of loading :

2. B.M. in the middle of interior span.

$$=\left(\frac{W_o}{8}+\frac{W_l}{12}+\frac{W_d}{24}\right)L^2$$

3. B.M. in the middle of end span.

$$=\left(\frac{W_o}{8}+\frac{W_l}{10}+\frac{W_d}{12}\right)L^2$$

4. B.M. at support next to end support.

$$=\left(\frac{W_d}{10}+\frac{W_l}{9}\right)L^2$$

5. B. M. at any other interior support.

$$=\left(\frac{W_d}{12}+\frac{W_l}{9}\right)L^2$$

$SF.=(0\cdot5\ W_o+0\cdot5\ W_l+0\cdot6W_d)\ L$

Where, W_d=Dead load due to flooring/roofing treatment etc. for nominal width of one cored unit, uniformly distributed.

W_l.—Super-imposed live load for nominal width of one cored unit, uniformly distributed.

The unit shall also be checked for safe stresses in shear and bond. When designing by ultimate load method, the unit shall be designed to have the required utilmate load carrying capacity with appropriate load factors for the operating load.

Design Tables.—Table 1 gives the main reinforcement for residential floor/roof loads required for various spans (2·5 to 4·2m) both simply supported and three or more equal continuous spans. The negative reinforcement in the joint between cored units at support for continuity is also given.

Table 2 gives the moment of resistance and shear resistance of cored units for stage 1 and stage II loading in case of floor/roofs having unequal continous spans, Table I is not to be used; but after arriving at the bending moments and shear forces, the reinforcement can be selected from Table 2.

TABLE 1. MAIN REINFORAEMENT IN CORED UNITS AND IN THE JOINT BETWEE UNITS AT SUPPORT FOR RESIDENTIAL FLOOR/ROOF LADS.

Effective span in metres.	Main Reinforcement in Units. Simply supported Span. M.S. bars. or Defomed. bars. No.	Dia mm.	No.	Dia mm.	Main Reinforcement in Units. 3 or more continuous spans. M.S. bars. or Deformed. bars. No.	Dia mm.	No.	Dia. mm.	Main Reinforcement at support. 3 or more continuous spans. M.S. bars or Deformed. bars. No.	Dia mm.	No.	Dia. mm.
4.2	2	14	2	12	2	12	2	10	1	14	1	12
4.0	2	12	2	10	2	10	2	8	1	12	1	10
3.5	2	12	2	8	2	10	2	8	1	12	1	8
3.0	2	10	2	8	2	8	2	6	1	10	1	8
2.5	2	8	2	6	2	8	2	6	1	8	1	6

NOTE.—Apart from self weight and live load as per Indian Standard, a load of 100 kg/m² rfloo finish or a load of 200kg/m² for weathering course has been considered in the case of floor/roof.

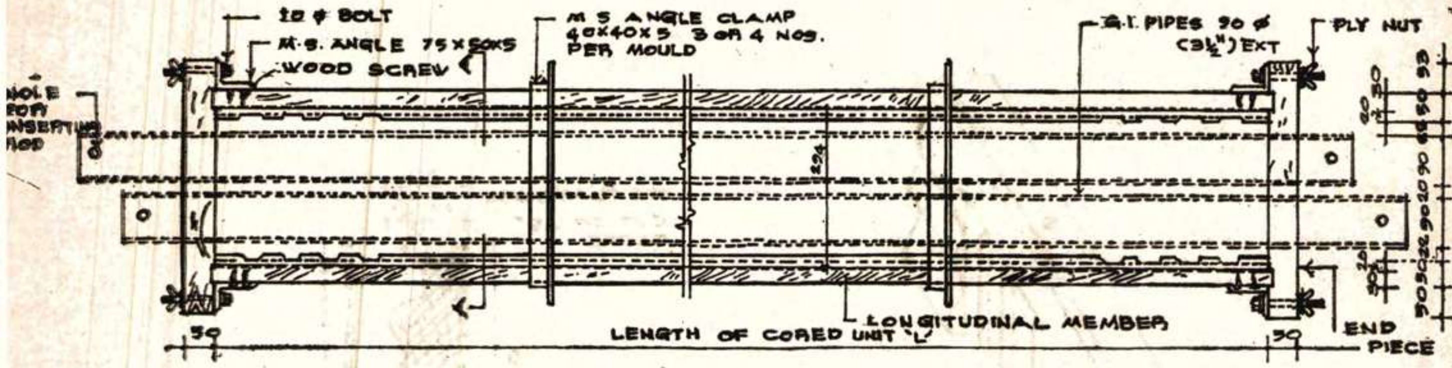
TABLE 2. ULTIMATE MOMENT OF RESISTANCE AND SHEAR RESISTANCE OF CORED UNITS DIFFERENT REINFORCEMENTS.

Reinfocement in units. Numbers	dia. mm.	Reinforcement at support. No.	dia. mm.	Stage I-Loading. Moment of resistance. kg. m.	Stage I-Loading. Shear resistance. kg. m.	Stage II Loading. Moment of resisiance at midspan. kg. m.	Stage II Loading. Moments of resistance of support. kg. m.	Stage II Loading. Shear resistance. kg.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
M.S. Bars.								
2	14	1	14	751	1,030	771	406	1,120
2	12	1	12	580	941	589	309	990
2	10	1	10	417	829	420	220	848
2	8	1	8	267	691	268	143	694
Deformed Bars.								
2	12	1	12	878	1,200	910	487	1,341
2	10	1	10	654	1,090	667	351	1,160
2	8	1	8	505	919	512	268	950
2	6	1	6	289	730	290	154	734

NOTES.— 1. The moment of resitance and shear resitance given are for 30 cm. width.

2. Concrete of grade M 150 is to be used.

3. Mild steel conforming to IS 432-1966 or cold twisted plain or deformed bars conforming to IS 1786-1966 are to be used a reinforcement.

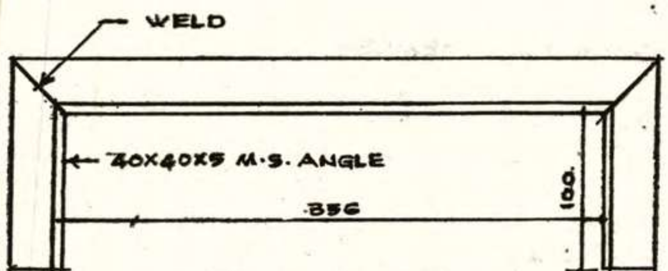


PLAN OF MOULD

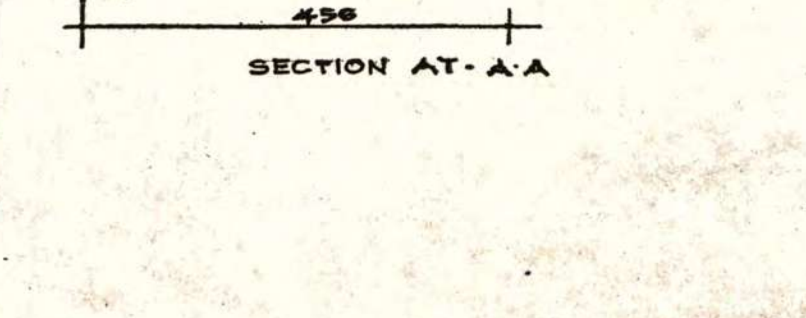
Mould :

The mould shall be made from well seasoned good quality timber. For casting very large number of units, the timber mould shall be stiffened with steel members or may be made entirely of steel. This will prove to be more advantageous and economical in the long run for large projects.

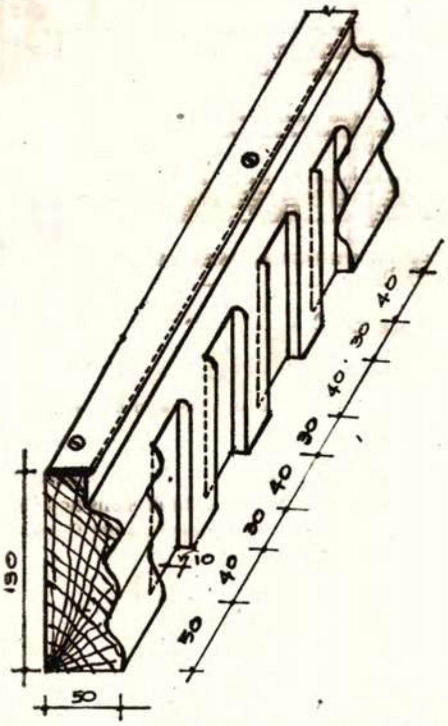
The mould consists of two longitudinal members, two end pieces, two G.I. pipes and clamps. The dimensions and shapes of various components of the mould may be taken as per Figures.



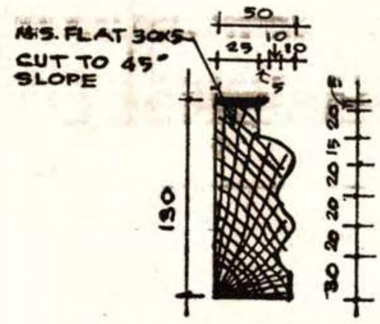
DETAIL OF CLAMP



SECTION AT - A·A



END VIEW OF LONGITUDINAL MEMBER



SECTION OF LONG. MEMBER

The G.I. pipes to be used shall have a smooth surface and shall be straight along their axis.

Casting and curing of units :

The inner sides of the longitudinal members and end pieces of the mould are oiled with burnt engine oil and assembled as shown in Figure 8 on a smooth and level surface casting platform, duly oiled. The reinforcement cage is placed in position and U clamps 2 to 4 numbers depending upon the length of the unit are inserted on the mould to prevent bulging during concreting. M. 150 concrete with 10 mm. and down graded aggregated is filled for the bottom flange portion. After oiling their surface, the G.I. pipes are introduced through the holes in the end pieces. Concrete is poured from the top and compacted with a plate vibrator. It is also possible to do concreting in one single operation provided due care is taken in vibration to see that no cavities are left below the pipes. During casting, the pipes are rotated a few times so as to break the bond between concrete and the pipes. The top of the units is finished rough. It is also possible to cast the units upside down and in this case, the top portion which will form the ceiling shall be finished smooth.

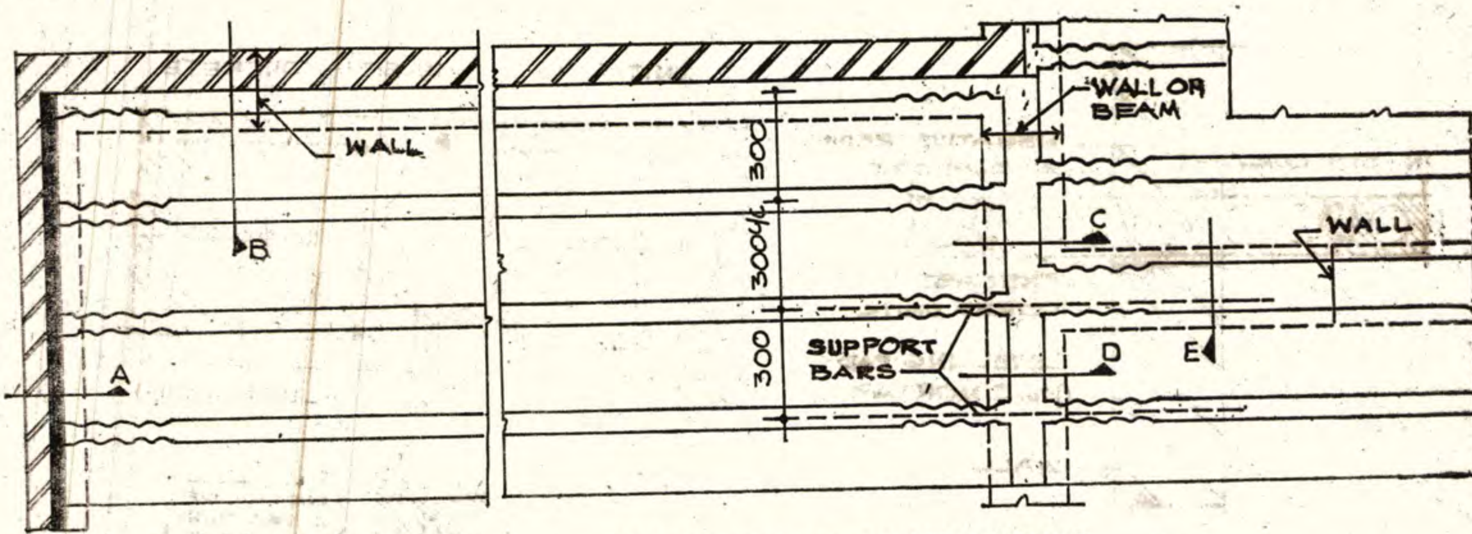
About one to one and a half hours after casting, depending upon the weather, the pipes are withdrawn, by rotating them radially and pulling out axially after providing support to see that the pipes remain in level. After the pipes are withdrawn, precast concrete discs 9 cm dia and 2.5 cm. thick shall be inserted into the cores and fixed at a distance of 7.5 cm. from the ends of the units. The mould is dismantled about 4 hours after casting, by first removing the end pipe Afterwards the sides are lightly tamped on the top to break the bond between concrete and mould. Subsequently the sides are moved out cleaned and oiled and the above mentioned process is repeated for further casting. A mould made of good quality timber, can be used at least 100 times while a steel mould can be used upto 500 times.

The freshly cast units are kept covered with wet gunny bags at the casting yard for 48 hours. After wards, the units are slightly pushed to break bond with floor, lifted carefully from the ends an transported to the curing yard manually or in trolly in their natural position, i.e., with the main reinforcement at the bottom. In case the units are cast upside down, they shall be turned to their natura position before transporting them. At curing yard, the units can be stacked one above the other upto 4 numbers in a row and covered with gunny bags or sand. The units must be cured for 14 days by sprinkling water over them and then air cured for another 14 days before placing them in position in any building.

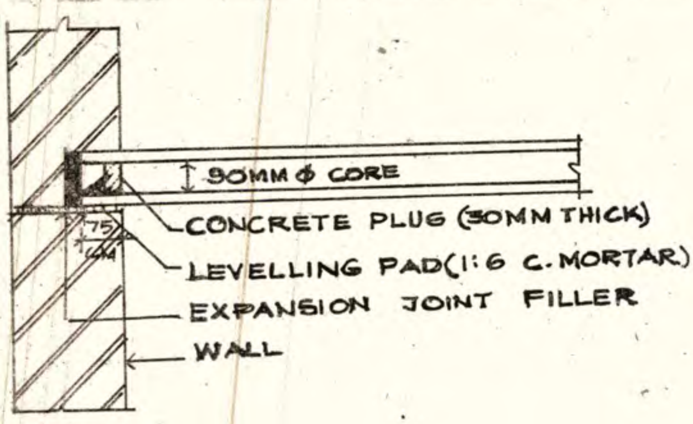
A mechanised method of production of cored units using pressure-*cum*-vibration technique has also been worked out (Project Proposal No. 27) for factory production.

Assembly of floor/roof :

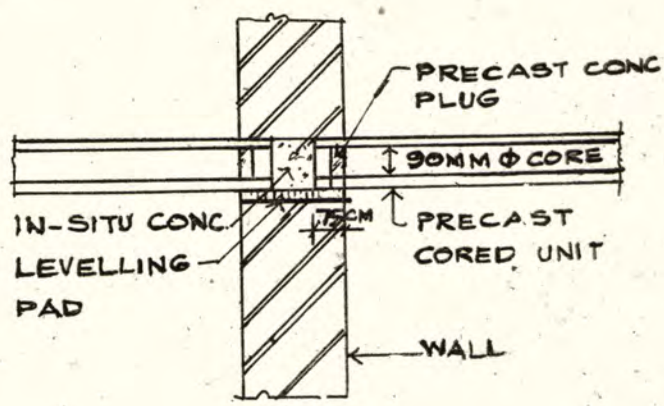
The top surface of wall or beam supports, as the case may be, is levelled. The units are lifted one by one manually or with the help of chain pulley block or mechanically with a hoist and placed side by side across the span to be covered. The units are then aligned and levelled properly as shown in Figures 10 to 16. Negative reinforcement in the case of continuous floor/roof slab is placed in position at support.



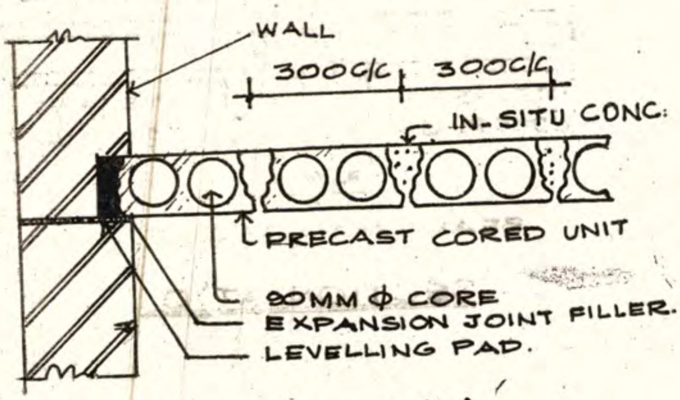
TOP PLAN OF CORED UNITS



SECTION AT 'A'



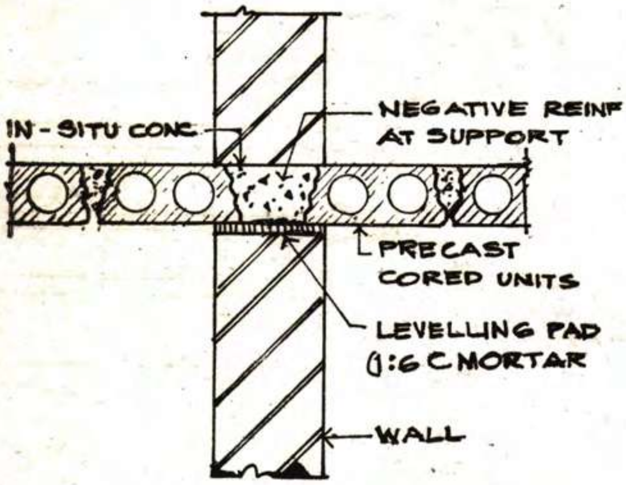
SECTION AT 'C'



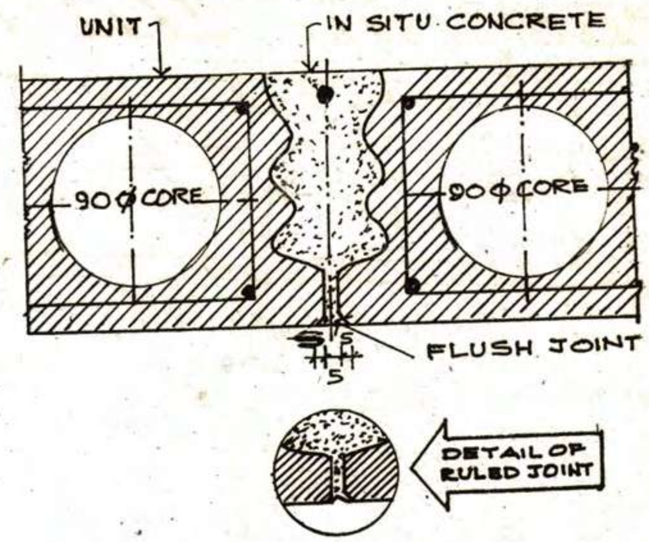
SECTION AT 'B'

Thin cement wash is applied to the sides of the units and the joints are filled with M. 150 concrete using 10 mm. and down graded aggregate and consolidated by rodding. The concrete is cured for 7 days and then dried. In case of floor, any flooring treatment such as I.P.S. or mosaic tiles or in-situ mosaic may be laid. The flooring shall be laid in bays with the bay lines in the direction of units coinciding with some joints between units. For roof, a coat of bitumen is first applied on the entire surface and then lime concrete or mud-phuska with tiles over it is laid. The joints between units at ceiling are finished with 1:4 cement : sand mortar applied with the help of a piec of wet gunny bag and finished with deep ruled lines (Figs.).

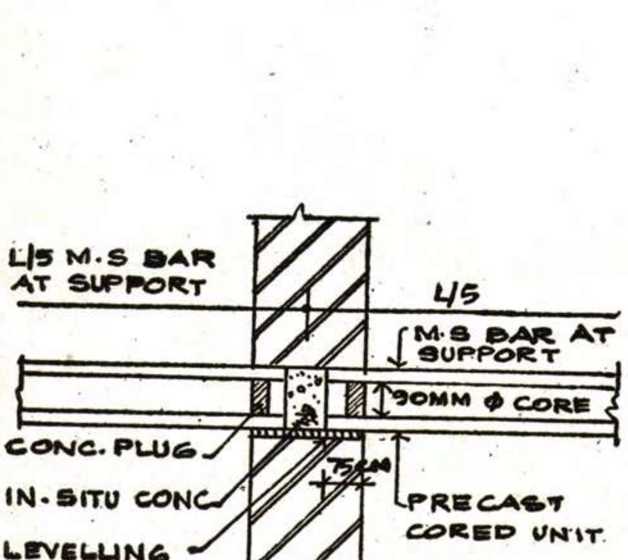
466-3—29



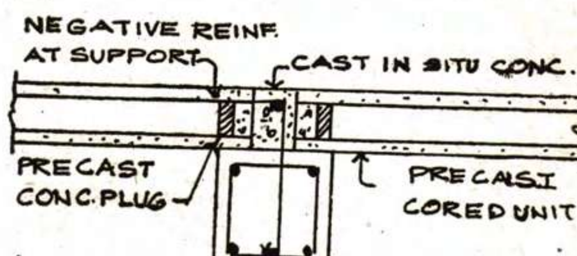
SECTION AT 'E'



DETAILS OF FLUSH & RULED JOINTS



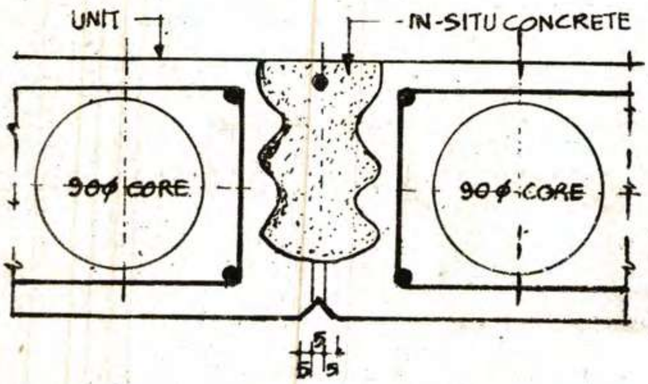
SECTION AT 'D'

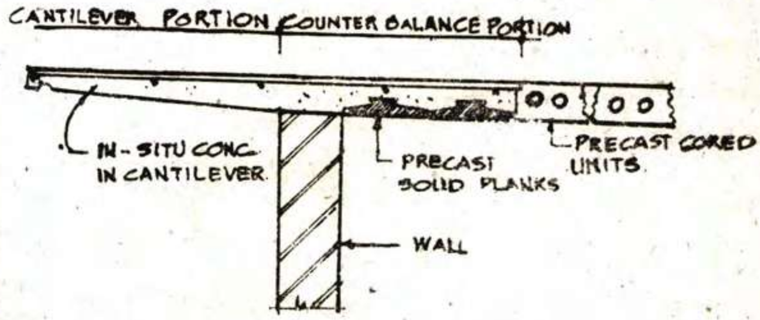


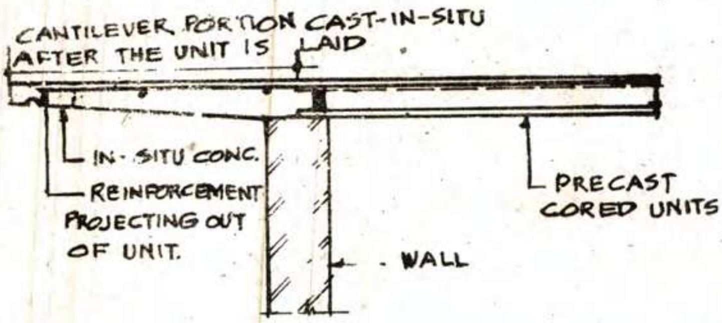
SECTION AT 'D'

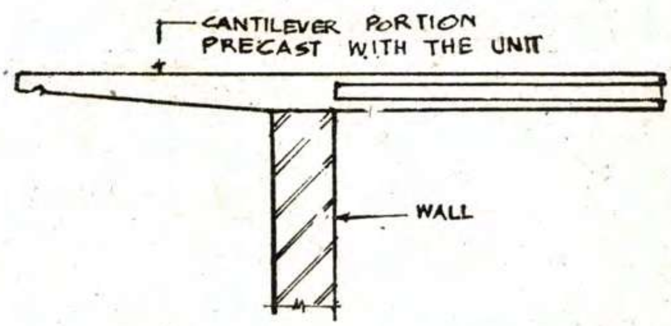
Balcony/Chajja projections—

These could be achieved in the following manner depending on their location in relation to units.









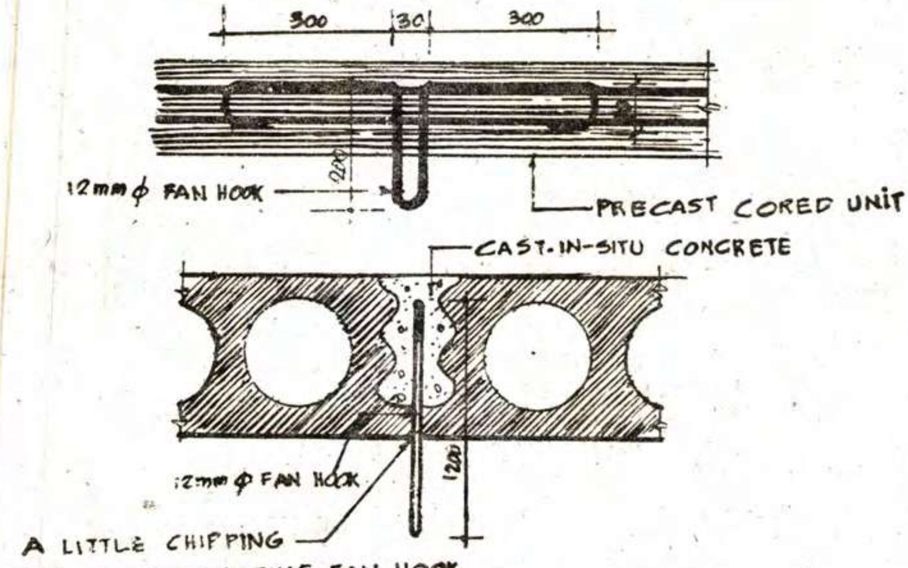
The cantilever across the span of the unit is provided in-situ (Fig.) by replacing the cored unit by precast solid planks for a distance sufficient to provide the restoring moment required to overcome the overturning moment caused by loads over cantilever portion Reinforcement is provided over these planks and projected out for the cantilever length and in-situ concrete is done. The cantilever across the span can also be provided by projecting the beam supporting the units and then placing cored units over the projected beam in the usual way.

In case of projections in the same direction as the length of units, the cantilever can be cast in-situ with reinforcement from units or from the joints between the units kept projecting out (Fig.) Alternatively, the unit itself can be cast with projection for short cantilever by properly designing and providing necessary reinforcement. (Fig.).

Fixtures.

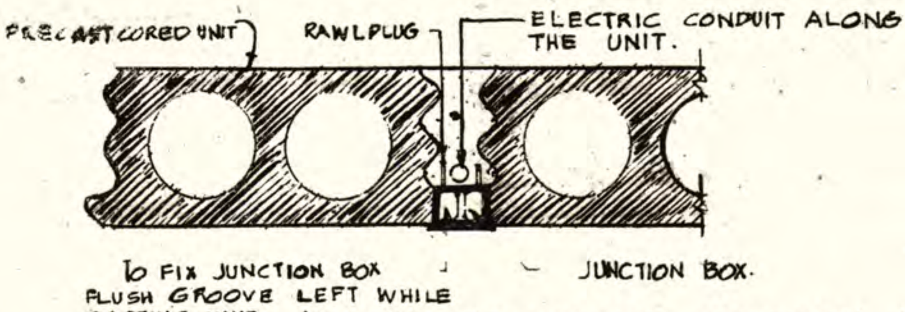
Various fixtures like fan hooks, electric conduits, etc., shall be fixed in the following manner :—

(1) *Fan hooks.*—These can be kept in the cast-in-situ concrete of the joints between units by slight chipping of the edges of the units at the location of the fan. (Fig.).

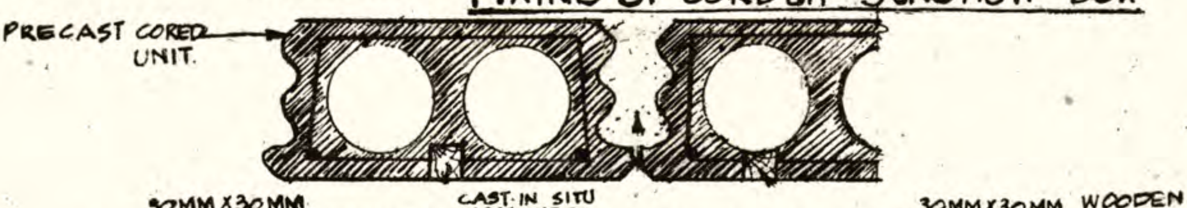


(2) *Electric conduits.*—These may be embedded in the cast-in-situ concrete of the joint. At right angles to the units they can be taken along the walls. Alternatively they could be placed in lime concrete or other cushioning material.

(3) *Electric junction boxes.*—These may be fixed with raw plugs in the cast-in-situ joint between units or embedded during fill·ing the joint (Fig.).



FIXING OF CONDUIT JUNCTION BOX.



FIXING OF WOODEN PLUGS

(4) *Wooden plugs for exposed wiring.*—These may be provided during casting the unit as shown in Fig.

Precautions.—(1) M 150 concrete with 10 mm. and down graded course aggregate shall be used for casting the units and filling joints between the units. It may be noted for genereal guidance that M 150 concrete corresponds approximately to 1:2:4 nominal mix by volume. The amount of water used for the mix shall be such that cement slurry does not flow out of the mould during vibration but only a thin layer of water appears on the top.

(2) While casting the units, the concrete shall be thoroughly compacted by means of a plate vibrator by moving the vibrator along the length of the unit and vibrating during all pours of concrete.

(3) The G.I. pipes shall be straight and oiled by burnt engine oil before inserting in the mould. In pulling the pipes out, first slight rotation shall be given. Rotation and pulling shall be done in sequence till the whole pipe is taken out, Timber planks 3 c.m. wide with a semicircular groove of pipe diameter shall be used to keep the pipes in level. If any minor cracks appear on the surface, they shall be closed in the green stage itself by applying neat cement slurry and finished with a trowel.

(4) Before demoulding, the longitudinal members of the mould shall be tamped by a wooden hammer to break the bond between the mould and the unit.

(5) After 48 hours of casting, the unit shall be slided by pushing on the casting floor to break the bond before lifting them from the floor. The units shall be lifted and handled by a minimum of four men by supporting them from the ends. In any case the cantilevering portion at the ends shall not be more than 30 cm.

(6) During all stages of handling, the units shall be kept such that the main reinforcement is at the bottom.

(7) No portion of the unit shall be broken or chipped once it is cast, except as indicated in the sheet.

(8) Only units fully cured for a minimum period of 28 days after casting, free from damage and cracks and sound in all respect shall be used in making floor/roof.

(9) During construction, no heavy loading shall be permitted over the units until the cast-in-situ concrete filled in the joints attains strength.

Material and labour requirement.—

The labour and materials required for preparation of the mould, casting, curing, transportation, hoisting and placing of units and completing the structural portion of the roof/floor is given below. From this basic data, knowing the prevailing rates of labour and materials, the cost of roof/floor can be worked out for any place. The actual quantity of steel will vary depending upon the span and loads and whether the roof/floor is designed as simply supported or continuous.

I. Mould and casting platform.—(i) Materials.

Timber required for a mould 3.6 m. long Including 25 per cent wastage	$=0.0671$ m^2
9 cm. outer diameter G.I. pipe	$=8.1$ m.
$40\times40\times5$ mm. angle irons for mps., etc.	$=2.5$ m.
30×5 mm. M.S. flat	$=7.2$ m.
10 mm. dia bolts 90 mm. long with nuts and washers	$=8$ Nos.

(ii) Labour—

Carpenter	= Man days.
Fitter	=1 Man day.
Mazdoor	=2 Man days.

(iii) Miscellaneous—

L. S. for nails, welding, etc.	Rs. 1.50 per mould.
Cost of casting platform	=Rs. 0.15 per unit.

NOTE.—A mould can be used for about 3 castings per day in summer and 2 castings per day in winter. A timber mould can be reused at least 100 times.

II. Casting of units.—The materials and labour required for casting and curing 40 cored units 3.6 m. long are given below :

(i) *Materials*—

Cement	20 bags.
Sand	1.5 m^2
10 mm. and down graded coarse aggregate	3.0 m^2
Steel (M.S. bars)	187 kg.*
3 mm. dia steel wire	19 kg.

* The quantity of steel is in case of 3 equal continuous spans.

(ii) *Labour*—

Masons	4 Man days.
Mazdoors	12 Man days.
Bar benders	2 Man days.
Helpers to bar benders	2 Man days.
Mixer operator	1 Man day.
Helpers to mixer operator	4 Man days.

(iii) *Miscellaneous*—

Cost of burnt engine oil to be used on mould sides, pipes and platform.	Rs. 18.00.
Water for mixing concrete and curing units.	5 K. lit.
Electricity required for operating vibrator and mixer.	10 K.W.H.
Lumpsum for mixer and vibrator	Rs. 4.80.

NOTE.—One mason and four mazdoors can cast 10 units per day.

III. Transporting unit by trolley—

Mazdoor required for transporting 40 units.	5 Nos.

The labour required is for trasporting the units in a trolley from the casting yard at the site of construction to different buildings in a housing colony within a radius of about 200 m.

Assuming the cost of trolley as Rs. 1,000 and the life of trolley as 12 months with 23 working days per month and number of units transported per day per trolley as 40.

Cost of trolley for transporting

$$40 \text{ units} = \frac{1{,}000}{12\times23} = \text{Rs. } 3.63.$$

IV. Hoisting and placing in position—

Mazdoors required to place 40 units at first floor (3 m. high).	=10 Nos.†
Scaffolding charges, etc., upto first floor L.S.	=Rs. 24.00.

Add 50 per cent of scaffolding charges for every extra floor levels to the value given for first floor upto fourth floor (12 m.).

† Add 3 Nos. of mazdoors for every extra floor levels to the value given for first floor upto fourth floor (12 m.) for manual lifting with or without chain pulley. In case mechanical hoist is used, no extra labour is required.

V. Finishing—

(Filling concrete in joints and pointing the V groove between units 40 Nos.).

(i) *Materials*—

M 150 concrete	0.71 m^3.
Mild steel in joints at support in continuous spans only.	22 kg.
Mortar 1 : 4 cement : sand for pointing including transportable scaffolding L.S.	Rs. 15.00

(ii) *Labour*—

Mason	2 Nos.
Mazdoors	4 Nos.

EXTRACT FROM **C.B.R.I.**

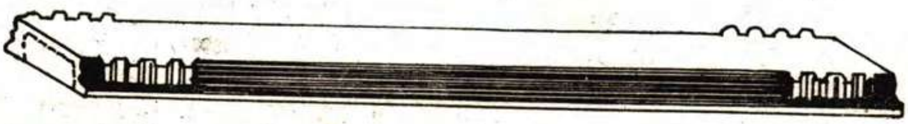
Data Sheet No. 5.

Channel unit for floor/roof.

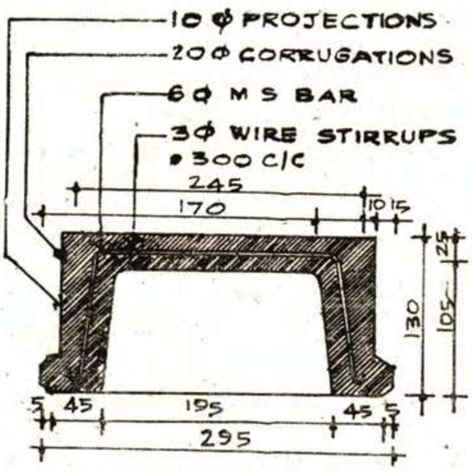
The unit is a precast R.C.C. element, trough shaped in section. It does not require any type of temporary support or propping during construction. It can be used for intermediary floors/roofs with conventional brick/stone walling or framed structure and no deck concrete is required.

Shape and Size—

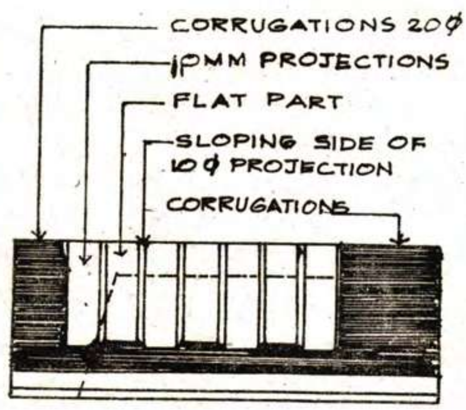
The cross sectional shape of the unit is in the form of a trough, the sides are corrugated and grooved at the ends to provide shear key action between adjacent units (Figs.). The nominal width of the unit is 300 or 600 mm and the depth is 130 mm. The length of the unit may be kept to suit the span to be covered but is generally kept between 2.5 to 4.2.m. The actual size of a unit is 295 mm×130 mm. it has a minimum flange/web thickness of 25mm and weighs about 36 kg./m. The other size is 595 mm×130 mm which has a minimum flange thickness of 35 mm with minimum web thickness of 25 mm and weighs about 54 kg./m. The corrugations on the sides of the units when filled with in-situ concrete develop monolithicity and also help in transferring the loads transversely



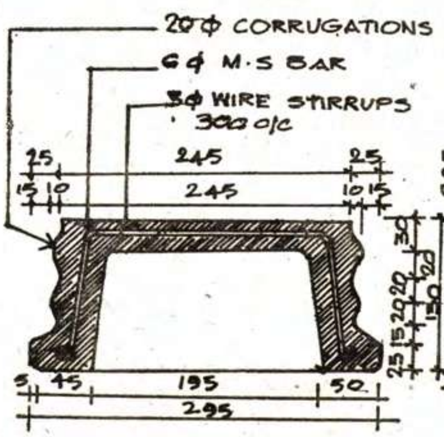
CHANNEL UNIT FOR FLOOR/ROOF



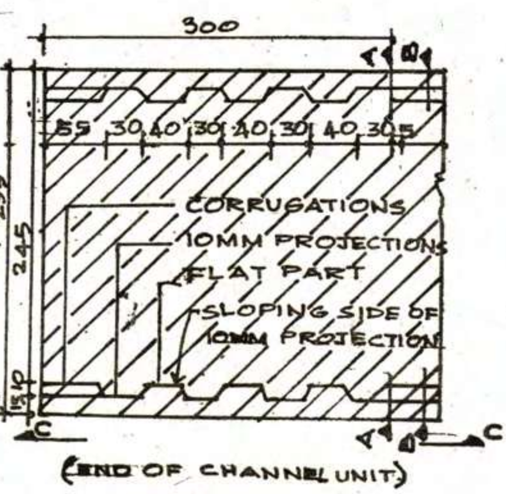
SECTION AT A-A



ELEVATION C-C



SECTION AT BB



TOP PLAN

Structural design—

The section and reinforcement of the channel unit may be designed either by working stress or ultimate load method. Depending upon the end conditions of the unit, it may be designed as simply supported or continuous. The units are designed for the following two stages of loading :—

(i) *Stage I-loading.*—The unit should be checked for handling stresses considering the permissible stress in concrete at the time of handling

At the time of laying the units, the load comprises of self-weigh of the unit and the weight of concrete in joints between two units and incidental live load.

The unit should be able to withstand this loading as simply supported beam.

(ii) *Stage II-loading.*—Full load acting on the unit under the appropriate end conditions *i.e.* simply supported or continuous.

When the floor/roof is of three or more continuous bays of approximately equal span, in absence of exact calculations, the following values may be taken for bending moments and shear forces for the two stages of loading.

1. B.M. at midspan = $(Wc+Wi)\times L^2/8$

S.F. $=(Wc+Wi)\times 0{\cdot}5L$

Where, Wc = dead weight of the unit including the in-situ concrete in joints between units for nominal width of one precast unit, uniformly distributed.

Wi = incidental live load for one channel unit, uniformly distributed.

L = Span.

2. **B.M.** in the middle of interior span.

$$=\left(\frac{Wc}{8}+\frac{Wl}{12}+\frac{Wd}{24}\right)L^2$$

3. **B.M.** in the middle of span

$$=\left(\frac{Wc}{8}+\frac{Wl}{10}+\frac{Wd}{12}\right)L^2$$

4. B.M. at support next to end support

$$=\left(\frac{Wd}{10}+\frac{Wl}{9}\right)L^2$$

5. **B.M.** at any other interior support

$$=\left(\frac{Wd}{12}+\frac{Wl}{9}\right)L^2$$

S.F. $=(0{\cdot}5Wc+0{\cdot}5Wl+0{\cdot}6Wd)L$

Where, Wd = Dead load due to flooring/roofing treatment, etc. for nominal width of one channel unit uniformly distributed.

Wl = Super-imposed live load for nominal width of one channel unit uniformly distributed.

The unit should also be checked for safe stresses in shear and bond. When designing by ultimate load method, the unit shall be desgined to have the required ultimate load carrying capacity with appropriate load factors for the operating load.

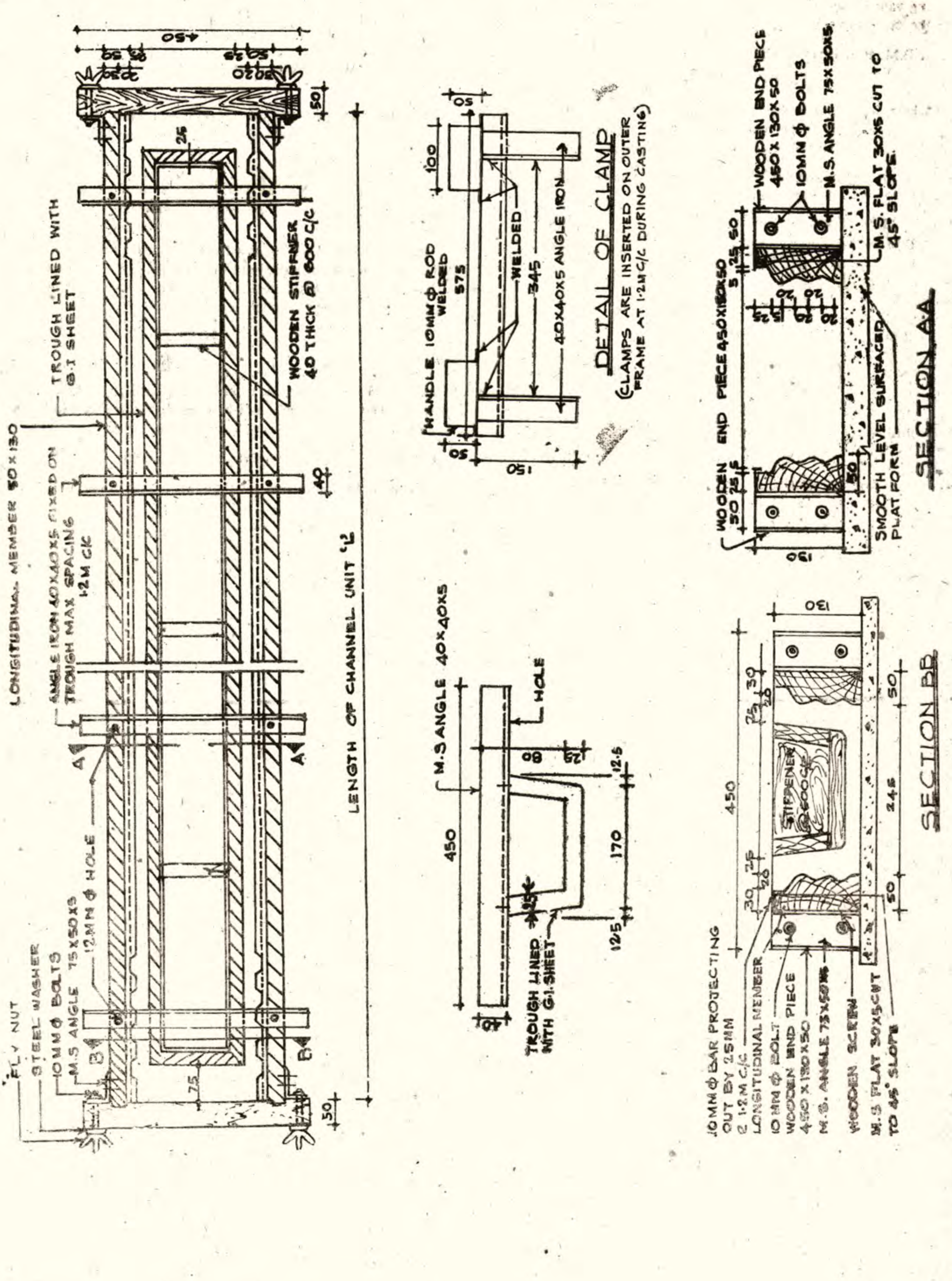
Mould—

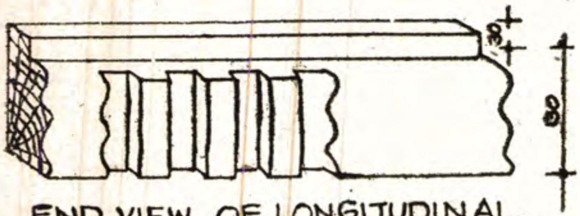
The mould should be made from well seasoned good quality timber or steel. The timber mould may be lined with steel sheets to be more advantageous and economical in the long run for large projects.

The mould consists mainly of two components:—

(i) the outer frame, and (ii) the inner trough frame.

The din nsions and shape of various components of the mou'd may be taken as per Figs.





END VIEW OF LONGITUDINAL MEMBER

Casting and curing of units.—

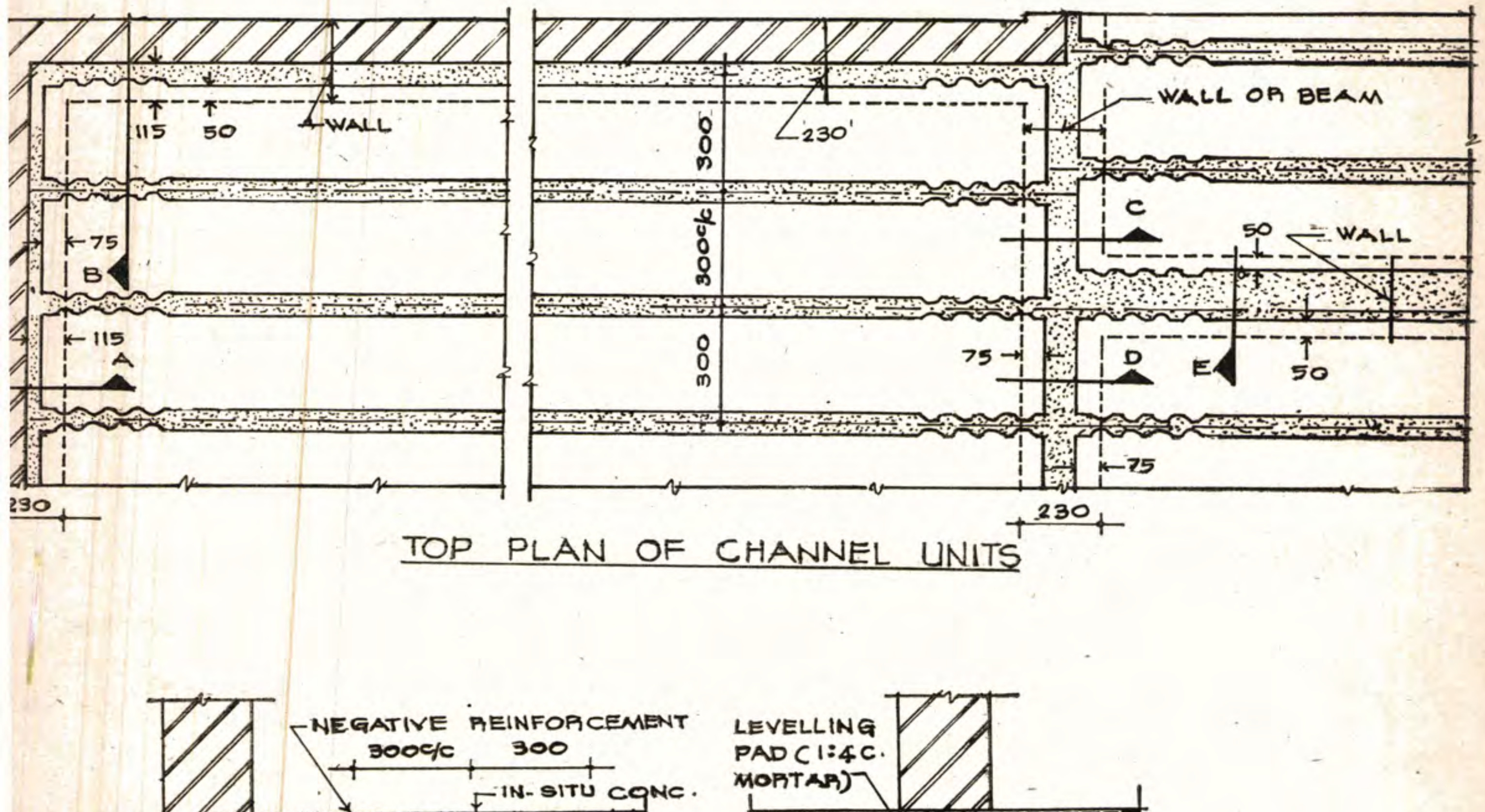
The inner side of outer frames of the mould is oiled and placed on a specially prepared smooth and level surfaced platform duly oiled as shown in Fig. The reinforcement cage is placed in position and M 150 concrete with 10 mm. graded aggregate is filled for the flange portion and vibrated with a plate vibrator. The trough frame is kept inside the outer frame and concrete is levelled by moving the trough frame to and fro. Afterwards the trough frame is fixed in position with the outer frame and U clamps are inserted on the outer frame. The webs of the channel unit are filled with M 150 concrete, vibrated and finished level.

After about one hour of casting (depending upon the weather conditions), the U clamps are pulled up and the trough frame is gently lifted off. The surface may be finished smooth with a trowel, if necessary. About three hours after casting, the outer frame is also stripped off. The unit is left undisturbed for 48 hours except that it is kept wet by occasional sprinkling of water or putting wet gunny bags. Afterwards the unit is turned to the position such that the flange is brought to the top. The unit is then transported to the curing yard by supporting at the ends and stacked with trough on top. The unit must be cured for 14 days by keeping the trough filled with water and air cured for another 14 days before placing in position in a building.

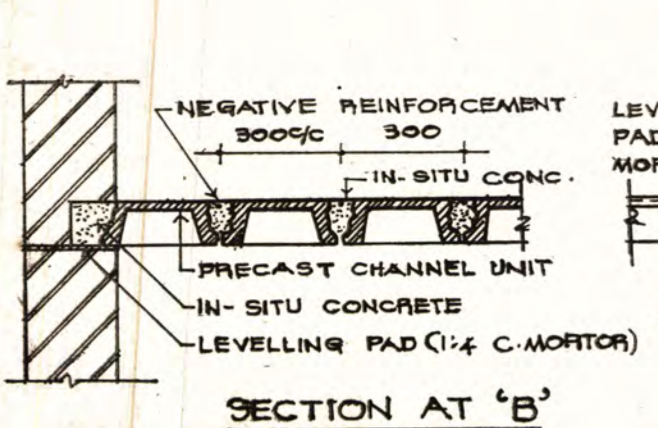
The mould is cleaned and oiled and the above mentioned proces is repeated for further casting.

Assembly of floor/roof.—

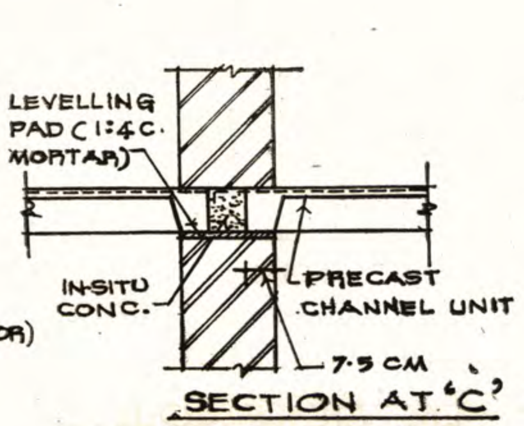
The top surface of wall or beam supports as, the case may be, is levelled. The units are lifted one by one manually or with the help of chain pulley block or mechanically with a hoist and placed side bd side across the span to be covered. The units are then aligned any levelled properly. Negative reinforcement in the case of continuous floor/roof slab is placed in position at support (Figs.)



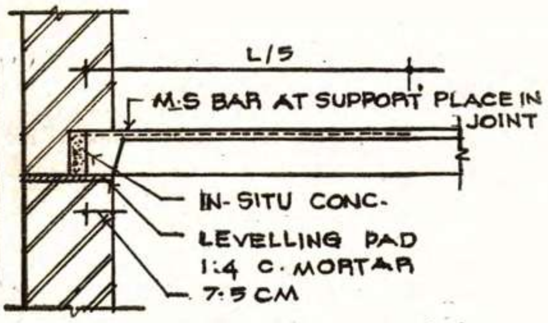
TOP PLAN OF CHANNEL UNITS



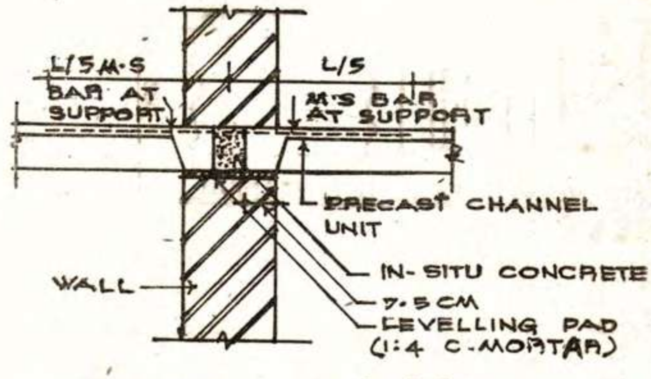
SECTION AT 'B'



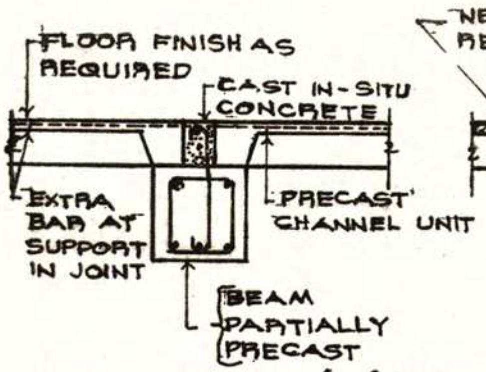
SECTION AT 'C'



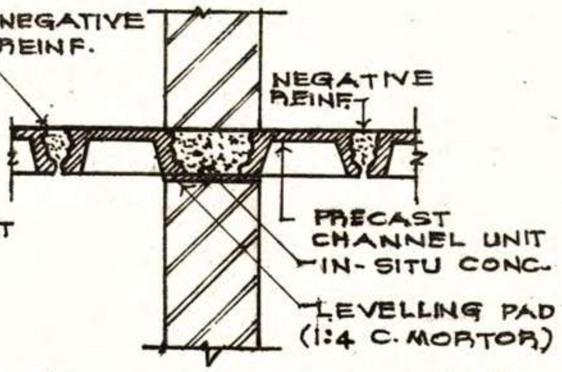
SECTION AT 'A'



SECTION AT 'D' (WALL)

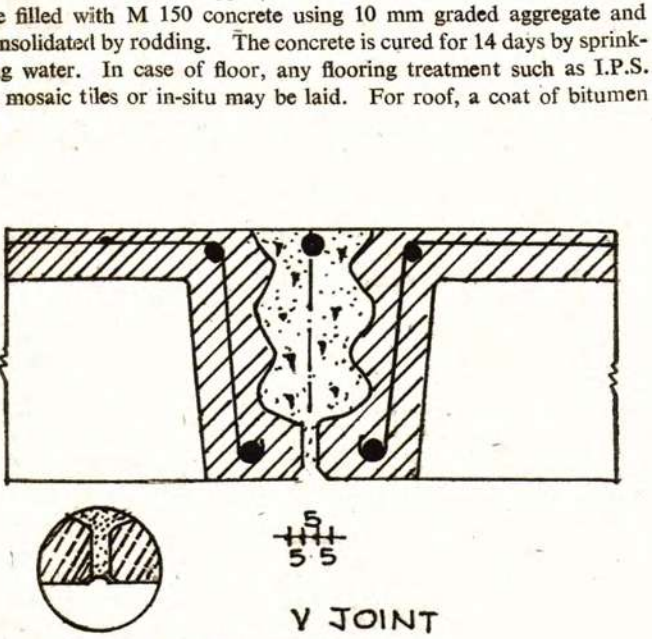


SECTION AT 'D'(BEAM)

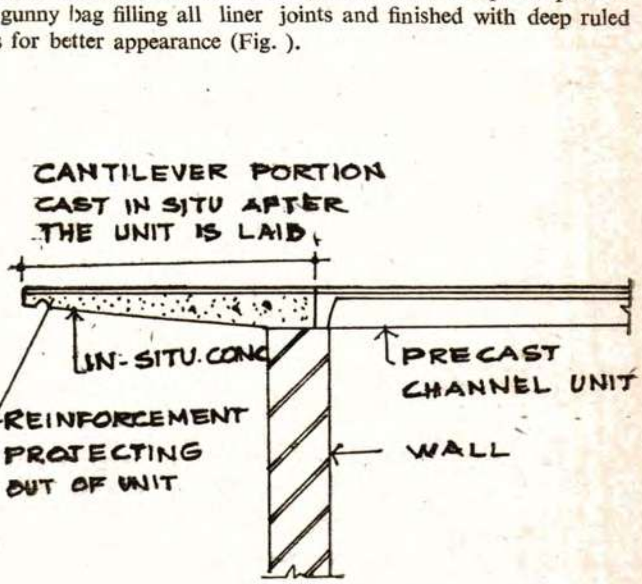


SECTION AT 'E'

Thin cement wash is applied to the sides of the units and the joints are filled with M 150 concrete using 10 mm graded aggregate and consolidated by rodding. The concrete is cured for 14 days by sprinkling water. In case of floor, any flooring treatment such as I.P.S. or mosaic tiles or in-situ may be laid. For roof, a coat of bitumen is first applied on the entire surface and then lime concrete or mud phuska with tiles over it is laid. On the joint between units in the ceiling 1 : 4 cement sand mortar is applied with the help of a piece of wet gunny bag filling all liner joints and finished with deep ruled lines for better appearance (Fig.).



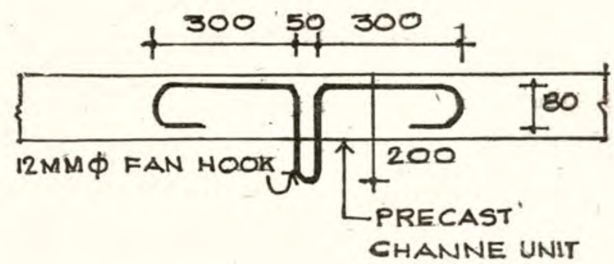
DETAIL OF JOINTS



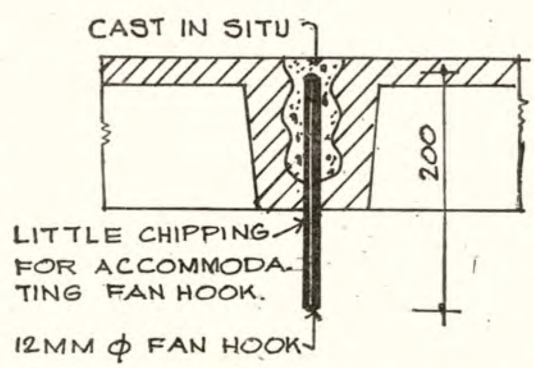
BALCONY CHHAJJA PROJECTION CONTINUOUS WITH UNIT

Balcony/chajja projections.—

These could be achieved in the following manner depending on their location in relation to units. In case of projections in the same direction as the length of units, the unit itslef can be kept projecting out for short cantilever by properly designing and providing necessary reinforcement. Alternatively the cantilever can be cast in-suit with reinforcement from units or form the joints between the units kept projecting out (Fig.).



The cantilever across the span of the unit is provided by replacing the channel unit by precast solid planks for a distance sufficient to provide the restoring moment required to overcome the overturning moment caused by loads over cantilever portion. Reinforcement is provided over these planks and projected out for the cantileve length and in-situ concrete is done. The cantilever across the span can also be provided by projecting the beam, supporting the units and then placing channel units over the projected beam in the usual way.



FIXING OF FAN HOOK

Fixtures.—

Various fixtures like fan hooks, elctric conduits, etc., should be fixed in the following manner :—

(1) *Fan hooks.*—They can be kept in the cast-in-situ concrete of the joints between untis by slight chipping of the edges of the units at the location of the fan (Fig.).

(2) *Electric conduits.*—They may be embedded in the cast-in-situ concrete of the joint. At right angles to the untis, they could be placed only in lime concrete or other cushioning material.

(3) *Electric junction boxes.*—They may be fixed with rawl, plugs in the cast-in-situ joint between untis or embedded during filling the joint.

(4) Wooden plugs may be provided as shown in Fig. .

Precautions.—

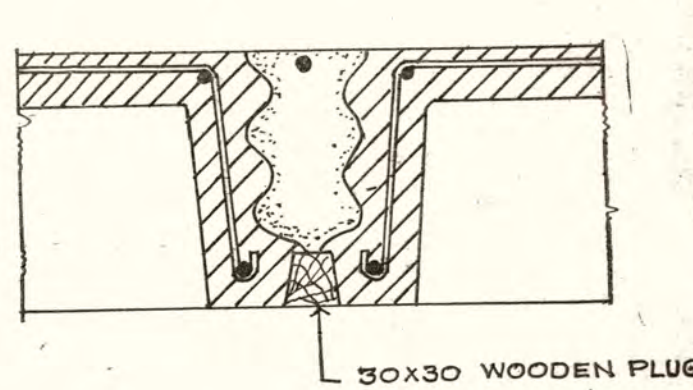
(1) During all stages of erection, handle the untis such that the main reinforcement is on the underside only.

(2) Position the slings for erection of unit near ends upto 0·20 L from either end of unit and nowhere else.

(3) No portion of the unit should be broken or chipped once it is cast except as indicated in the sheet.

(4) Only fully cured units free from damage and cracks and sound in all respects should be used in making floor or roof.

(5) During construction no heavy loading should be permitted over the units unitl the cast-in-situ concrete filled in the joints attains strength.



FIXING OF WOODEN PLUG

Material and labour requirement.—

The labour and materials required for preparation of the mould, casting, curing, transportation, hositing and placing of units and completing the structural portion of the roof/floor is given below. From this basic data, knowing the prevailing rates of labour and materials, the cost of roof/floor can be worked out for any place. The actual quantity of steel will vary depending upon the spans and loads and whether the roof/floor is designed as simply supported or continuous.

I. Mould and casting platform.—

(i) Materials—

Timber required for a mould 3·6 m long including 25 per cent wastage	0.105m³
40X40X5 mm angle irons for fixing the trough to mould	4·5 m
75X50X5 mm angle iron for U clamp	0·52 m
30X5 mm M.S. flat	7·2 m
G.I. Sheet 30 gauge	1·7 m²
10 mm dia bolts 90 mm long with fly nuts and washers	8 nos.

(ii) Labour—

Carpenter	3 days.
Fitter	1·5 days.
Mazdoor	3 days.

(iii) Miscellaneous—

L.S. for nails, welding, etc.	Rs. 2·00
No. of reuses of the mould	100
Cost of casting platform	Re. 0.30/unit.

NOTE.—A mould can be used for about 3 castings per day in summer and 2 castings per day in winter.

II. Casting of units.—

The materials and labour required for casting and curing 40 channel units 3·6 m long is given below :—

(i) Materials—

Cement	15 bags.
Sand	1·05 m³
10 mm graded aggregate	2·1 m²
Steel	244 kg. *
3 mm dia steel wire	16·5 kg.

(ii) Labour—

Masons	4 Nos.
Mazdoors	12 Nos.
Mixer operator	1 No.
Helpers to mixer operator	3 Nos.
Bar bender	2 Nos.
Helper to bar bender	2 Nos.

(iii) Miscellaneous—

Cost of kerosene grease mixture to be used on mould sides and platform	Re. 0·25/unit.
Water for mixing concrete and curing units ..	·5 K. lit.
Electricity required for operating vibrator and mixer	10 KWH.
Lumpsum for mixer and vibrator	Rs. 4·80

NOTE.—One mason and three mazdoors can cast 10 units per day.

III. Transporting units by trolley.—

Mazdoors required for transporting 40 units .. 4 Nos.

The labour required is for transporting the units in a trolley from the casting yard at the site of construction in a radius of about 200m to different buildings in a housing colony.

Taking the cost of trolley as Rs. 1,000, life of trolley as 12 months working days 23 per month and number of units transported per day per trolley as 40, cost of trolley for transporting 40 units.

$$= \frac{1,000}{12X23} = \text{Rs. } 3{\cdot}63$$

IV. Hoisting and placing in Position.— †

Mazdoors required to place 40 units at first floor (3 m high)	8 Nos.
Scaffolding charges, etc., upto first floor (3m high) L.S.	Rs. 20·00

V. Finishing.—

Filling concrete in joints and pointing in V groove between units—40 Nos.

Add 50 per cent of scaffolding charges for every extra floor level to the value given for first floor upto four floors (12 m).

(i) Material—

M 150 concrete	0·71 m³
Mortar 1 : 4 cement : sand for pointing including transportable scaffolding L.S.	Rs. 15

(ii) Labour—

Masons	2 Nos.
Mazdoors	4 Nos.

*The quantity of steel is in case of 3 equal continuous spans.

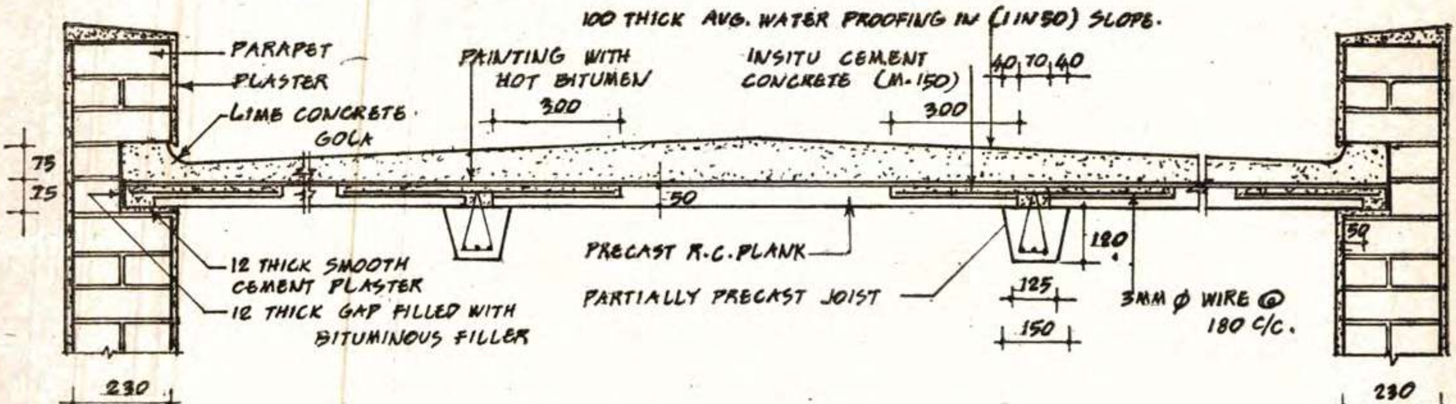
†Add 2 Nos. of mazdoors for every extra floor levels to the value given for first floor up to four floors (12 m). for manual lifting with or without chainpulley. In case mechanical hoist is used, no extra labour is required.

EXTRACT FROM C.B.R.I.

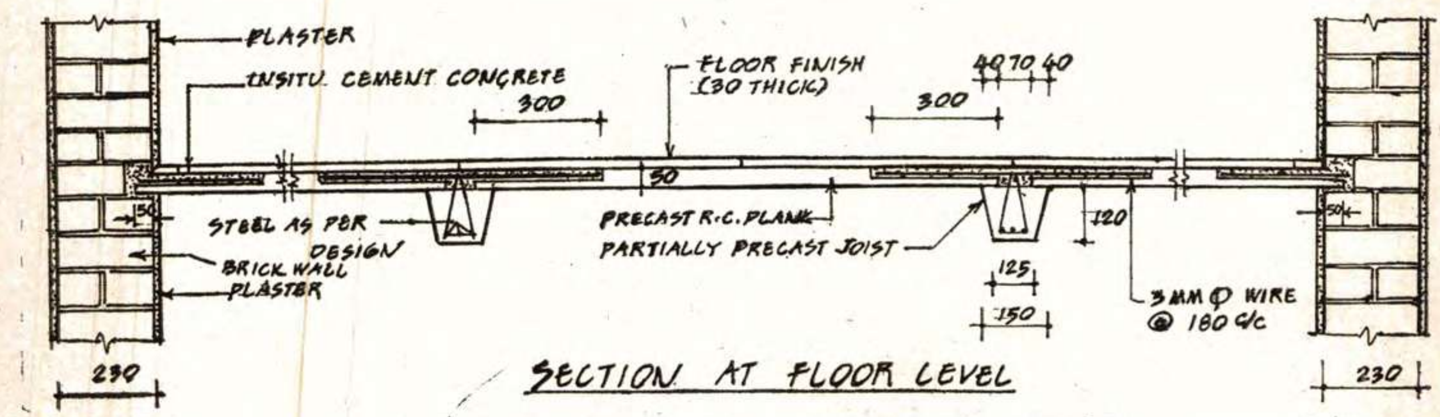
Data sheet No. 7.

Precast R.C. plank flooring/roofing scheme.

The scheme consists of precast R. C. plank supported over partially precast reinforced concrete joist (Fig.). It can be used for floors/roofs with load bearing walls and framed structures for residential buildings. The flooring is laid directly over the planks after the in-situ concrete in haunches has been laid and cured. The weathering course for the roof is laid after painting the roof area with a coat of bitumen at the rate of 1.7 kg/m². This scheme has been successfully adopted in some housing projects.



SECTION AT ROOF LEVEL



SECTION AT FLOOR LEVEL

PRECAST R.C. PLANK SCHEME

Elements of floor/roof :

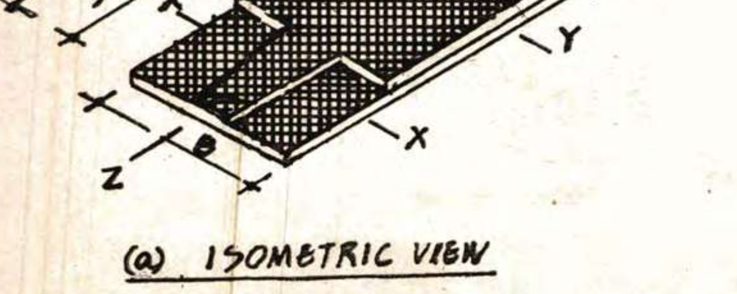
The floor/roof consists of the following elements :—

(i) Precast R. C. Plank.

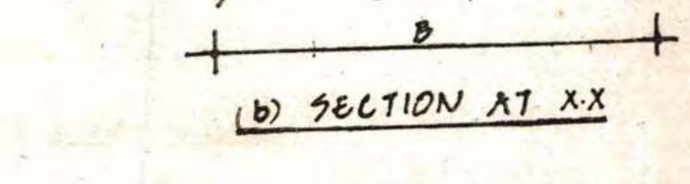
(ii) Partially Precast R. C. Joist.

Precast R. C. plank :

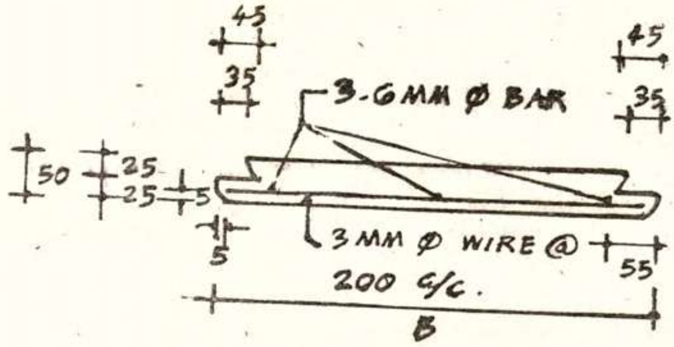
It is partly 5 cm. thick and partly 2.5 cm. thick (Fig.) of M.S. reinforcement and M—150 concrete. It may be made on sizes up to 120 cm × 45 cm. and 130 cm. × 40 cm. The maximum weight of the unit is 50 kg. For W.C. the size of plank is restricted 130 cm. × 30 cm. In case of kitchen, bath and W.C. having span more than 130 cm. and the planks bear on walls, the shape of the plank shall be as shown in (Fig.).



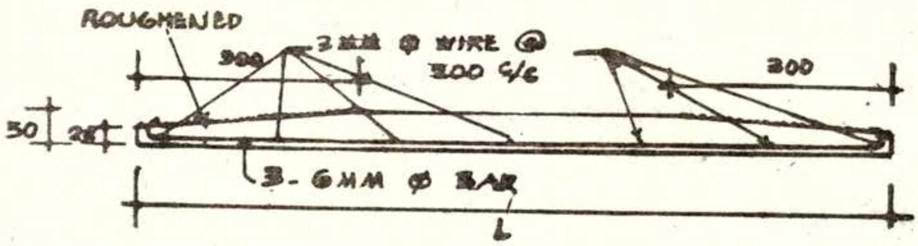
(a) ISOMETRIC VIEW



(b) SECTION AT X.X

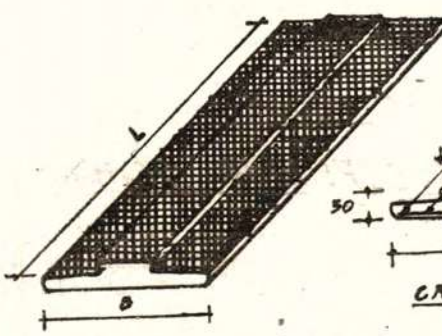


(C) SECTION AT Y-Y

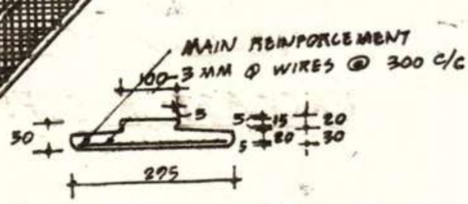


(d) SECTION AT Z-Z

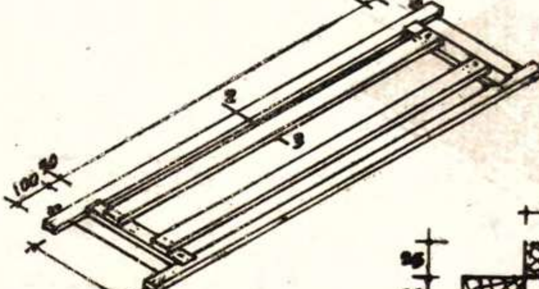
PRECAST R.C. PLANK.



ISOMETRIC VIEW OF PLANK.



CROSS SECTION

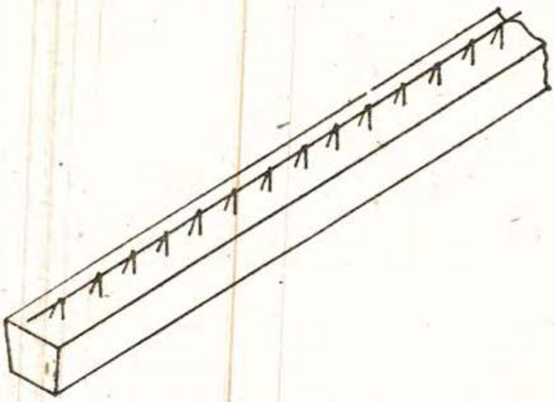


ISOMETRIC VIEW OF BOARD

SECTION ON 2-2

Partially precast R.C. joist.

It is a trapezoidal shaped joist (Fig.). It is designed as a Composite Tee beam with 5.0 cm. thick flange comprising of 2.5 cm precast and 2.5 cm. laid in-situ M-150 concrete.



PARTIALLY PRECAST JOIST

Structural design :

The flooring/roofing scheme is designed on ultimate load method in accordance with IS 456—1964 "Code of Practice for Plain and reinforced concrete". Apart from self weight and live load as specified in IS 875—"Code of pratice for structural safety of buildings-loading standards", a load of 100 kg/m^2 for floor finish in case of intermediate floor and a load of 200 kg/m^2 for waterproofing treatment for roof has been considered. The Precast Plank for floor as well as roo has 3 numbers of 6 mm. dia. M.S. bars as main reinforcement and the transverse reinforcement consists of 3 mm. dia. M. S. wire at 20 cm. c/c.

The joist is designed as simply supported Tee beam with 5.0 cm. thick flange. The reinforcement is provided as per design requirements depending upon the spacing and span of the joist. Ultimate moment of resistance of Tee beam with different reinforcements are given in Table 1 for ready reference.

TABLE—1

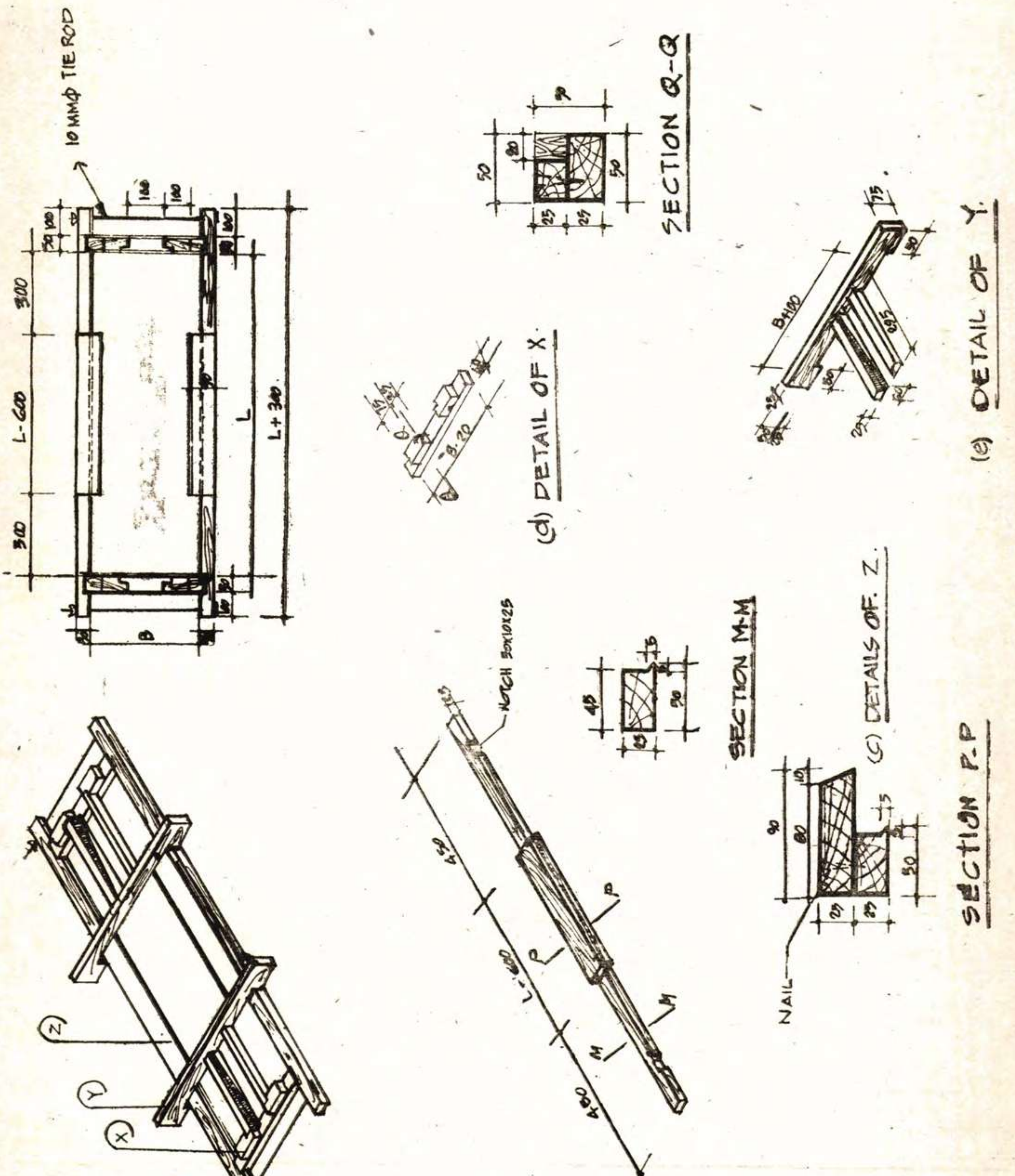
Ultimate moment of reristance with different reinforcement for partially Precast joists (Bottom width 125 mm. *Top width* 150 mm *depth of precast portion* 120 mm, *and overall depth with in-situ concrete* 150 mm).

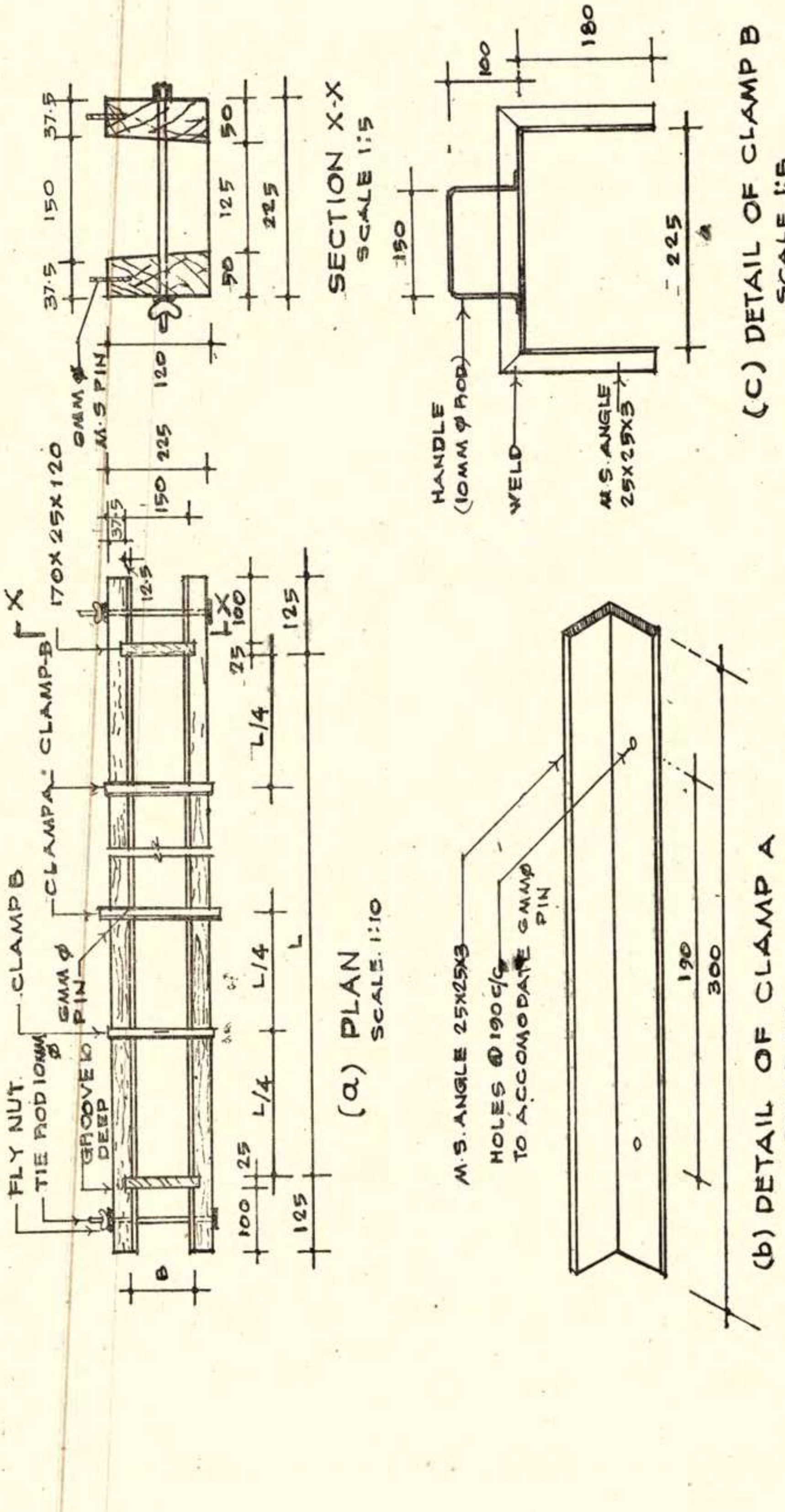
A. M.S. Bars								
Ultimate moment of Resistance (kg. m.)	850	970	1060	1180	1450	1630	1730	1990
Area of Reinforcement (cm^2)	2.356	2.702	3.047	3.393	4.272	4.806	5.152	6.032
Reinforcement.	3–10 mm	2–10 mm +1–12 mm	2–12 mm +1–10 mm	3–12 mm	2–12 mm +1–16 mm	2–16 mm +1–10mm	2–16 mm +1–12 mm	3–16 mm
B. Deformed bars								
Ultimate Moment of Resistance (kg. m.)	920	1200	1300	1350	1530	1710	1870	2200
Area of Reinforcement (cm^2)	1.571	2.073	2.262	2.356	2.702	3.047	3.393	4·273
Reinforcement.	2–10 mm	2–10 mm + 1–8 mm	2–12 mm	3–10 mm	2–10mm +1–12 mm	2–12 mm +1–10 mm	3-12 mm	1–16 mm +2–12mm

NOTE : Mild Steel confiorming to IS 432–1966 and cold twisted plain or deformed bars conforming to IS 1786–1966 are to be use as reinforcement.

Mould :

The mould is made from well seasoned good quality timber, For Precast plank, the mould consists of two longitudinal members, two end pieces and two tapering members (Fig.). The mould for partially precast joist consists of two longitudinal members, two end pieces, Clamp 'A' and clamp 'B' (Fig.).





MOULD FOR PARTIALLY PRECAST JOIST

Casting and curing :—

R. C. plank :

The inner sides of the mould which shall be in contact with concrete are oiled. The bottom frame is assembled and placed on a casting platform having either mould oil applied or wrinkle free paper or G.1. sheet spread in length and width sufficient to cover the mould. The reinforcement cage with mortar cover of 12 mm. is placed inside the mould and M 150 cement concrete with 10 mm and down graded aggregate is poured to a depth such that after compaction with plate vibrator it becomes 2.5 cm. thick. The two tapering members of the mould are then fixed and M150 concrete as above poured in middle and the sides. Compaction of concrete is again done by plate vibrator and concrete finished in level with mould. The top surface is made rough by trowel marking. After half an hour of casting, the two tapering members are lifted up and reused for further casting after cleaning and oiling. The bottom sides of the mould are removed two hours after concreting depending upon weather, by light tamping and opening the nuts. After 24 to 36 hours, the cast unit is first slided by push and then tilted through 90° on long edge. It is transported in vertical position and stacked against a support in the same position for curing by sprinkling water for 14 days and air cured for another 14 days befo re these are laid for floor / roof.

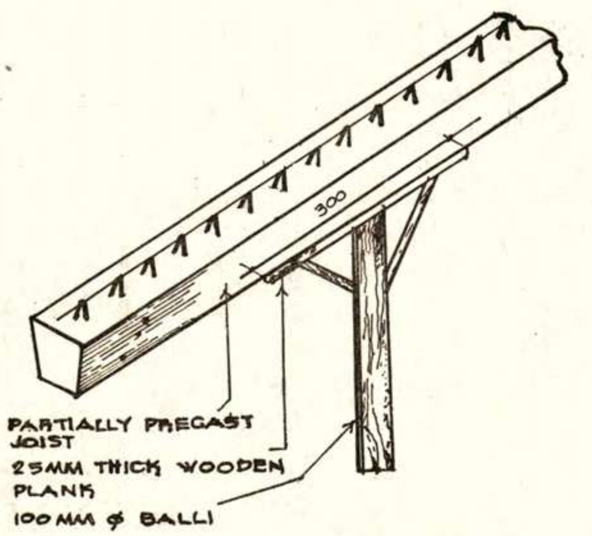
Partially precast joist:

The joist is cast in the normal manner. The reinforcement cage with mortar cover of 20 mm is kept in the mould and clamps 2 to 3 in number depending on the length of joist are fixed over the mould. Cement concrete M 150 with 15 mm and down graded aggregate is poured in the mould and well compacted by placing a Plate Vibrator, on the mould top. The mould is stripped after 3 to 4 hours of casting. The joists are transported to the curing area by holding near the ends. These are water cured for a minimum period of 14 days followed by air drying for 14 days before these are laid in buildings.

Erection and assembly of floor/roof:

The floor/roof is assembled in the following sequence :—

(i) Place the joists in position, align and level. Immediately after erection, prop them at middle with a prop having a timber plank of at least 30 cm length fixed at bearing level (Fig.).

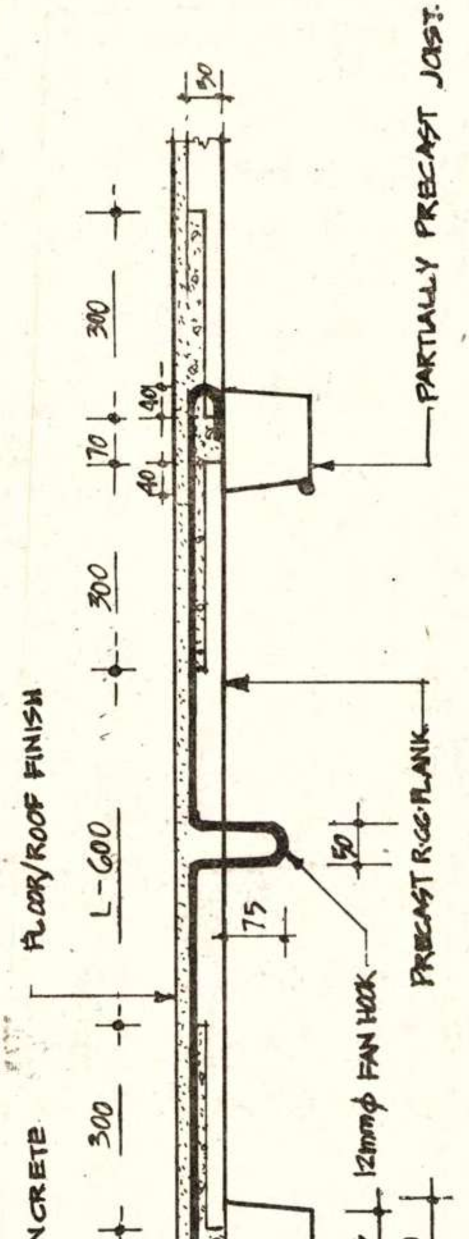


PROPPING OF PARTIALLY-PRECAST JOIST

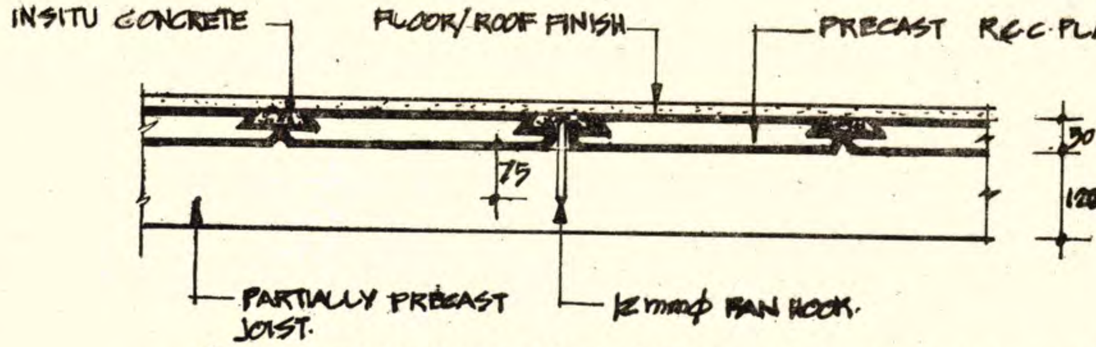
(ii) Level the top surface of the wall and beam with 1 : 6 cement s and mortar where the planks have to bear.

(iii) Place the precast planks over the joists and or wall side by side.

(iv) Provide fan hook while placing the planks over the jois (Fig.).



(a) ALONG THE PRECAST PLANK JOINTS.



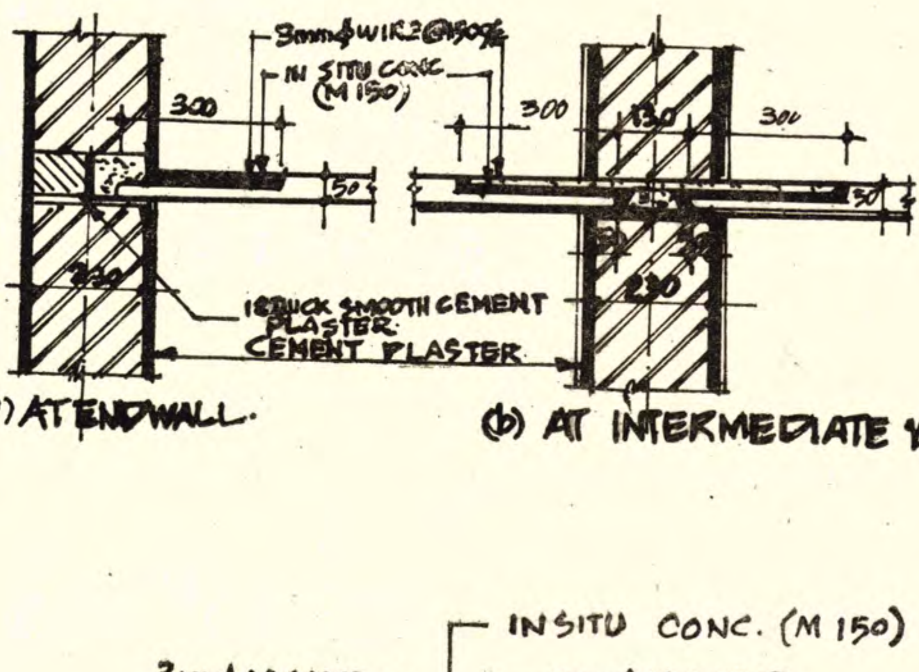
(b) ACROSS THE PRECAST PLANK JOINTS

(v) Place distribution reinforcement of 3 mm dia M.S. wire 2 Nos. parallel to joist and two numbers per plank across the joist in the haunch portion of precast planks and properly tie up with the Projecting reinforcement of joist.

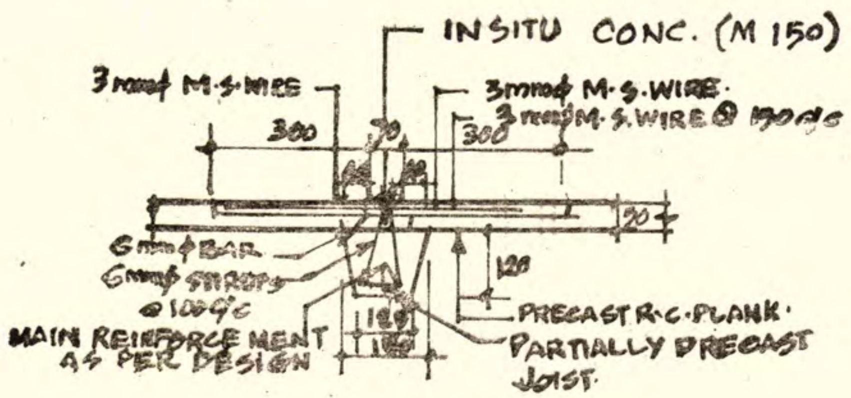
(vi) For roof, in case of continuous span, provide one 10 mm dia. M.S. bar over the support of the joist extending 1/4th of the span on both sides of the wall.

(vii) Apply cement water at 2 kg. cement/10 m² over the precast voist and in haunch portions where in-situ concrete is to be laid.

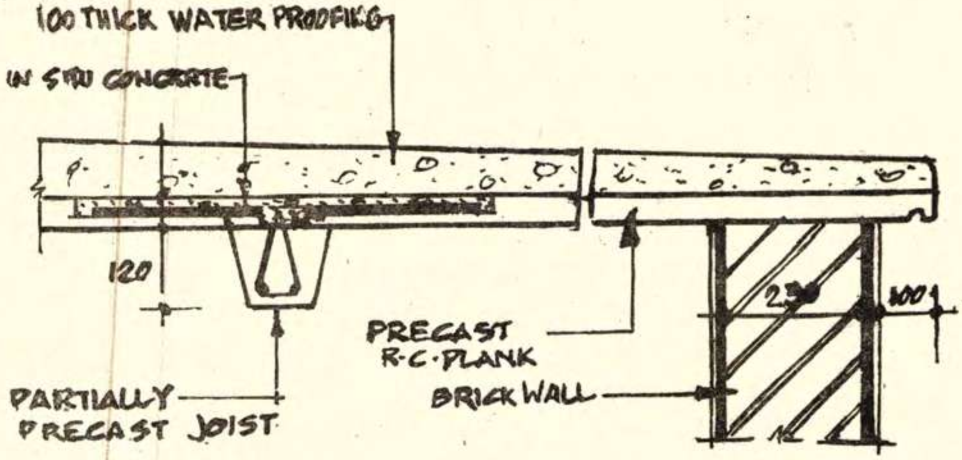
(viii) Lay cement concrete M-150 with 10 mm and down graded coarse aggregate over the joists and in haunches between the planks and level the top flush with the middle portion of plank. The details of in situ concreting for various bearing positions are shown in (Fig.). In case of roof without parapet, it is better to have planks projecting out for avoiding leakage. A maximum projection of 10cm. in planks can be given in either direction shown in Fig. Further, by providing shuttering laying reinforcement and concreting a maximum projection of 50cm can be provided as shown in Fig.

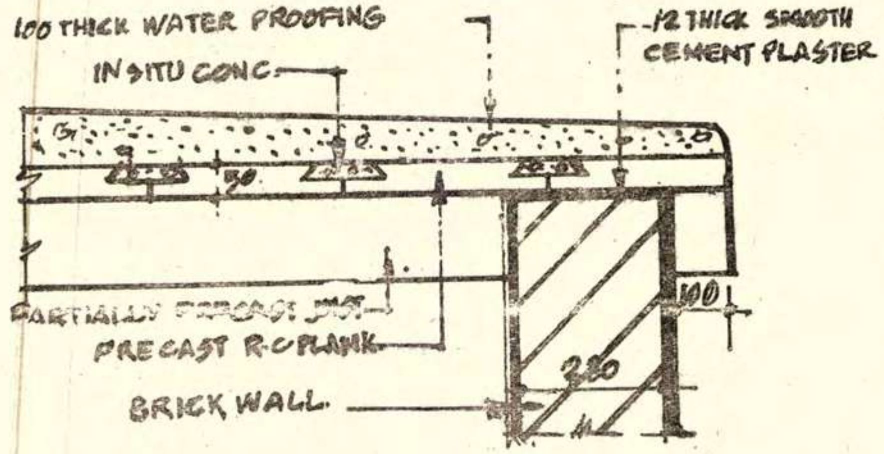


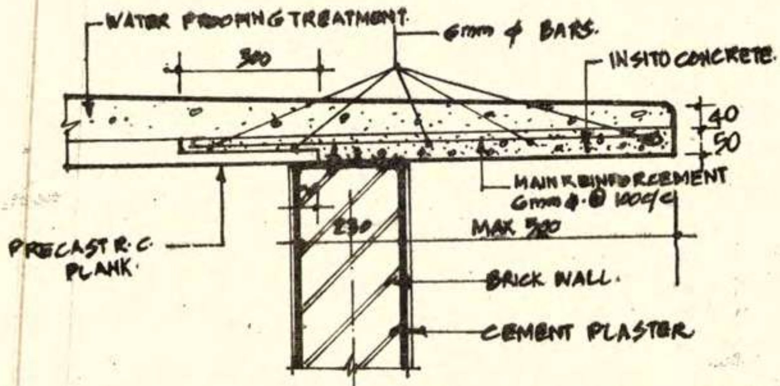
(a) AT END WALL. (b) AT INTERMEDIATE WALL.



(C) AT BEAM SUPPORT.







(C) CANTILEVER AT ROOF LEVEL WITH INSITU CONCRETE.

DETAIL OF ROOF WITHOUT PARAPET.

(ix) Cure the in-situ concrete for a minimum period of 10 days.

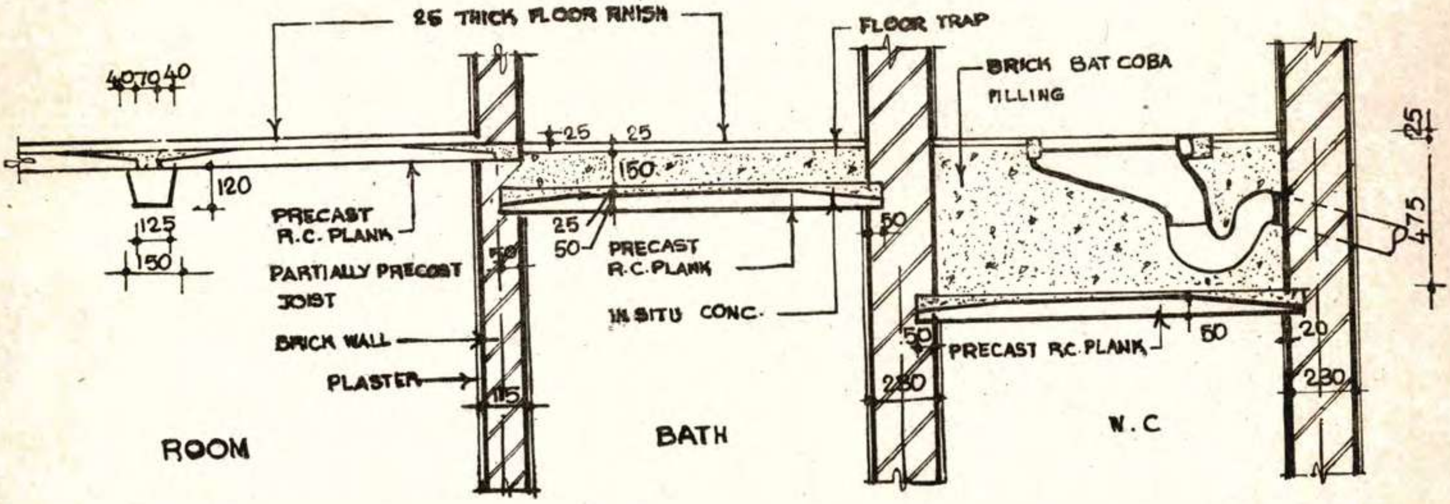
(x) Do not remove the prop of the joist before the curing period is over. In case of double and more storeyed buildings, the prop for the joist should be maintained in all the floors till the in-situ concrete on roof has attained strength to avoid concentrated load at a point.

(xi) Provide floor finish or water proofing treatment directly over the planks as the case may be. In case of in-situ concrete floor, one of the joint of the floor bays should be kept over the joint of the planks.

(xii) Provide 'V' groove pointing in cement sand mortar 1:4 in the ceiling along the joints of planks.

Service Area:

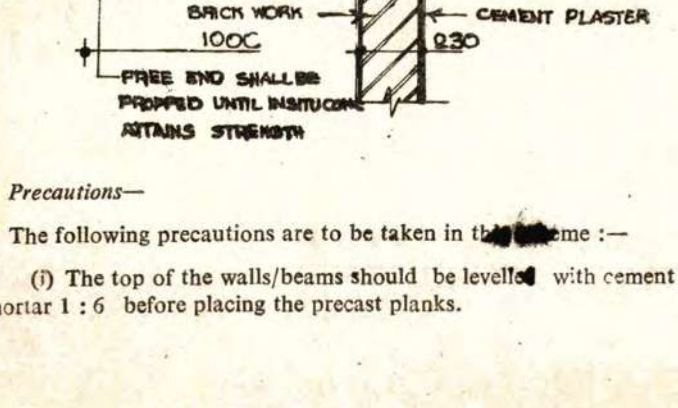
In service area the pipes, floor trap, W.C. pan, etc., are provided, so the supporting slab has to be sunk.



The details are shown in (Fig.). To take care of the additional load of the filling and also to make the floor leak-proof in addition to haunch filling, 2.5 cm thick M-150 concrete is also laid over top of the planks.

Balcony/chajja projections—

Balcony projections are provided along the partially precast joists. The joist is to be designed with an overhang carrying the superimposed loads for balcony as specified in I.S. 875-1964, in addition to the self-load and load due to railing. The main reinforcement of the overhang is provided at the top in the in-situ concrete, the precast portion taking the compression. The free end of the joist is to be propped adequately until the in-situ concrete attains sufficient strength (Fig.).



Precautions—

The following precautions are to be taken in this scheme :—

(i) The top of the walls/beams should be levelled with cement mortar 1 : 6 before placing the precast planks.

(ii) The precast plank should be provided with a minimum bearing of 5·0 cm. and 4·0 cm on the load bearing wall and jois respectively. The joist should be provided a minimum be raring of 10 cm.

(iii) Concentrated load should not be allowed on the planks till the in-situ concrete has set and attained strength.

(iv) Minimum clear cover to the main reinforcement bars should be 12 mm. for planks and 20 mm. for joists.

(v) Partially precast joist should be propped immediately after erection and should be kept in position until the in-situ concrete laid in the haunches attains strength.

(vi) The workers should not walk on the planks before concrete is laid in haunches and has attained strength. Proper cat-walks should be provided resting on joists/walls for carrying out the insitu concreting operation.

(vii) 10 mm. and down graded coarse aggregate should be used both for casting of the planks and filling the haunches between the units. For joists, 15 mm. and down graded aggregate should be used.

(viii) The precast units should be water cured for a minimum period of 14 days followed by air-drying for 14 days before their use in building.

(ix) Partition walls should not be constructed over the planks.

(x) "V" groove pointing on the ceiling should be done after concrete in haunches has been laid.

Material and labour requirements:—

The materials and labour required for preparation of the mould, casting, curing transportation, hoisting and placing of units and completing the structural portion of the floor/roof is given below

The quantity of steel in joist will vary depending upon the span and loads and may be worked out from Table 1. From the basic data given below, the cost of roof/floor can be worked out for any place by putting the prevailing rates of material and labour.

Basic data (For calculation of Cost)—

I. Moulds—

1. Precast R.C. Plank (1,300 × 400 × 50 mm.)—

(*a*) Materials—

Timber (Deodar/Teak)	0·0125 m3
M.S. tie rods 10 mm. Ø 60 cm. long with washer and nut	2 Nos.
Sundries for nails, etc. (L.S.)	Re. 1·00

(*b*) Labour—

Carpenter	0·6 day
Mazdoors	0·6 day

NOTE.—One mould can be used for 60 castings.

2. Partially Precast R.C. Joist (length 3·5 m.)

(*a*) Materials—

Timber (Deodar/Teak)	0·0575m^3
M.S. tie rods 10 mm. dia. 25 cm. long with washer and nut	2 Nos.
M.S. angle iron clamps made of 25 × 25 × 3 mm	2 Nos.

(*b*) Labour—

Carpenter	0·5 day
Mazdoor	0·5 day

NOTE.—One mould can be used for 100 castings.

II. Casting of components.—

1. Precast R.C. Plank (1,300 × 400 × 50 mm)—

(*a*) *Materials—*

Cement	6·24 kg.
Coarse aggregate 10 mm and down	0·0175 m^3
Fine aggregate-sand .. .. (Total Cement concrete) 1 : 2 : 4=0·0196m^3.	0·0088m^3
M.S. reinforcement 6 mm dia. bars	0·90 kg.
M.S. wire 3 mm. dia.	0·14 kg.
G.I. binding wire (24 gauge)	0·01 kg.

(*b*) Labour for Precasting, Curing and Stacking—

Mason	1/20 day
Mazdoor	1/10 day
Bhisti (Waterman)	1/200 day
Barbender	1/40 day
Helper with Barbender	1/80 day

(*c*) Miscellaneous—

Casting platform	Rs. 0·10
Mould oil and old papers..	Rs. 0·10
Vibrator and Electric Charges	Rs. 0·10
T. and P. and Water Charges	Rs. 0·10

NOTE.—With one mould, three to four castings can be done in one day.

2. Partially Precast R.C. Joist (Length 3·50 m)—

(*a*) *Materials—*

Cement	18·40 kg.
Coarse aggregate 15 mm. and down	0·0519 m^3
Fine aggregate-sand ..	0·0259 m^3
(Total cement concrete) 1 : 2 : 4 0·0577 m^3	
M.S. Reinforcement (6 mm. dia. and up to 16 mm. dia)	16·06 kg.
G.I. binding wire (24 gauge)	0·06 kg.

(*b*) ***Labour for Precasting, Curing and Stacking—***

Mason	1/20 day
Mazdoor	3/20 day
Bhisti (Waterman)	1/100 day
Barbender..	1/6 day
Helper with bar bender	1/12 day

(*c*) ***Miscellaneous—***

Casting platform	Re. 0·20
Mould oil and paper	Re. 0·20
Vibrator and Electric Charges	Re. 0·15
T. and P. and water charges	Re. 0·25

NOTE.—With one mould, two castings can be done in one day.

III. Erection and assembly.—

(Transportation within 30 m. lead and erection upto 6 m. lift.)

1. Partially precast joist—

(*a*) *Propping Material—*

(Balli, Wedges, etc.) L.S.	Re. 1·00

(*b*) *Labour—*

Mason	1/20 day
Mazdoor	1/5 day
Carpenter (for propping only)	1/20 day

2. Precast R.C. Plank—

(*a*) *Material—*

(Cement morter 1 : 6)

Cement	0·08 kg.
Sand	0·0003 m^3

(*b*) *Labour—*

Mason	1/40 day
Mazdoor	3/40 day

IV. Insitu concreting between planks and over beams—
(10·0 m² floor/roof area)—

(*a*) *Material—*

Cement	42·75 kg.
Coarse aggregate 10 mm and down	0·120 m³
Fine aggregate-sand (Total cement concrete 1 : 2 : 4=0·1336 m³).	0·060 m³
M.S. 3 mm dia. wire	2·20 kg.
G.I. binding wire (24 gauge)	0·06 kg.

(*b*) *Labour* (upto 6 m lift)—

Mason	1/5 day
Mazdoor	2/5 day
Bhisti (Waterman)	1/5 day
Barbender	1/20 day

(*c*) *Miscellaneous—*

Providing catwalks etc., L.S.	Rs. 2·50
T. and P. and Water charges	Rs. 1·50

V. Finishing—

(10·0 m² floor/roof area) 'V' Groove pointing in cement mortar 1 : 4 for ceiling.

(*a*) *Material—*

Cement	0·8 kg.
Sand	0·002 m³

(*b*) *Labour—*

Mason	1/6 day
Mazdoor	1/6 day
Providing scaffolding (L.S.)	Rs. 2·00

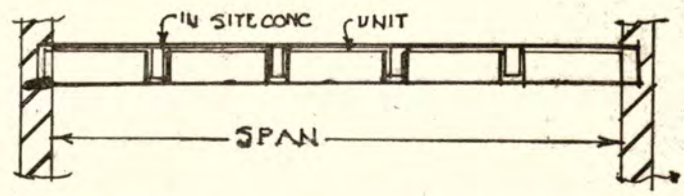
NOTE.—1. The contractor's profit and overheads are to be added.

2. With a gang of 1 mason and 3 Mazdoors having two moulds for joist and four moulds for planks, 4 joists and 16 planks can be cast in one day.

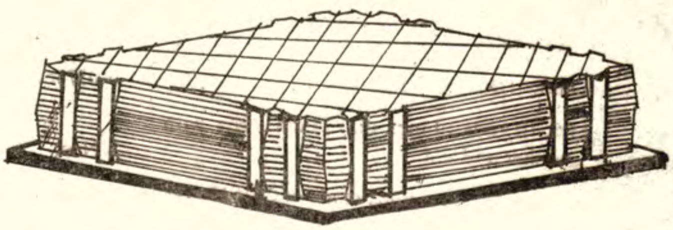
EXTRACT FROM C.B.R.I.
Data Sheet No. 6.

Waffle unit for roof/floor—

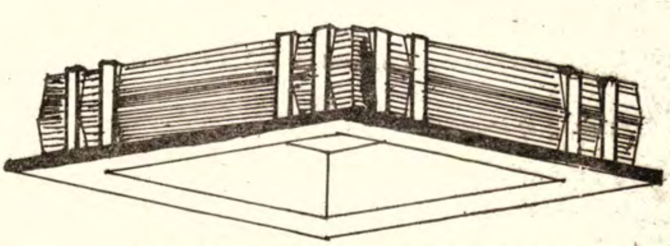
This scheme is suitable for roofs/floors spanning in two directions, having a span of 9 m or above in either direction. It consists of nominally reinforced precast concrete units called waffle units laid in a grid pattern and cast-in-situ concrete in the joints between them, together with the required amount of reinforcement (Fig.) No. deck concrete is provided over the units. The finsihed slab has a pleasant grid pattern in the soffit.



WAFFLE UNITS LAID IN GRID PATTERN



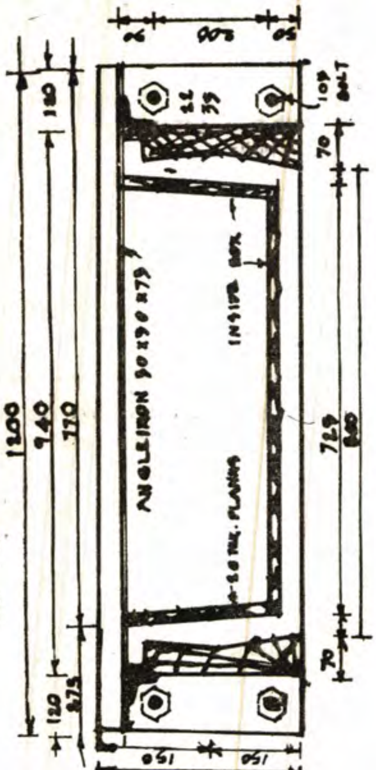
TOP VIEW OF WAFFLE UNIT



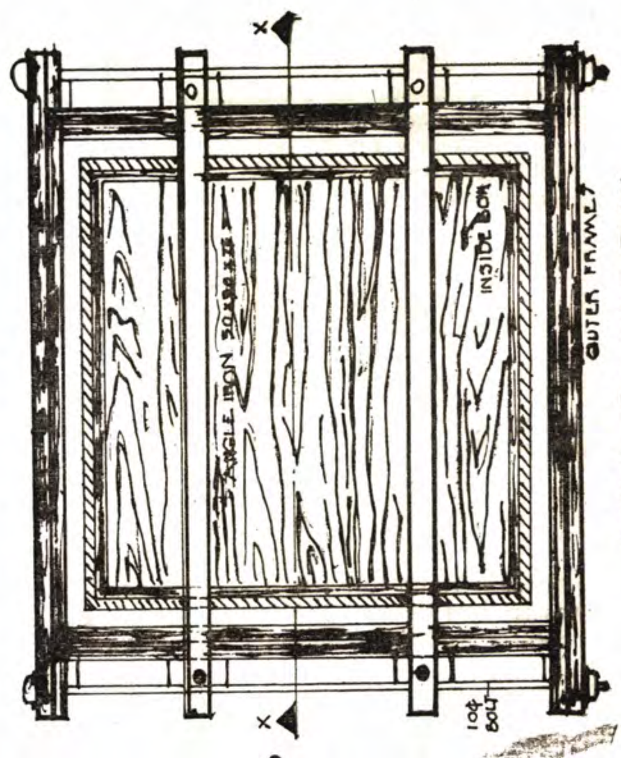
BOTTOM VIEW OF WAFFLE UNIT.

Shape and size.—

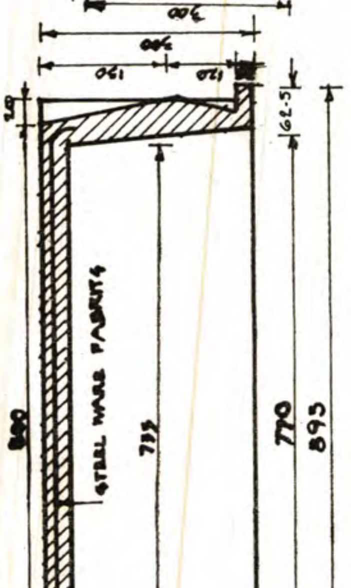
Th units are of the shape of an inverted trough, square or rectangular in plan, having lateral dimensions upto 120 cm. Instead of having projections from the web at the bottom on all the four sides, the units could also be made with projections only on two opposite sides or with no projection at all. The thickness of the top flange and the side webs are as shown in the details (Fig.). Nominal reinforcement is provided in the flnage in the form of steel wire fabric having 3 mm dia. wires @ 15 cm c/c bothways.



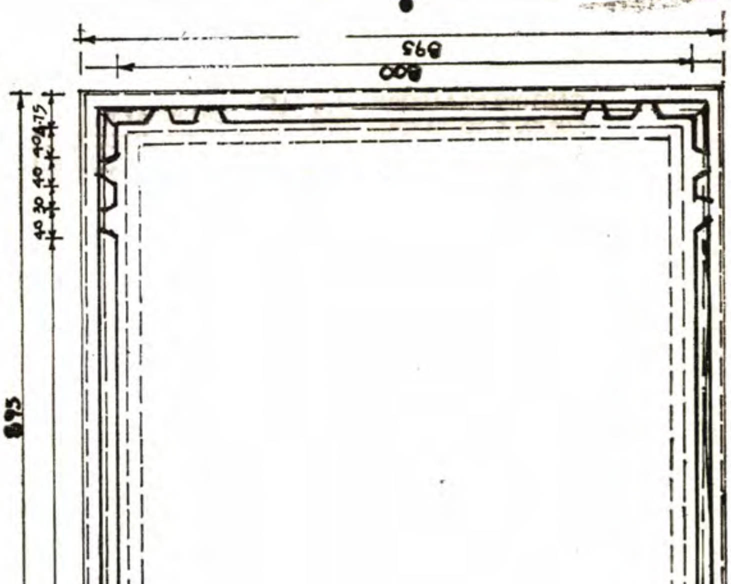
SECTION AT X-X



DETAIL OF MOULD PLAN.



CROSS SECTION OF WAFFLE UNIT.



TOP PLAN OF WAFFLE UNIT.

Structural design :

The gird slabs may be analysed by any of the methods of analysis for two awy slabs given in I.S. : 456-1964 or by any other acceptable method of analysis. The midspan sections are designed as Tee sections with precast flange taking the compression and main reinforcement at the bottom of insitu concrete taking the tension. The suppor sections are designed as doubly reinforced rectangular beams with a wdith equal to the sum of the thicknesses of the precast webs and width of insitu concrete joint. A judicious choice of lateral size of unit and their depth has to be made before proceeding with the abovs calculations.

Tests :

Tests were carried out on the units and slabs in accordance with **I.S.: 456-1964** and were found to be highly satisfactory.

The floor assembly also withstood the ultimate load specified in **the** Code for **which** it was designed without undergoing any excessive **deflection**. The pattern of cracks showed that at the ultimate load, **the** slab behaves in conformity with the yield line theory. When tested for resistance to impact, no apparent distress was observed when sand bags weighing 25 kg. were dropped from a height of 1.2 m.

Mould :

The mould consists, mainly, of two parts as shown in the detail (Fig. .) :

(i) Peripheral frame which forms the sides of the units.

(ii) **Inside box,** which forms the trough, together with two angle iron lifting handles by which the box is removed.

The top of the unit is formed by the casting platform itself.

Material :

(i) *Concrete.*—Normally cement concrete of grade M 150 with **12 mm. and down aggregates are used.** However concrete of higher **strength** may be used, as per design requirement, where required.

(ii) *Reinforcement.*—(*a*) As already mentioned, individual units are reinforced with hard drawn steel wire fabric, consisting of 3 mm dia. wires at a spacing of 15 cm c/c.

(*b*) Main reinforcement in the joints may be either plain mild steel bars or deformed high strength bars, depending on the choice of the designer as also on the availability.

Method of casting and curing :

The units are cast upside down in the following steps. (Fig.):

(i) Three coats of grease-kerosene oil mixture are applied on the casting platform and to the moulds.

(ii) The peripheral frame of the mould is placed on the platform.

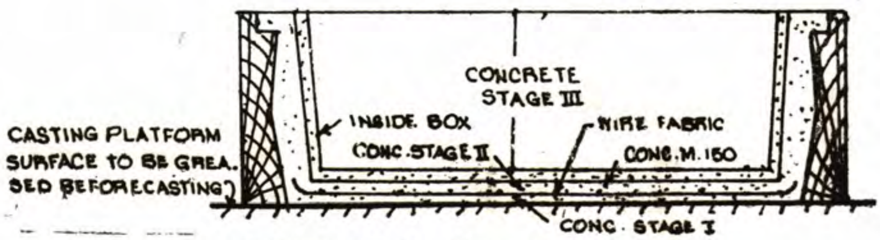
(iii) Fresh concrete of required grade is poured into the frame in an even thickness of about half the flange thickness and compacted.

(iv) The wire fabric reinforcement is placed on the poured concrete and pressed on it.

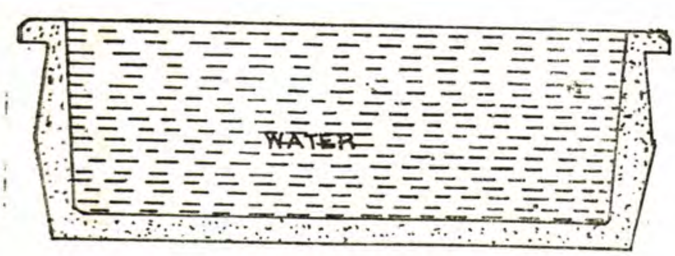
(v) More concrete is poured to a total thickness equal to that of the flange.

(vi) The inside box is put in position.

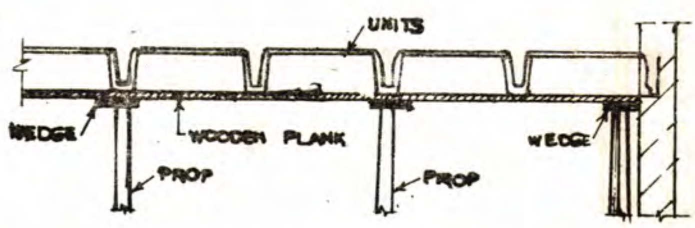
(vii) Concrete is poured to form the webs.



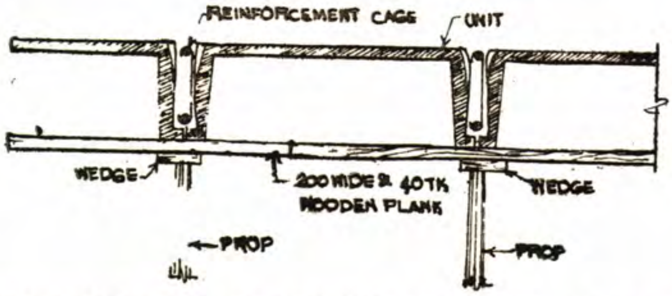
METHOD OF CASTING.



METHOD OF CURING.



FORM WORK FOR SLAB ASSEMBLY.



ARRANGEMENT OF REINFORCEMENT IN SLAB.

(viii) A plate vibrator is put against the mould and vibrated thoroughly.

(ix) After about an hour or so, depending upon the weather, the inside box is removed and the inside faces are given a finishing touch.

(x) After about 24 hours, the unit, together with the peripheral frame, is slightly moved to break the bond between the platform and the unit, if there is any.

(xi) Next, the peripheral frame is removed.

(xii) The unit is cured by ponding water in it for 14 days and for about another week in air.

(xiii) The unit is now ready for use in construction.

Formwork for slab assembly :

Partial shuttering (Fig.) is necessary for supporting the slab assembly during the construction and its attainment of strength. 200 mm. wide and 40 mm. thick planks at a spacing equal to the nominal size of the units are placed in one direction only, supported by adequate propping and shoring at the desired level.

Assembly of roof/floor slabs :

The main assembly is done in the following steps (Fig.):—

(i) The supporting formwork is levelled and checked.

(ii) Units are lifted and placed on the shuttering in grid pattern.

(iii) Reinforcement cage is placed together with spacer block to maintain cover.

(iv) Fresh concrete of required grade is poured in the joint and made flush with the top of the unit.

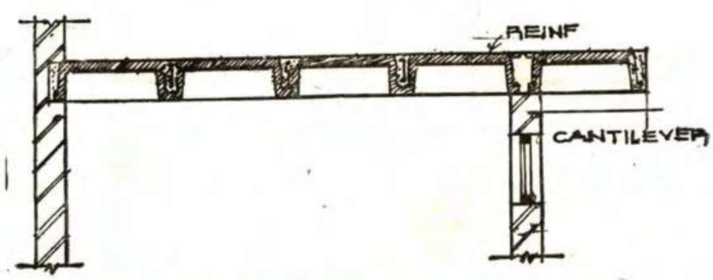
(v) It is compacted properly by rodding or by a plate vibrator.

(vi) Water cured for at least 14 days.

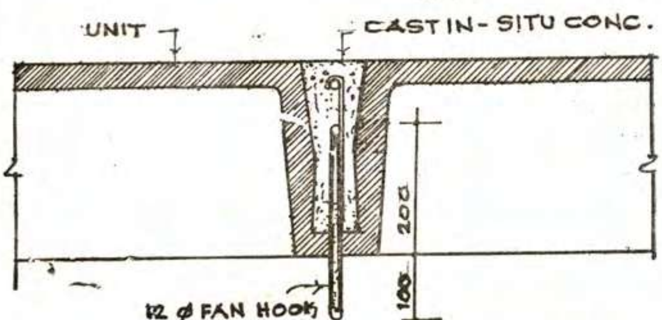
(vii) Shuttering may be struck off after 14 days of casting.

Balcony/chajja projections :

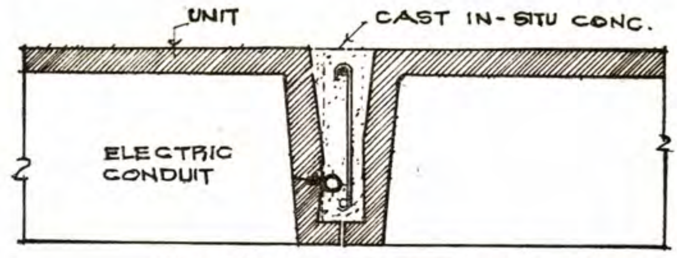
These could be achieved by projecting the slabs over the walls or beams as shown in the detail (Fig.). The analysis for design will be same as that for a conventional RCC slab, on the basis of any accepted method of analysis.



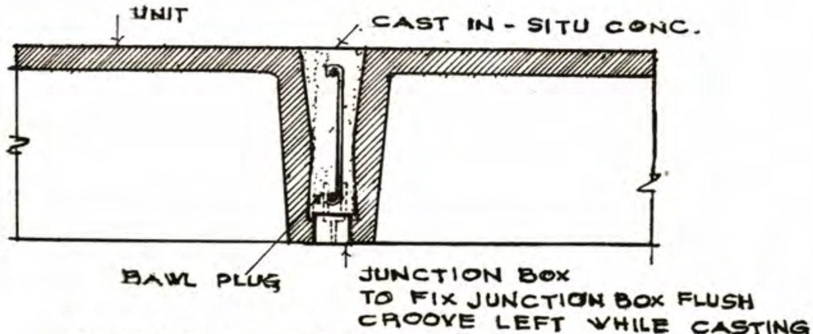
BALCONY/CHAJJA PROJECTION



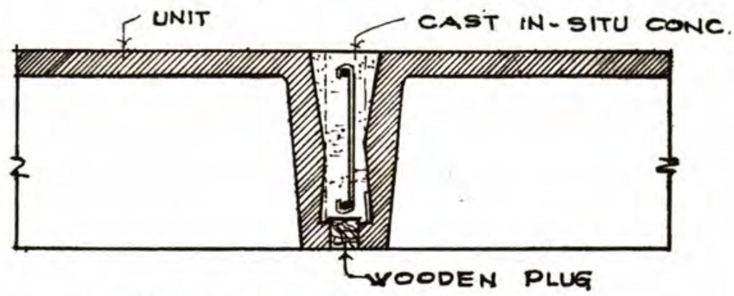
FIXING OF FAN HOOK



PLACING OF CONDUIT PIPE



FIXING OF JUNCTION BOX



FIXING OF WOODEN PLUG

Fixtures.

Various fixtures like fan hooks, electric conduits, etc., can be fixed in the following manner :—

(i) *Fan hooks.*—Casting them in the cast in-situ concrete of the joints (Fig.). Slight chipping of the edges, for allowing the projection of the hook below the ceiling and keeping the spacing of the units uniform, may be done.

(ii) *Electric conduits, junction box and wooden plugs.*— Conduit of maximum diameter of 20 mm. can be taken through the joints between the units (Fig.). Junction box and wooden plugs can also be placed in the joints as shown in the details (Fig.). The positions of these fixtures should be decided before hand, so that all of them can be placed in position at the time of in-situ concreting.

Precautions.

1. The concrete used shall be of the specified grade with 12 mm. and down graded coarse aggregate. The water-cement ratio for the concrete mix shall be controlled such that the cement slurry does not flow out of the mould during vibration, but only a thin layer of water appears on the top.

2. While casting the units, the concrete shall be thoroughly compacted by means of a plate vibrator and by tamping on the outside of the mould.

3. The units shall be handled carefully to prevent breakage of edges and corners.

4. Holes, fixtures, etc., required for electrical fittings, and other services shall be preplanned and provided in the unit during casting. No portion of the unit shall be broken or chipped off once it is cast, except as indicated in this Data Sheet.

5. Only units fully cured for a minimum period of 28 days after casting, free from damage and cracks and sound in all respects shall be used in making floor/roof.

6. The shuttering shall be inspected and approved by the Engineer in-charge. before the units are lifted and placed on it.

7. After placing the units, the alignment shall be checked in both the directions with strings to ensure that the ribs are straight. In no case, a deviation of more than 5 mm. shall be permitted throughout the length.

8. Before filling the joints between the units with concrete, the sides of the units shall be cleaned and wetted and a coat of cement slurry with 0·5 kg. of cement per square metre of the area shall be applied with a wide brush or cloth.

9. During concreting, care shall be taken to ensure that the reinforcement remains in its proper place.

Material and labour requirement :

The labour and materials required for fabrication of the mould, shuttering, casting, curing, transportation, hoisting and placing of the units, fabricating and placing the reinforcement, filling the joints with concrete and finishing the ceiling are given below. From this basic data, knowing the prevailing rates of labour and materials, the cost could be worked out for any place. The data given here is for 10 sq. m. of area and the nominal size of waffle unit has been taken as 100 × 100 × 30 cm. The actual quantity of steel required will vary depending upon the span and loads and whether the roof/floor is designed as simply supported or continuous.

1. *Mould* (*One No.*)—

(*a*) *Material*—

Deodar wood	0·146 cu. m.
G.I. sheet 26 gauge	1·87 sq. m.
Angle iron 50 × 50 × 6 mm.	11·0 kg.
10 mm. dia bolt 1·10 m. long with nut and washer (2 Nos.)	1·5 kg.
Add for nails, screws, etc. L.S.	Rs. 2·00

(*b*) *Labour*—

Carpenter	1·5 mandays
Mazdoor	1·5 mandays
Fitter	1/4 manday

NOTE.—A mould can be reused 100 times. With one mould, two units can be cast per day.

2· *Casting*—

(*a*) *Material*—

Cement	4 bags
Fine aggregate	0·27 cu. m.
Coarse aggregate	0·54 cu. m.
3 mm. dia steel wire	8·0 kg.

(*b*) *Labour*—

Mason	2·0 mandays
Bar bender	0·1 manday
Mazdoor	4·0 mandays
Bhisti	0·5 manday

(*c*) *Miscellaneous*—

Casting platform L.S.	Rs. 2·00
Burnt engine oil, used newspaper, T & P, etc. L.S.	Rs. 4·00
Mixer and vibrator L.S.	Rs. 2·00
Electricity	1 K.W.H.
Water	1 K. litre

3. *Shuttering*—

(*a*) *Material*—

7·5 cm. dia. ballies 3·5 m. long	8 Nos.
15 cm. × 4 cm. planks	8 m.
2·5 cm. dia. bamboo for bracing	8 Nos.
(These materials can be reused 16 times)	
Nails, etc. L.S.	Rs. 2·00

(*b*) *Labour*—

Carpenter	1/2 manday
Mazdoor	1/2 manday

4. *Transportation, placing in position and concreting*—

(*a*) *Material*—

Cement	3·4 bags
Fine aggregate	0·23 cu. m.
Course aggregate (12 mm. and down) ..	0·46 cu. m.
Steel	90 kg.
T & P, etc. L.S.	Rs. 5·00

(*b*) *Labour*—

Mason	1 manday
Bar bender	0·9 manday
Mazdoor	4 mandays
Bhisti	1/3 manday

5. *Finishing*—

(*a*) *Material*—

Cement	0·15 bag.
Sand	0·015 cu.m.

(*b*) *Labour*—

Mason	1/8 manday
Mazdoor	1/4 manday

(*c*) Scaffolding L.S. .. .. Rs. 2·00

EXTRACT FROM I.S. 2911 (PART III) 1980.

Code of practice for design and construction of pile foundations Part III—under reamed piles.

2. *Terminology* :

2.0. For the purpose of this standard, the following definitions shall apply.

2.1. *Allowable load.*—The load which may be applied to a pile after taking into account its ultimate load capacity, pile spacing overall bearing capacity of the ground below the pile, the allowable settlement, negative skin friction and the loading conditions including reversal of loads.

2.2. *Batter pile* (*Raker pile*).—The pile which is installed at an angle to the vertical.

2.3. *B a ing pil:.*—A pile formed in the ground for transmitting the load of structure to the soil by the resistance developed at its or along its surface or both. It may be formed either vertically or at an inclination (Batter Pile) and may be required to take uplift. When it is primarily meant for resisting uplift or pull it is called an 'Anchor pile'. If the pile supports the load primarily by resistance developed at the pile point or base it is referred to as an 'End Bearing Pile' and if the load is supported primarily by friction along its surface, the pile is termed as 'Friction Pile'.

2.4. *Bored cast in situ pile.*—A pile formed within the ground by excavating or boring a hole within it, with or without the use of a temporary casing and subsequently filling it with plain or reinforced concrete. When the easing is left permanently it is termed as cased pile and when the easing is taken out it is termed as uncased pile. In installing a bored pile, the sides of the borehole (when it does. not stand by itself) is required to be stabilized with the aid of a temporary casing, or with the aid of drilling mud of suitable consistency.

2.5. *Bored compaction pile.*—A board cast *in situ* pile with or without bulb(s) in which the compaction of surrounding ground and freshly filled concrete in pile bore is simultaneously achieved by suitable mothod. If the pile with bulb(s), it is known 'under-reamed bored compaction pile'.

2.6. *Cut-off level.*—It is the level where the installed pile is cut-off to support the pile caps or beams or any other structural components at that level.

2.7. *Datum bar.*—A rigid bar placed on immovable supports.

2.8. *Factor of safety.*—The ratio of the ultimate load capacity of a pile to the safe load of a pile.

2.9. *Initial test.*—It is carried out on test pile(s) generally made for the purpose with a view to determining the safe load or ultimate load capacity or both.

2.10. *Kentledge.*—Dead weight used for applying a test load on pile.

2.11. *Multi-under-reamed pile.*—An under-reamed pile having more than one bulb. The pile having two bulbs is known as double under-reamed pile.

2.12. *Net displacement,*—Net movement of the pile top after the pile has been subjected to a test load and subsequently released.

2.13. *Routine (Check) tests.*—It is carried out on a working pile with a view to determining displacement corresponding to the allowable load.

2.14. *Safe load.*—It is a load on a pile derived by applying a factor of safety on ultimate load capacity of pile or as determined by pile load test or as obtained in accordance with *5.2.3.3.*

2.15. *Test pile.*—A pile which is selected for load-testing and which is subsequently loaded for that purpose. The test pile may form a working pile itself if subject to routine load test with up to one and one-half times the safe load in case of compression test and equal to safe load in uplift and lateral thrust.

2.16. *Total displaeement (Gross).*—The total movement of the pile top under a given load.

2.17. *Total elastic displacement.*—This is the magnitude of the displacement of the pile due to rebound cuased at the top after removal of given test load. This comprises two components as follows :—

(*a*) Elastic displacement of the soil participating in load transfer; and

(*b*) Elastic displacement of the pile shaft.

2.18. *Trial pile.*—One or more piles, which are not working pile, that may be installed initially to assess load carrying capacity of the piles. These are tested either to their ultimate bearing capacity or to twice estimated safe load.

2.19. *Ultimate load capacity.*—The maximum load which a pile can carry before failure of ground (when the soil fails by shear) or failure of pile materials.

2.20. *Under-reamed pile.*—A bored cast *in situ* or bored compaction concrete pile with an enlarged bulb(s) made by either cutting or scooping out the soil or by any other suitable process.

2.21. *Working load.*—The load assigned to a pile according to design.

2.22. *Working pile.*—A pile forming part of foundation of a structural system.

3. *Necessary information.*

3.1 For the satisfactory design and construction of bored cast *in situ* and bored compacted under-reamed piles and the pile foundation, the information on the following aspects is necessary.

(*a*) Site investigation data as laid down in IS : 1892-1979* or any other relevant Indian Standard. Sections of trial borings, supplemented wherever appropriate by penetration tests, should incorporate data/information sufficiently on soil condition below the anticipated level of pile tip.

The nature of the subsoil both around and beneath the proposed pile should be indicated on the basis of appropriate tests of strength, compressibility, etc., Ground-water levels and conditions (such as artesian conditions) should be indicated be Rsesults of chemical tests to ascertain the sulphate and the chloride content and ground-water should be indicated particularly in areas where large scale piling is envisaged or where such information is not generally available.

(*b*) A qualitative indication of the degree of expansiveness of soil is given in Appendix A. The free swell test will be carried out according to IS: 2720 (Part XL)-1977

(*c*) In case of bridge foundations, data on high flood level, maximum scouring depth, normal water level during working season, etc.

Method of test for soils, Part XL Determination of free swells index of soils.

In case of marine construction, necessary information as listed in IS : 4651 (Part I)-1974 should be provided.

(*d*) In case rock is encountered, adequate description of the rock to convey its physical conditions as well as its strength characteristics should be indicated.

In case of weathered rock, adequate physical description and its expected physical behaviour on boring should be indicated.

(*e*) General plan and cross section of the building showing type of structural frame, including basement, if any, in relation to the proposed pile cap top levels.

(*f*) The general layout of the structure showing estimated load vertical and horizontal, moments and torque at the top of pile caps, but excluding the weight of the piles and caps. The top levels, of finished pile caps shall be clearly indicated.

(g) It is preferable to have the dead load, equipment and live loads separately indicated. Loads and monoments for wind and earthquake should also be separately indicated.

(h) Sufficient information about structure existing near by should be provided.

3.2. As far as possible, all information in **3.1** shall bemade availble to the agency responsible for the design and/or construction of piles and/or foundation work.

3.3. The design details of pile foundation shall indicate the information necessary for setting out the layout of each pile within a cap, cut-off levels, finished cap levels. orientation of cap in the foundation plan and the safe capacity of each type of piles, etc.,

3.4. Due note shall be taken of the experience of under-reamed and other piles in the area close to the proposed site and any soil strata report thereof.

4. *Materials.*

4.1. *Cement.*—The cement used shall conform to the requirement of I.S: 269-1976, IS: 455-1976, IS: 8041-1978, IS: 6909-1973 IS: 1489-1976.

4.2. *Steel.*—Reinforcement steel shall conform to I,S, 432 part 1 1966 or IS: 1139-1966 or IS: 1786-1979 or IS: 226-175. The stresses allowed in steel should conform to IS: 456-1978.

4.2.1 For under-reamed bored compaction piles, the reinforcement cage shall be prepared by welding the hoop bars to withstand the stresses during compaction process.

4.3 *Concrete.*

4.3.1. Materials and methods of manufacture for cement concrete shall in general be in accordance with the method of concreting under the conditions of pile installation.

4.3.2 Consistency of concrete for cast *in situ* piles shall be suitable to the method of installation of piles. Concrete shall be so designed or chosen as to have homogeneous mix having a flowable character consistent with the method of concreting under the given condition of pile installation. In acheiving these results, minor dieviations in the mix proportions used in structual concrete may be necessary.

4.3.3. Slump of concrete shall range between 100 mm to 150 mm for concreting in water-free unlined boreholse. For concreting by tremie, a slump of 150 mm to 200 mm shall be used.

4.3.4 In case of tremie concreting for piles of smaller diameter and depth of up to 10m, the minimum cement content should be 350kg/m3 of concrete. For piles of large diameter and/or deeper piles, the minimum cement content should be 400kg/m3 of concrete. For design purpose, the strength of concrete mix may be taken equivalent to M15 and M20. respectively, for concrete with cement of 350 kg/m3 and 400 kg/m^3. Where concrete of higher strength is needed, richer concrete mix with higher cement content may be designed. In case of piles subsequently exposed to free water or in case of piles where concreting is done under water or drilling mud using methods other than the tremie 10 percent extra cement over that required for the design grade of concrete at the specified slump shall be used subject to the minmum quantities of cement specified above.

4.3.5 For the concrete, water and aggregates specifications laid down in IS: 456-1978 shall be followed in general. Natural rounded shingle of a appropriate size may also be used as coarsed aggregate. It helps to give high slump with less water cement ratio. For tremic concreting aggregates having nominal size more than 20mm should not be used.

4.3.6. The concrete for piles in aggressive surrounding due to presence of sulphates, etc., should have a concrete mix of appropriate type of cement in suitable proportion.

4.3.6.1. If the concentration of sulphates (measured as SO3) exceeds one percent in soil or 2500 parts per million (ppm) in water a mix using 400 Kg/m3 of sulphate resisting Portland cement should be used. For soils with 0.5 to 1 per cent of sulphates or ground water with 1,200 to 2,500 ppm, the mix should have 330 kg/m3 of sulphate resisting Portland cement. For concentrations lesser than above concrete mix with 330 kg/m3 ordinary Portland cement or 310 kg/m3 sulphate resisting should be used. In place of ordinay Portland cement, pozzolana cement/blast furnace slag cement may be used.

4.3.6.2. Concentration of sulphates up to 0.2 per cent in soi and 300 ppm in water may be inconsequential.

4.3.7. For bored compaction piles rapid hardening cement (*see* **4.1**) shall not be used. To facilitate construction, admixtures for retardin the setting of concrete may be used.

5. *Design considerations.*

5.1. *General*—Under-reamed pile foundations shall be designed in such a way that the load from the structure they support, can be transmitted to the soil without causing any soil failure and without causing such settlement, differential or total, under permanent transient loading as may result in structural damage and/or functional distress. The pile shaft should have adequate structural capacity to withstand all loads (vertical, axial or otherwise) and moments which are to be transmitted to the subsoil.

5.1.1. In deep deposits of expansive soils the minimum length of piles, irrespective of any other considerations, shall be 3.5 m below ground level. If the expansive soil deposits are of shallow depth and overlying non-expansive soil strata of good bearing or rock, piles of smaller length can also be provided. In recently filled up grounds or other strata or poor bearing, the piles should pass through them and rest in good bearing strata.

5.1.2. The diameter of under-reamed bulbs may vary from **2 to 3** times stem diameter depending upon the feasibility of construction and design requirements. In bored cast *in situ* under-reamed pile the bulb diameter shall normally be 2.5 times, and in under reamed compaction piles two times.

5.1.3. For piles up to 30 cm diameter, the spacing of bulbs should not exceed **1.5 times** the diameter of bulb. For piles of diameter greater than 30 cm spacing can be reduced to **1.25** times the steam diameter.

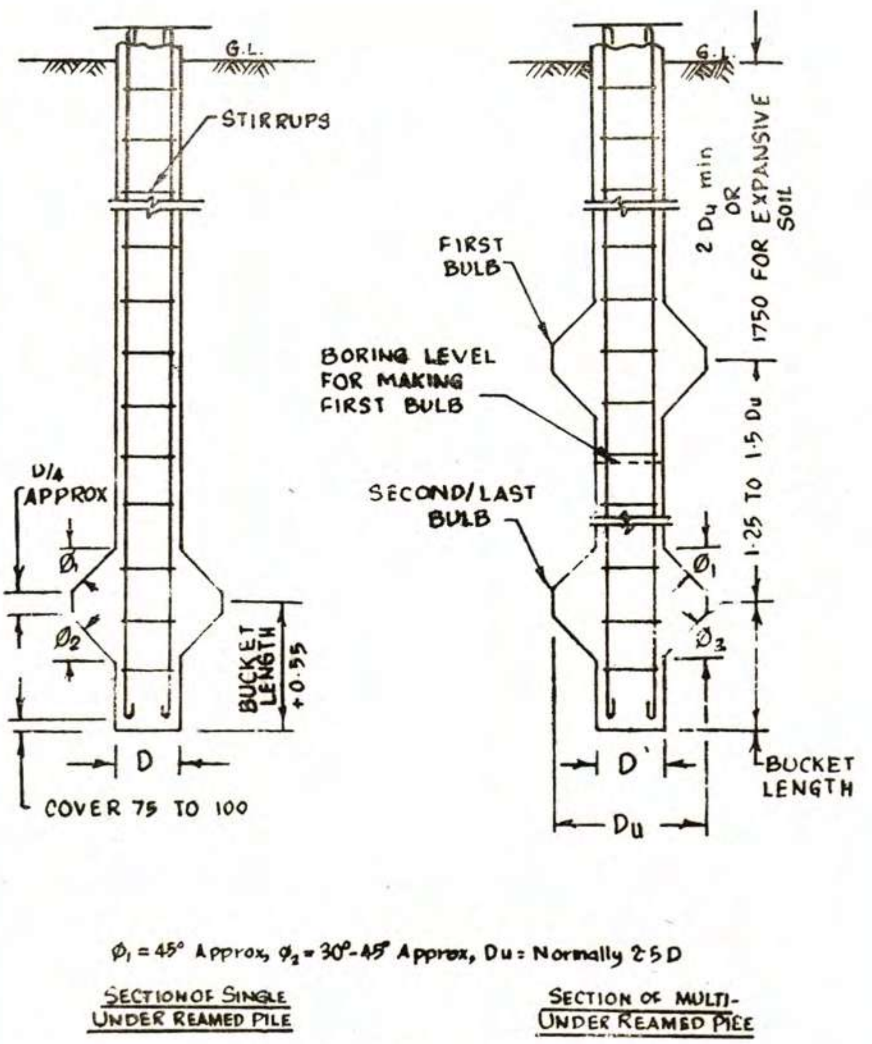
5.1.4. The top-most bulb should be at a minimum depth of 2 times the bulb diameter. In expansive soils it should also not be less than 1.75 m below ground level. The minimum clearance below the underside of pile cap embedded in the ground and the bulb should be a minimum 1.5 times the bulb diameter.

5.1.5. Under-reamed piles with more than two bulbs are n advisable without ensuring their feasibility in strata needing stabiliz-tion of boreholes by drilling mud. The number of bulbs in case of bored compaction piles should not exceed two in such strata.

5.1.6. The minimum diameter of stem for borehole needing stabili-zation by drilling mud should be 25 cm.

5.1.7. The minimum diameter of steam for strata consisting of harmful constituents, such as sulphates, should be 30 cm.

5.1.8. For guidance typical details of bored cast *in situ* under-reamed pile foundations are shown in Fig.



TYPICAL DETAILS OF BORED CAST *in situ* UNDER-REAMED PILE FOUNDATIONS

5.1.9. For batter piles, a batter of 30° for piles in dry ground ›nditions and 15° with horizontal for water or drilling mud filled ›les should generally not be exceeded. The under-reamed compac- ›n piles are normally constructed up to a batter of 15°.

5.2. *Design of piles*—The load carrying capacity of under-reamed le depends mainly on the pile diamensions and soil strata. Axial ›ad on a pile is transmitted by point bearing at the toe and the rojected area of the bulb(s) and skin friction along the pile stem. ›epending upon the nature of soil and pile geometry, in addition › the skin friction on steam, friction can develop on the soil cylinder etween the extreme bulbs. In under-reamed compaction piles ıe mechanism of load transfer remains the same but soil properties nproved by compaction process are considered. In uplift load, oint bearing component at toe is absent but unlike other straight ıaft piles, point bearing on an anular projection of the bulb is present ateral load and moment are sustained by horizontal soil reaction eveloped along the pile length, which depends on several factors.

The design of piles be such that it has an adequate factor of safety :

(*a*) as a structural member to transmit the imposed loads, and

(*b*) against failure of strata due to reaching ultimate strength. 'urther it should ensure that the desired limit of settlement is not xceeded.

5.2.1. *Pile as a structural member*—The pile should have adequate trength to sustain the design loads. The pile cross-section should ›e checked for combined effect of vertical loads (compressive and ıplift) and/or lateral loads and moments. The stem should be lesigned as a short column considerating both concrete and steel *see* 5.2.2.) by the limit state method or working stress method. In ase of latter, the permissible increase in stresses shall be taken for vind and seismic loads. (*see* IS : 875-1964 and IS : 1893-1975.)

5.2.2. *Reinforcement in Piles.*—The provision of reinforcement vill depend on nature and magnitude of loads, nature of strata and nethod of installation. It should be adequate for vertical load, ateral load and moments, acting individually or in combination. t may be curtailed at appropriate depth subject to provision given n *5.2.2.1.* and *5.2.2.2.*

5.2.2.1. The minimum area of longitudinal reinforcement in tem should be 0.4 per cent of mild steel (or equivalent deformed steel). Reinforcement is to be provided in the full length irrespective of any ›ther considerations and is further subject to the condition that a ninimum number of three 10-mm diameter mild steel or three 8-mm liameter high strength steel bars shall be provided. The transverse einforcement as circular strirups shall not be less than 6-mm diameter nild steel bars at a spacing of not more than the stem diameter or ›0 cm whichever is less

In under-reamed compaction piles, a minimum number of four, 2-mm diameter mild steel or four 10-mm diameter high strength teel bars shall be provided. For piles of lenghths exceeding 5 m ınd or 37.5 cm diameter, a minimum number of six 12-mm diameter ›ars of mild or high strength steel shall be provided. For piles ›xceeding 40 cm. dia, a minimum number of six 12-mm diameter nild or high strength steel bars shall be provided. The circular tirrups for piles of lengths exceeding 5 m. and diameter exceeding 37.5 cm. shall be of 8 mm. diameter bars.

5.2.2.2. For piles subjected to uplift loads, adequate reinforcement shall be provided to take full uplift which shall not be curtailed ıt any stage.

5.2.2.3. For piles up to 30 cm. diameter, if concreting is done by tremie, equivalent amount of steel placed centrally may be provided

5.2.2.4. The minimum clear over the longitudinal reinforcement shall be 40 mm. In aggressive enviornment of sulphates, etc., it may be increased to 75 mm.

5.2.3. *Safe Load.*—Safe load on a pile can be determined from (*a*) calculating ultimate load from soil properties and applying suitable factor of safety, (*b*) load test on pile as provided in IS : 2911 (Part IV)-1979 a ıd (*c*) Sa fe load tables.

5.2.3.1. *Safe load from ultimate load capacity.*—The ultimate load capacity of a pile can be calculated from soil properties. The soil properties required are strength parameters, cohesion, angle of internal friction and soil density. If these properties are not available directly from laboratory and field tests, they may be indirectly obtained from *in situ* penetration test data (IS : 4968 (Part II)-1976 and IS : 6403-1971). The success of the approach essentially depends how realistically the soil properties are determined or deduceǔ

(*a*) *Clayey soils.*

For clayey soils the ultimate load carrying capacity of an under-reamed pile may be worked out from the following expressions :

$$Qu = Ap\ Nc\ Cp + Aa\ Nc\ C^1a + C^1a_1\ A^1s + \propto .\ Ca.\ As$$

where

Qu (kg) = ultimate bearing capacity of pile ;

Ap (cm^2) = cross-sectional area of pile stem at toe level ;

Nc—bearing capacity factor, usually taken as 9 ;.

Cp (kgf/cm^2)—cohesion of the soil around toe ;

Aa (cm^2)—$\overline{\overline{\sqcap}}/4\ (D^2u - D^2)$ where Du (cm) and D (cm) are the under-reamed bulb and stem diameter, respectively ;

C^1a (kgf/cm^2)—average cohesion of soil around the under-reamed bulbs ;

$\propto$ —reduction factor (usually taken 0.5 for clays) ;

Ca (kgf/cm^2)—average cohesion of the soil along the pile st‹ m

As (cm^2)—surface area of the stem ; and

A^1s (cm^2)—surface area of the cylinder circumscribing the under reamed bulbs.

The above expression holds for the usual spacing of under-ream‹ d bulbs spaced at not more than one-and-a half times their diameter.

NOTE 1.—The first two terms in formula are for bearing and the last two for friction components.

NOTE 2.—If the pile is with one bulb only the third term will not occur.

NOTE 3.—For calculating uplift load first term will not occur in formula.

Sandy soils.

For sandy soils the following expression be used :

$$\begin{aligned} Qu = & Ap.\left(\tfrac{1}{2} D.\ \lambda.\ N\lambda + \lambda\ df.\ Nq\right) & r = n \\ & + Aa\left(\tfrac{1}{2} Du.\ n.\ \lambda.\ N\lambda + \lambda\ Nq\right. & \Sigma\ dr. \\ & + \tfrac{1}{2}\pi\ D.\ \lambda.\ K \tan\delta \times \left(d_1^2 + d_f^2 - d_n^2\right) & r = 1 \end{aligned}$$

where

Ap (cm²)—$\pi/4\ D^2$, where D (cm) is stem diameter ;

Aa (cm²) —$\pi/4\ (Du^2 - D^2)$ where Du (cm) is the under-reamed bulb diameter ;

n—number of under-reamed bulbs ;

λ (kg/cm³)—average unit weight of soil (submerged unit weight in strata below water table) ;

$N\lambda$ and Nq—bearing capacity factors depending upon the angle of internal friction ;

dr (cm)—depth of the centre of different under-reamed bulbs below ground level ;

d_f (cm)—total depth of pile below ground level ;

K—earth pressure coefficient (usually taken 1.75 dfore sandy soils) ;

δ—angle of wall friction (may be taken equal to the angle of internal friction ϕ) ;

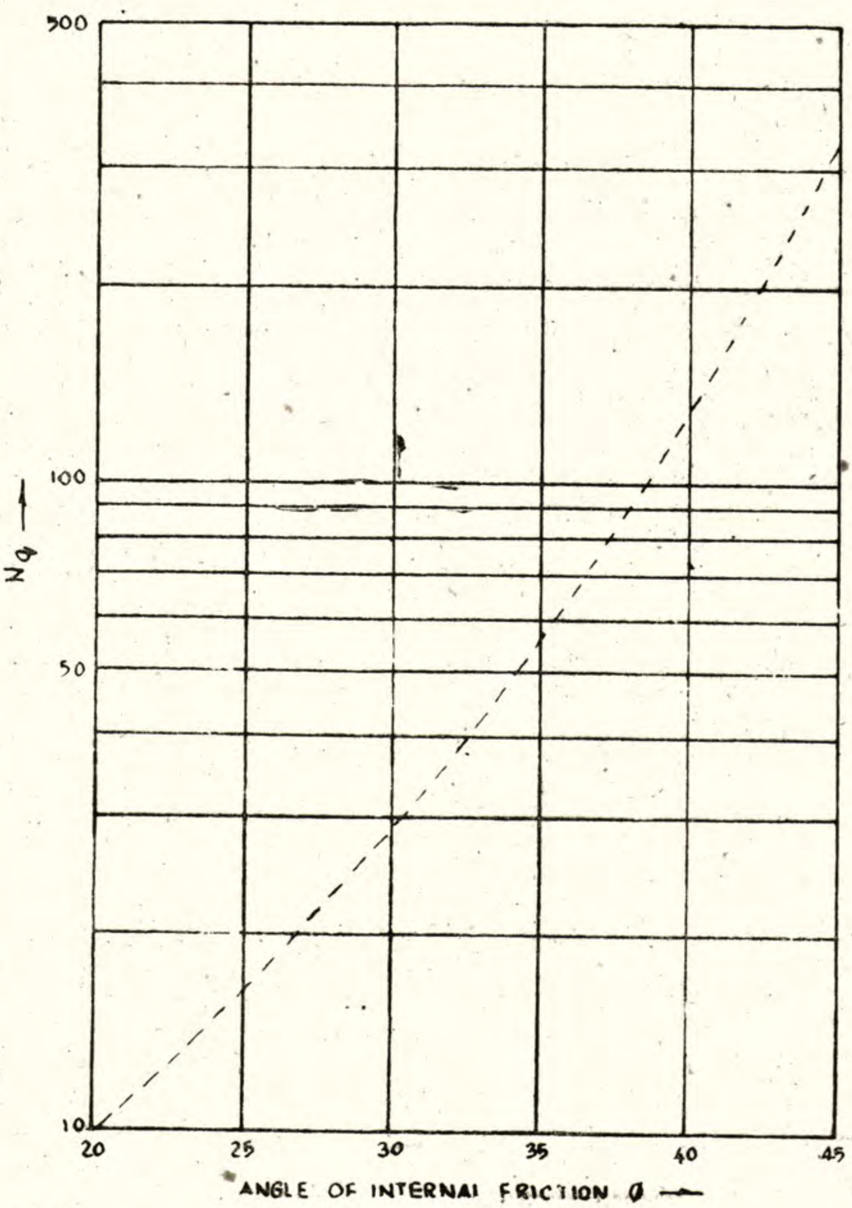
d_1 (cm)—depth of the centre of first under-reamed bulb ; and

dn (cm)—depth of the centre of the last under-reamed bulb.

NOTE 1.—The first two terms in the formula are for bearing component and the last one for friction component.

NOTE 2.—For uplift bearing on tip, Ap will not occur.

NOTE 3.—$N\lambda$ will be as specified in IS : 6403-1971 and Nq will be taken from Fig. . This factor, apart from the angle of internal friction $\varnothing$ depends upon the method of instalation of pile and the component containing this factor will generally be over estimated (up to about twice) in board piles.



BEARING CAPACITY FACTOR-Nq

(c) Soil strata having both cohesion and friction.

In soil strata having both cohesion and friction or in layered strata having two types of soil, the bearing capacity may be estimated using both the formula. However, in such cases the load tests will be a better guide.

(d) Compaction piles in sandy strata.

For bored compaction piles in sandy strata, the formula in **5.2.3.1.(b)** shall be applicable but the modified value of Ø will be used as given below :

where $\phi_1 = (Ø+40)/2$

Øλ = angle of internal friction of virgin soil.

The values of $N\lambda$, Nq and δ are taken corresponding to ϕ_1

The value of the earth pressure coefficient K will be 3.

(e) Piles resting on rock.

For piles resting on rock, the bearing component will be obtained by multiplying the safe bearing capacity of rock with bearing area of pile stem plus the bearing provided by the bulb portion.

(f) Factors of safety.

To obtain safe load in compression and uplift from ultimate load capacity generally the factors of safety will be **2.5 and 3**, respectively. But in case of bored compaction piles with bulb diameter twice the shaft diameter, the factor of safety in compression should be taken 2.25.

5.2.3.2. *Safe load from pile load tests.*—The safe load on pile(s) in compression uplift and lateral can be determined by carrying out load test on piles in accordance with IS : 2911 (Part IV)-1979. In sizable work (more than two hundred piles) where detailed information about the strata and the guidance of past experience is not availble, there should be a minimum of two pile load tests before finalizing the safe load on piles.

NOTE.– It is unlikely that two similar pile load tests give the same load-deflection behaviour. Also, ground conditions, position of water table, moisture content in soil and desiccation of top strata, can affect the load tests conducted at different times of the year. These factors should be kept in view while deciding the safe load.

5.2.3.3. In the absence of actual tests and detailed investigations, the safe load on under-reamed piles of bulb diameter 2.5 times the stem diameter may be taken as given in Appendix B.

5.2.3.4. The lesser of the two safe loads obtained from *5 2 3 1* and *5.2.3.3* should be used in designs. Higher values can be used if established by initial load tests.

5.2.3.5 *Permissible increase over safe load on piles*—

(a) Overloading—When a pile designed for a certain safe load is found to fall just short of the required load carried by it, an overload of up to 10 per cent of the safe load on pile may be allowed on each pile. The total overloading on group should not be more than 10 per cent of the safe load on group, nor more than 40 per cent of the safe load on single pile.

(b) Transient loading—The maximum permissible increase over the safe load of a pile as arising out of wind loading is 25 per cent. In case of loads and moments arising out of earthquake effects the increase over the safe load on a pile may be limited to the provisions contained in IS : 1893-1975. For seismic loads, under-reamed piles shall be treated as point bearing piles. The seismic and wind forces will not be considered to act simultaneously. For transient loading arising out of superimposed loads, no increase generally may be allowed. For broken wire conditions in transmission line tower foundations, permissible increase will be as provided in IS : 4091-1979.

NOTE—If any increase in load on a pile has already been permitted for reasons other than *5 2.3 5*, the total increase over safe load including those of *5.2 3.5* shall not exceed 50 per cent.

5.2.4. *Negative skin friction or drag down force*—When a soil stratum through which a pile shaft has penetrated into an underlying hard stratum , compresses as a result of either it being unconsolidated or it being under a newly placed fill or as a result of remoulding during driving of the pile, a drag-down force is generated into the pile shaft up to a point in depth where the surrounding soil does not move downward relative to the pile shaft.

NOTE—Estimation of this darg-down force is still under investigation although a few empirical approaches are in use. The concept is constantly under revision and, therefore, no definite proposal embodied in this standard. (Recognition of the existence of such a phenomenon shall be made and suitable reduction shall be made t the allowable load where appropriate. There is no evidence to show that the use of drilling fluids for the construction of piles affects the skin friction.)

5.2.5 *Lateral load on piles*—A pile may be subjected to transverse force from a number of causes, such as wind, earthquake, water current, earth pressures, effect of moving vehicles or ships, plant and equipment, etc. The lateral load carrying capacity of a single pile depends not only on the horizontal subgrade modulus of the surrounding soil but also on the structural strength of the pile shaft against bending consequent upon application of a lateral load. While considering leteral load on piles, effect of other existent loads including the axial load on the pile should be taken into consideration for checking the structural capacity of the shaft.

Piles under the action of lateral load and moment can be analysed by the modulus of subgrade reaction approaches. Due to the presence of bulbs, , under-reamed piles tend to behave more as rigid piles and the analysis can be, done on rigid pole basis. Normally reinforced long single bulb piles which are not rigid may be analysed after the generalized solutions of Matlock and Release for sandy soils and Broms for clayey soils. For lateral loads with or without axial loads, up to those given in the Table 1 of Appendix B, no analysis may be necessary, if external moment is not acting. In the absence of actual *in situ* test values from prtotype pile load test, the modulus of subgrade reaction values may be taken from the Table 2 given in Appendix C.

NOTE—It may be kept in view that modulus of subgrade reaction is a critical factor in the above analysis, yet there is no precise method for determinimg it. Therefore, it will be realistic to ascertain the adequacy of design by field tests.

5.2.6 *Batter pile (Raker pile)*—Raker Piles are normallty provided where vertical piles cannot resist the required applied horizontal forces. In the Preliminary design the load on raker pile is generally considered to be axail. The distribution of load between raker and vertical piles in a group may be determined by graphical or analytical methods. Where necessary, due consideration should be given to secondary bending induced as a result of the pile cap movement, particularly when the cap is rigid. Free standing raker piles are subjected to bending moments due to their own weight or external forces from other causes. Raker piles embedded in fill or consolidating deposits may become laterally loaded owing to the settlement of the surrounding soil.

5.2.7 *Spacing of piles*—

5.2.7.1 Spacing of piles shall be considered in relation to the nature of ground, the types of piles and the manner in which the piles transfer the load to the ground.

5.2.7.2 Generally the centre to centre spacing for bored cast *in situ* under-reamed piles in a group should be two times the bulb diameter ($2Du$)) It shall not be less than $1.5Du$. For under-grade beams the maximum spacing of piles should generally not exceed 3m. In under-reamed compaction piles, generally the spacing should not be less than $1.5Du$. If the adjacent piles are of different diameter, an average value of bulb diameter should be taken for spacing.

5.2.8 *Grouping and layout*—

5.2.8.1 For bored case *in situ* under-reamed piles at usual spacing of $2Du$, the group capacity will be equal to the safe load of individual pile multiplied by the number of piles in the group. For piles at a spacing of $1.5Du$ the safe load assigned per pile in a group should be reduced by 10 per cent.

In under-reamed compaction piles, at the usual spacing of $1.5Du$, the group capacity will be equal to the safe load on individual pile multiplied by the number of piles in the group.

NOTE—In under-reamed compaction piles, the capacity of the group may be more than given in *5 2 8 1* on account of the compaction effect.

5.2.8.2 In non-expansive soils, when the cap of the pile group is cast directly on reasonably firm stratum it may additionally contribute towards the bearing capacity of the group.

5.2.8.3 The settlement of pile groups depends upon soil and pile characteristics, spacing, group size method of installation and magnitude and nature of loading. In clays sometimes long term settlements can become important while in sands almost all the settlements will be over quickly.

A group of free standing piles is likely to settle more than a single pile but this increase may be marginal if the safe load on the pile is according to *5 2 3* and *5 2 8 1*.

NOTE 1—The settlement, in case of piles in sand, are generally computed from empirical relations. A suggested relationship for estimating settlements of free standing under-reamed pile groups in sands is :

$$S_g = S_1 \sqrt{B/D}$$

where

S_g = settlement of group in cm.

S_1 = settlement of single pile in cm ; piles are under the same safe load per pile,

B = distance between outer piles centre in cm, and

D = pile stem diameter in cm.

In clays the immediate settlements are computed using theory of elasticity and the long term settlements by consolidation theory. For he later, the pile group is considered as a footing at the centres of the ower most bulbs.

It may be noted that computed settlements, by the above approache particularly for piles in clay, are very large as compared to actually occuring in practice.

NOTE 2—For the groups with caps resting on ground settlements are comparable with an isloated pile.

NOTE 3—In the case of under-reamed compaction piles with cap resting on ground, which is very often the case, the settlements of groups may be even less than the settlement of an isolated pile.

5.2.8.4 In case of structure supported on single pile/group of piles, resulting into large variation in the number of piles from column to column it is likely that a high order of differential settlement may result depending on the type of subsoil supporting the piles. Such high order of differential settlement may be either catered for in the structural design or it may be suitably reduced by judicious choice of variations in the actual pile loadings. For example, a single pile cap may be loaded to a level higher than that of a pile in a group in order to achieve reduced differential settlement between two adjacent pile caps supported on differential number of piles.

5.2.8.5 In load bearing walls, piles should generally be provided under all wall junctions to avoid point loads on beams. Positions of intermediate piles are then decided by keeping door openings fall in between two piles as far as possible.

5.3 *Grade beams*

5.3.1. The grade beams supporting the walls shall be designed taking due account of arching effect due to masonry above beam. The beam with mansonry due to composite action behaves as a deep beam.

For the design of beams, a maximum bending moment of $wl^2/50$, where w is uniformly distributed load per metre run (worked out by considering a maximum height of two storeys in structures with load bearing walls and one storey in framed structurers) and l is the effective span in metres, will be taken if the beams are supported during construction till the masonry above it gains strength. The value of bending moment shall be increased to $wl^2/30$ if the beams are not supported. For considering composite action the minimum height of wall shall be 0.6 times the beam span. The brick strength should not be less than 30 kgf/cm². For concentrated loads and other loads which come directly over the beam, full bending moment should be considered.

5.3.2 The minimum overall depth of grade beams shall be 150mm. The reinforcement at bottom should be kept continuous in all the beams and an equal amount may be provided at top to a distance of quarter span both ways from the pile centres.

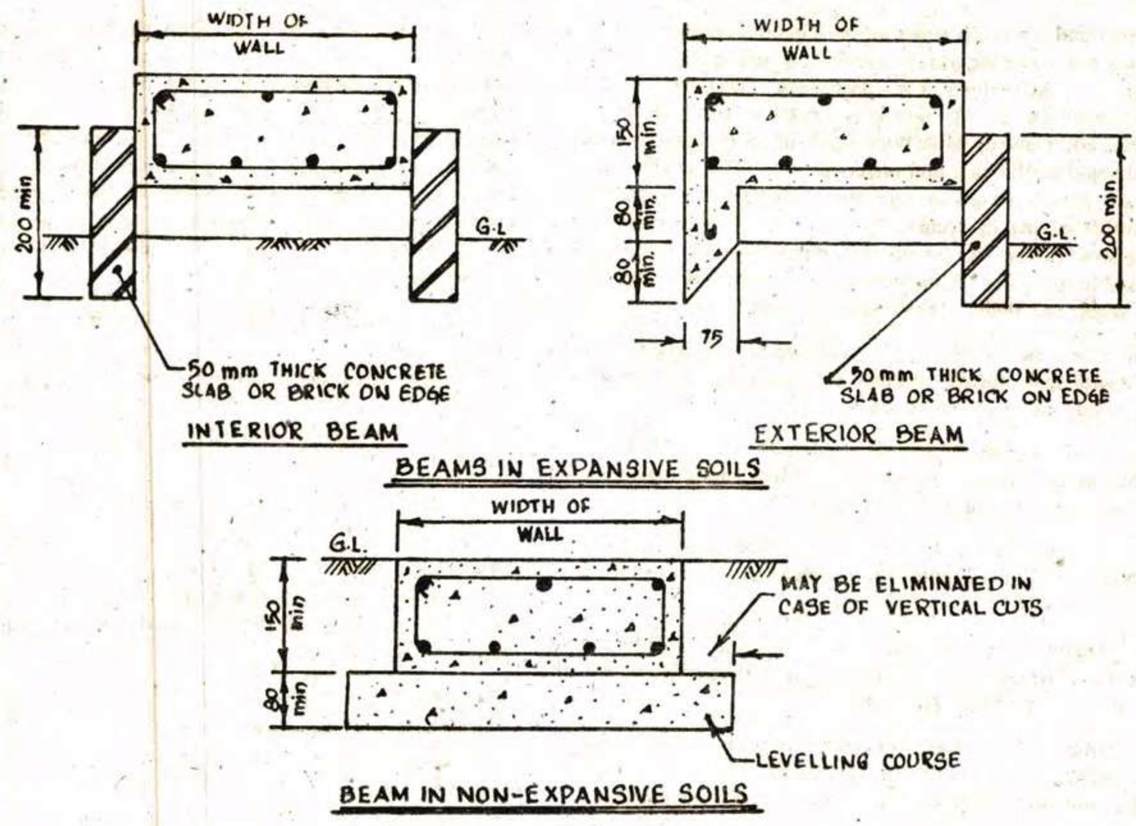
The longitudinal reinforcement both at bottom and top should not be less than three bars of 10 mm diameter mild steel (or equivalent deformed steel).

Stirrups of 6-mm diameter bars should be at a 300 mm spacing which should be reduced to 100 mm at the door openings near the wall edge up to a distance of *three times* the depth of beam. No shear connectors are necessary in wall.

5.3.3 In expansive soil, the grade beams shall be kept a minimum of 80 mm clear off the ground. In other soils, the beams may rest on ground over a levelling concrete course of about 80 mm (*see* Fig.). In this case, part load may be considered to be borne by the ground and it may be accounted for in the design of piles. However, the beams should be designed as per clause *5.3.1*.

5.3.4 In case of exterior beams over piles in expansive soils, a ledge projection of 75 mm thickness and extending 80 mm into ground (*see* Fig.) shall be provided on outer side of beam.

5.4 **Design of Pile Cap**—Pile caps are generally designed considering pile reactions as either concentracted loads or distributed loads. The depth of pile cap should be adequate for the shear for diagonal tension and it should also provide for necessary anchorage of reinforcement both for ths column and the piles.



TYPICAL SECTIONS OF GRADE BEAMS *All dimensions are in millimeters.*

5.4.1. The pile caps may be designed by assuming that the load from column or pedestal is dispersed at 45° from the top of the cap up to the mid depth of the pile cap from the base of the column or pedestal. The reaction from piles may also be taken to be distributed at 45° from the edge of the pile, upto the mid-depth of the pile cap. On this basis, the maximum bending moment and shear forces should be worked out at critical sections.

5.4.2. When pile reactions are considered as point loads, the critical section for shear in diagonal tension is taken at a distance equal to half the depth of cap from the face of the column or pedestal. For bending moment and shear for bond, the critical section is taken at the face of the column or pedestal. In computing the external shear or the critical section the entire reaction of any pile of diameter D whose centre is located at $D/2$ or more outside the section shall be assumed as producing shear on the section; the reaction from any pile whose centre is located at $D/2$ or more inside the section shall be assumed as producing no shear on the section.

For intermediate position of the pile centre, the portion of the pile reaction to be assumed as producing shear on the section shall be based on straight line interpolation between full value at $D/2$ outside the section and Zero value inside the section.

5.4.3. The cap may also be designed as a soild slab carrying concentrated loads from piles. A square/rectangular pile cap can be divided in four triangular/trapezoidal areas by drawing diagonal lines at 45° from the corners. When the pile is cut by the line, the load on this pile is shared equally between the adjacent areas. The reaction of piles under an area will be taken towards producing shear. The bending moment are assumed to act from the centre of piles under an area at the face of the nearest pedestal or column.

5.4.4. Full dimension of the cap shall be taken as width to analyse the section for bending and shear in respective direction. Method of analysis and allowable strees may be according to **IS : 456-1978.**

5.4.5. The clear overhang of the pile cap beyond the outer most pile in the group shall normally be 100 to 150 mm, depending upon the pile size.

5.4.6. The cap is generally cast over a 75 mm thick levelling course of concrete. The clear cover for main reinforcement in the cap slab shall be not less than 75 mm.

5.4.7. The pile should project 40 mm into the cap concrete.

6. *Equipment and accessories*

6.1. The slection of equipment and accessories will depend upon the type of under-reamed piles, site conditions and nature of strata. Also it will depend on economic considerations and availability of manually or power operated equipment.

6.2. A typical list of equipment for manual construction is given in Appendix D.

6.3. Bore holes may be made by earth auges. In case of manual boring, an auger boring guide shall be used to keep the bores vertica or to the desired inclination and in position.

After the bore is made to the required depth, enlarging of the base shall be carried out by means of an under-reaming tool.

6.4. In ground with high water table having unstable pile bores, boring and under-reaming may be carried out using a suitable drilling mud. General guidelines for bentonite drilling mud are given in appendix E. In normally met soil strata, drilling mud can be poured from top while boring and under reaming can be done by normal spiral earth auger and under-reamer. The level of drilling mud should always be about one metre above water table or the level at which caving in occurs. In case of very unstable strata with excessive caving in, continous circulation of drilling mud using suitable pumping equipment and tripod, etc., along with modified auger and under-reamer may be used.

6.5. Sometimes permeable strata overlying a rim clayey stratum may be cased and normal boring and under-reaming operation may be carried out in clayey stratum.

6.6. To avoid irregular shape and widening of bore hole in very loose strata at top, a casing pipe of suitable length may be used temporarily during boring and concreting.

6.7. For improved control over the inclination of batter piles, and tripod hoist with fixed pully should be used for lowering in of under-reaming tools.

6.8 For placing the concrete in bore holes full or drilling mud or subsoil water, tremie pipe of not less than 150 mm diameter with flap valve at the bottom should be used.

6.9 For batter under-reamed piles, the reinforcement cage should be placed guiding it by a chute or any other suitable method. If concreting is not done by tremie, it should be by done by chute.

6.10 In under-reamed compaction piles, suitable devices should be used for guiding the movement of drop weight and specified core assembly for its vertical driving. For operating the drop weights of adequate capacity, suitable winch with hoisting attachment should be used.

7. *Construction.*

7.1. Under-reamed piles may be constructed by selecting suitable installation techniques at a given site depending on subsoil strata conditions and type of under-reamed pile and number of bulbs.

7.2 In construction with the equipment given in 6, initially, boring guide is fixed with its lower frame levelled for making desired angular adjustment for piles at batter. Boring is done up to required depth and m under-reaming is completed.

7.2.1 In order to achieve proper under-reamed bulb, the depth of bore hole should be checked brefore starting under-reaming. It should also be checked during under-reaming and any extra soil at the bottom of bore hole removed by auger before reinserting the under reaming tool.

7.2.2 The completion of desired under-reamed bulb is ascertained by (*a*) the vertical movement of the handle, and (*b*) when no further soil is cut.

7.2.3 In double or multi-under-reamed piles, boring is first completed to the depth required for the (top) under-ream only and after completing the under-reaming, boring is extended further for the second under-ream and the process is repeated.

7.3 *Control of alignment*—The piles shall be installed as correctly as possible at the correct location and truly vertical (or at the specified batter). Great care shall be exercised in respect of single pile or piles in two-pile groups under a column. As a guide, for vertical piles a deviation of 1.5 percent and for raker piles a deviation of 4 per cent shall not normally be exceeded. In special cases, a closer tolerance may be necessary. Piles shall not deviate more than 75 mm or one quarter the stem diameter, whichever is less (75 mm or $6D/10$ whichever is more in case of piles having diameter more than 600 mm) from the designed position at the working level. In the case of single pile under a column, the positional deviation should not be more than 50 mm or one quarter of the stem diameter whichever is less (100 mm in case of piles having diameter more than 600 mm). For piles where cut-off is at substantial depths, the design should provide for the worst combination of the above tolerances in position and inclination.

In case of piles deviating beyond these limits, corrective measures where necessary may be taken in the form of increasing pile size, provision of extra reinforcement in the pile, redesign of pile cap and pile ties. If the resulting eccentricity cannot be taken care of by the above measures, the piles should be replaced or supplemented by one or more additional piles.

NOTE—In case of raker piles up to a rake of 1 in 6, there may be no reduction in the capacity of the pile unless otherwise stated.

7.4 Concreting shall be done as soon as possible after completing the pile bore. The bore hole full or drilling mud shoud not be left unconcreted for more than 12 to 24 hours depending upon the stability of bore hole.

7.5 For placing concrete in pile bores, a funnel should be used and method of concreting should be such that the entire volume of the pile bore is filled up without the formation of voids and/or mixing of soil and drilling fluid in the concrete.

7.5.1 In empty bore holes for under-reamed piles a small quantity of concrete is poured to give about a 100 mm layer of concrete at the bottom. Reinforcement is lowered next and positioned correctly. Then concrete is pored to fill up the bore hole. Care should be taken that soil is not scrapped from sides if rodding is done for compaction. Vibrators shall not be used.

7.5.2 If the water is confined up to the bucket length portion at the toe and seepage is low, the water should be bailed out and concreting should be done as in **7.5.1.**

7.5.3. In case the pile bore is stabilized with drilling mud or by maintaining water head within the bore hole, the bottom of bore hole shall be carefully cleaned by flushing it with fresh drilling mud and pile bore will be checked for its depth immediately before concreting.

Concreting shall be done by tremie method. The tremie should have a valve at its bottom and lowered with its valve closed at the start and filled up with concrete. The valve is then opened to permit the flow of concrete which permits the upwards displacement of drilling mud. The pouring should be continuous and tremie is gradually lifted up such that the tremie pipe opening remains always in the concrete. If the final stage the quantity of concrete in tremie should be enough so that on final withdrawal some concrete spills over the ground.

NOTE 1—The concrete should be coherent, rich in cement not less than 350 kgf/m^3) and of slump not less than 150mm.

NOTE 2—The tremie pipe should always penetrate well into the concrete with an adequate margin of safety against accidental withdrawal of the pipe is surged to discharge the concrete.

NOTE 3—The pile should be concreted wholly by tremie and the method of deposition should not be changed part way up the pile, to prevent the laitance from being entrapped within the pile.

NOTE 4—All tremie tubes should be scrupulously cleaned before and after use.

NOTE 5—Normally concreting of the piles should be uninterrupted. In the exceptional case of interruption of concreting, but which can be resumed within 1 or 2 hours, the tremie shall not be taken out of the concrete. Instead it shall be raised and lowered slowly, from time to time to prevent the concrete around the tremie from setting. Concreting should be resumed by introducing a little richer concrete with a slump of about 200 mm for easy displacement of the partly set concrete. If the concreting cannot be resumed before final set-up of concrete already placed the pile so cast may be rejected, or used with modifications.

NOTE 6—In case of withdrawl of tremie out of the concrete, either accidentally or to remove a chock in the tremie, the tremie may be re-introduced in a manner to prevent impregenation of laitance or scum lying on the top of the concrete already deposited in the bore.

7.5.4. In inclined piles, the concreting should be done through a chute or by tremie method.

7.5.5. For under-reamed bore compaction piles, the pile bore is first filled up without placing any reinforcement. Concreting is done as in **7.5.1** depending upon situation. Soon after, the specified core assembly shall be driven and extra concrete shall be poured in simultaneously to keep the level of concrete up to ground level. If hollow driving pipe is used in core assembly, the pipe shall be withdrawn after filling it with fresh concrete which will be left behind.

NOTE—In under reamed bored compaction piles, concreting should be uninterupted and notes (5) and 6) under clause 7.5.3 will not apply.

7.5.6. The top of concrete in a pile shall be brought above the cut-off level to permit removal of all laitance and weak concrete before capping and to ensure good concrete at the cut-off level for proper embedment into the pile cap.

7.5.7. Where cut-off level is less than 1.5 metre below working level, concrete shall be cast to a minimum of 300 mm above cut-off level. For each additional 0.3 m increase in cut off level below working level, additional coverage of 50 mm minimum shall be allowed. Higher allowance may be necessary depending on the length of the pile. When concrete is placed by tremie method, it shall be cast to the piling platform level to permit overflow of concrete for visual inspection or to a minimum of one metre above cut-off level. In the circumstance where cut-off level is below ground water, the need to maintain a pressure on the unset concrete equal to or greater than water pressure should be observed and accordingly length of extra concrete above cut-off level shall be determined.

7.5.8. *Defective pile*—In case, defective piles are formed, they shall be removed or left in place whichever is convenient without affecting performance of the adjacent piles or the cap as a whole. Additional piles shall be provided to replace them as directed.

7.5.9. Any deviation from the designed location alignment or load capacity of any pile shall be noted and adequate measures taken well before the concreting of the pile cap and plinth beam if the deviations are beyond the permissible limit.

7.5.10. *Estimation of concrete quantity*.—The extra concrete required for each bored cast *in situ* under-reamed bulb of 2.5 times the stem diameter may be taken equal to a stem length of 4 to 4.5 times its diameter, depending on the nature of strata and other sit conditions. The volume of concrete actually placed shall be observed in the case of few piles initially cast and the average figure obtained may be used as a guide for working out the quantities of the concrete and cement for subsequent piles.

For under-reamed compaction piles the amount of concrete used is about 1.2 times of the under-reamed cast *in situ* piles.

NOTE—If the estimates of concrete consumption is on the volume of bore holes and not on the basis of concrete quantity actually consumed, the concrete used may be found smaller than estimated and cement consumption may work out to be less.

7.5.11. *Recording of pile details*—A competent person at site should keep records of necessary information about the construction of piles. The following may be recorded :

(*a*) Date and sequence of installation of piles in a group ;

(*b*) Pile details.—Length, diameter of stem and bulbs, number of bulbs, type of pile, reinforcement, etc ;

(*c*) Cut-off level and working level ;

(*d*) Method of boring ;

(*e*) Ground water level ;

(*f*) Any other information.

APPENDIX A.

[*Clause* 3.1 (b).]

DEGREE OF EXPANSIVENESS.

A-1. The degree of expansiveness and consquent damage to the structures with light loading may be qualitatively judged as shown below :

Degree of expansiveness	*Differential free swell, percent*
Low	Less than 20
Moderate	20 to 35
High	35 to 50
Very high	Greater than 50

A-1.1 In areas of soil showing high or very high differential free swell values, conventional shallow strips footings may not be adequate.

APPENDIX B.

(*Clauses* 5.2.3.3. *and* 5.2.5)

SAFE LOAD ON UNDER-REAMED PILES.

B-1. *Safe load table.*

B-1.1 The safe bearing, uplift and lateral loads for under-reamed piles given in Table 1 apply to both medium compact ($10 < N < 30$) sandy soils and clayey soils of medium ($4 < N < 8$) consistency including expansive soils. The values are for piles with bulb diameter equal to two-and -a-half times the shaft diameter.

The columns (3) and (4) of on Table 1 provide the minimum pile lengths for single and double under-reamed piles respectively, in deep deposit of expansive soils. Also the length given for 375 mm diameter double under-reamed piles and more in other soils are minimum. The values given for double under-reamed piles in columns (9) and (13) are only applicable in expansive soils. The reinforcement shown is mild steel and it is adequate for loads in compression and lateral thrusts [Columns (8), (9), (16) and (17)]. For uplift [Column (12) and (13)], requisite amount of steel should be provided. In expansive soils, the reinforcement shown in Table 1 is adequate to take upward drag due to heaving up of the soil.

The concrete considered is M 15. The cover requirements will be as provided in **5.2.2.**

B-1.2 Safe loads for piles of lengths different from those shown in Table 1 can be obtained considering the decrease or increase as from columns 10, 11, 14 and 15 for the specific case.

B-1.3 Safe loads for piles with more than two bulbs in expansive soils and more than one bulb in all other soils (including non-expansive clayey soils) can be worked out from Table 1 by adding 50 per cent of the loads shown in columns (8) or (12) for each additional bulb in the values given in these columns. The additional capacity for increased length required to accommodate bulbs should be obtained from column (10) and (14).

B-1.4 Values given in columns (16) and (17) for lateral thrusts may not be increased or decreased for change in pile lengths. Also for multi-under reamed piles the values should not increase than those given in column (17). For longer and/or multi-under reamed piles higher lateral thrusts may be adopted after establishing from field load tests.

B-1.5 For dense sandy ($N \geq 30$) and stiff clayey ($N \geq 8$) soils, the safe loads in compression and uplift obtained from Table 1 may be increased by 25 per cent. The lateral thrust values should not be increased unless the stability and strength of top soil (strata up to a depth of about three times the pile shaft diameter) is ascertained and found adequate. For piles in loose ($4 < N \leq 10$) sandy and soft ($2 < N \leq 4$) clayey soils, the safe loads should be taken 0.75 times the values shown in the Table. For every loose ($N \leq 4$) sandy and very soft ($N \leq 2$) clayey soils the values obtained from the Table should be reduced by 50 per cent.

B-1.6 The safe loads obtained from Table 1, should be reduced by 25 per cent if the pile bore holes are full of subsoil water of drilling mud during concreting. No such reduction may be done it the water is confined to the shaft portion below the bottom-most bulb

B-1.7 The safe loads in uplift and compression given by in Table-1 or obtained in accordance with **B-1.2** to **B-1.6** should be reduced by 15 per cent for piles with bulb of twice the stem diameter. But no such reduction is required for lateral loads shown in Table 1.

B-1.8 The safe loads for under-reamed compaction piles can be worked out by increasing the safe load of equivalent bored cast *in situ* under-reamed pile obtained from Table 1 by 1.5 times in case of medium ($10 < N < 30$) and 1.75 times in case of loose to very loose ($N \leq 10$) sandy soils. Depending upon the nature and initial compactness of strata, pile geometry and lay-out of piles, this increase may be up to a factor of 2 and initial load tests are suggested to arrive at final safe load values for design in case of sizable works. The values of lateral loads should not be increased by more than 1.5 times in all cases. In obtaining safe load of compaction pile the reduction for pile bore holes full of subsoil water or drilling mud during concreting should be taken 15 percent instead of 25 percent as given in **B-1.6.** The reduction for piles with twice the bulb diameter is to be taken 10 percent instead of 15 per cent as given in **B-1.7.** The provision of reinforcement in under-reamed compaction piles will also be guided as stipulated in **5.2.2.1.**

B-1.9 The safe loads in Table 1, and the recommendations made to obtain safe load in different cases (**B-1.2** to **B-1.8**) are based on extensive pile load tests. The loads thus obtained may be taken equal to two-thirds the loads corresponding to deflection of 12 mm for loads in compression and uplift. The deflections corresponding to respective safe loads will be about 6 mm and 4 mm. The deflection at safe lateral load will be about 4 mm. The values given in Table 1 will be normally on conservative side. For working out ultimate compressive and uplift loads, if defined as loads corresponding to 25 mm deflection on load-deflection curve, the value obtained from Table 1 can be doubled. But in case of lateral thrust twice the values in Table 1 should be considered corresponding to deflection of 1 mm only.

B-1.10 The permissible increase over safe loads obtained from Table 1 should be taken as stipulated in 5.2.3.5 for respective conditions. Also the group capacity should be obtained in accordance with **5.2.8.**

TABLE 1—SAFE LOAD FOR VERTICAL BORED CAST *in situ* UNDER-REAMED PILES IN SANDY AND CLAYEY SOILS INCLUDING BLACK COTTON SOILS.

Size		*Length*		*Mild steel reinforcement.*			*Compression.*	
Diameter of pile.	*Under reamed diameter.*	*Single under-reamed.*	*Double under-reamed.*	*Longitudinal reinforcement.*		*Rings spacing of 6 mm dia-rings.*	*Single under-reamed.*	*Double under-reamed.*
cm	cm	m	m	No.	Dia mm	cm	t	t
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
20	50	3.5	3.5	3	10	18	8	12
25	62.5	3.5	3.5	4	10	22	12	18
30	75	3.5	3.5	4	12	25	16	24
37.5	94	3.5	3.75	5	12	30	24	36
40	100	3.5	4.0	6	12	30	28.	42
45	112.5	3.5	4.5	7	12	30	35	52.5
50	125	3.5	5.0	9	12	30	42	63

Compression.		*Safe loads uplift resistance.*				*Lateral thrust.*	
Increase per 30 cm Length	*Decrease per 30 cm Length.*	*Single under-reamed.*	*Double under-reamed.*	*Increase per 30 cm length.*	*Decrease per 30 cm length.*	*Single under-reamed.*	*Double under-reamed.*
t	t	t	t	t	t	t	t
(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
0.9	0.7	4	6	0.65	0.55	1.0	1.2
1.15	0.9	6	9	0.85	0.70	1.5	1.8
1.4	1.1	8	12	1.05	0.85	2.0	2.4
1.8	1.4	12	18	1.35	1.10	3.0	3.6
1.9	1.5	14	21	1.45	1.15	3.4	4.0
2.15	1.7	17.5	25.75	1.60	1.30	4.0	4.8
2.4	1.9	21	31.5	1.80	1.45	4.5	5.4

B-1.11 For piles subjected to external moments and or larger total loads than those given in Table 1, the pile should be designed properly and requisite amount of steel should be provided.

NOTE.—For obtaining safe loads from Table 1, '*N*' value (standard penetration test value) a weighted average should be taken up to a depth equal to the bulb diameter below the pile toe. In case of predominantly silty soils, the guiding '*N*' value for obtaining safe loads may be taken between the values given for sandy and clayey soils.

APPENDIX C.

(*Clause* 5.2.5)

MODULUS OF SUBGRADE

C-1. The values of the constant of modulus of horizontal subgrade reaction n_h in sand or the modulus of subgrade reaction, *K*, in clay may be taken from Tables 2 and 3.

TABLE—2—TYPICAL VALUES OF OF n_h

SOIL TYPE	n_h IN kg/cm^3	
	Dry.	*Submerged.*
Loose sand	0.260	0.146
Medium sand	0.775	0.526
Dense sand	2.076	1.245
Very loose sand under repeated loading.	..	0.041

TABLE—3—TYPICAL VALUES OF *K* **(for preloaded clay)**

Unconfined compressive strength kg/cm^3	*Range of value of* $K\ kg/cm^2$	*Probable value* $K\ kg/cm^2$
(1)	(2)	(3)
0.2 to 0.4	7 to 42	7.73
1 to 2	32 to 65	48.79
2 to 4	65 to 130	79.73
4	—	195.46

APPENDIX D

(*Clause* 6.2)

EQUIPMENT FOR UNDER-REAMED PILES
(MANUAL CONSTRUCTION)

D–1 Equipment **:**

D-1.1 : Normally the following equipment will be required in manual operation :

(*a*) An auger ;

(*b*) An under-reamer ;

(*c*) A boring guide ; and

(*d*) Accessories like spare extensions, cutting tool, concreting funnel, etc.

D-1.1.1. : For the piles of size larger than 30 cm. and for larger depths additional equipment required will be a portable tripod hoist with a manually operated winch.

466-3—34

D-1.1.2 : For piles in high ground water table and unstable soil conditions, boring and under-reaming shall be carried out with bentonite slurry using suitable equipment. Tremie pipe shall be used for concreting.

D-1.1.3 : The additional equipment normally required for under reamed compaction pile are the following :

(*a*) Drop weight for driving the core assembly ; and

(*b*) Pipe or solid core.

APPENDIX E.

(*Clause* 6.4)

BASIC PROPERTIES OF DRILLING MUD (BENTONITE).

E-1 Properties **:**

E-1.1 : The bentonite suspension used in bore holes is basically a clay of montmorillonite group having exchangeable sodium cations. Because of the presence of medium cations bentonite on dispersion will break down into small plate like particles having a negative charge on the surfaces and positive charge on the edges. When the dispersion is left to stand undisturbed, the particlues become oriented building up a mechanical structure of its own, the mechanical structture held by electrical bonds is observable as a jelly like mass or jell material. When the jell is agitated, the weak electrical bonds are broken and the dispersion becomes fluid.

E-2. Functions **:**

E-2 1 : The action of bentonite in stabilizing the sides of bore hole is primarily due to the thixotropic property of bentonite suspensions. The thixotropic property of bentonite suspension permits the material to have the consistency of a fluid when introduced into the excavation and when undisturbed forms a jelly which when agitated becomes a fluid again.

E-2.2 : In the case of a granular soil, the bentonite suspension penetrates into the sides under positive pressure and after a while forms a jelly. The bentonite suspension gets deposited on the sides of the hole and makes the surface impervious and imparts a plastering effect. In impervious clay, the bentonite does not penetrate into the soil, but deposits only a thin film on the surface of the hole. Under such conditions, stability, is derived from the hydro-static head of the suspension

E-3. Specifications **:**

E-3 *1* : The bentonite suspension used for piling work shall satisfy the following requirements :

(*a*) The liquid limit of bentonite when tested in accordance with IS : 2720 (Part V)-1965 shall be more than 300 per cent and less than 450 per cent.

(*b*) The sand content of the bentonite powder shall not be greater han 7 per cent.

NOTE.—The purpose of limiting the sand content is mainly to control and reduce the wear and tear of the pumping equipment.

(*c*) Bentonite solution should be made by mixing it with fresh water using pump for circulation. The relative density of the bentonite solution should be between 1.034 and 1.10.

(*d*) The differential free swell shall be more than 540 per cent.

CIRCULAR No. 176 OF 1981.

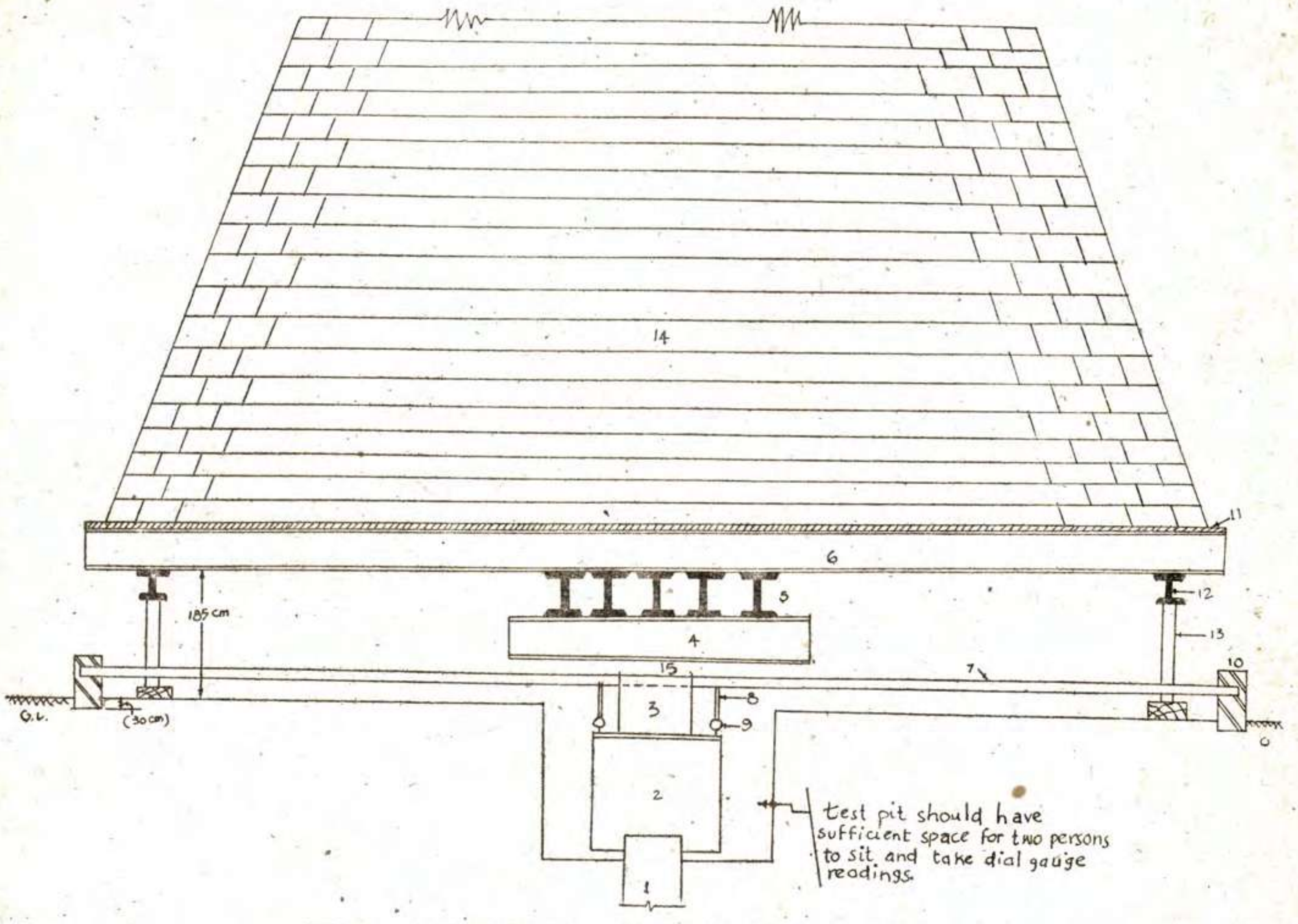
Circular Memo. No. Wks. III (5)/87221/81-176, dated 12*th May* 1981.

LOAD TEST ON PILES.

PROCEDURE TO BE FOLLOWED.

When a load test has to be conducted on a pile, the following proce dure shall be adhered to strictly without any lapse. The procedure is almost common both for an Initial Test on a Test Pile or a Routine Cyclic test on a working pile, except for a few differences which are xplained at appropriate places below. If there be any lenience or apse in observing the procedure strictly, that will result into incorrect assessment of pile capacity and rather over estimated pile capacity.

(*a*) *Testing the load test equipments.*—The equipments employed for conducting a load test are : (I) Hydralic oil tank fitted with a pressure gauge, pump handle and release valve (2) Hose pipe to carry the hydraulic oil to jack, the oil being under pressure (3) a Jack of appropriate capacity ; (4) deflectometres or dial gauges and (5) datum bars.



SECTION ON TEST PIT FOR LOAD TEST ON PILE.

1. R.C.C. PILE, 2. R.C.C. PILE CAP, 3. JACK, 4. ROLLED STEEL JOIST BOLTED TO MAIN JOIST, 5. MAIN R.S.J SUPPORTED BY WOODEN BLOCKS UP TO 185 Cm HIGH AT EITHER ENDS. TO HAVE A CLEAR HEAD ROOM, 6. SECONDARY R.S.J. 7. DATUM BARS, 8. MAGNETIC BASED SUSPENDER, 9. DIAL GAUGE, 10. MASONRY/ CONCRETE SUPPORT, 11. PLATFORM SUPPORTING SAND BAGS, 12. R.S.J. SUPPORT, 13. CASURINA FOLES AT 120 Cm INTERVALS, 14. SAND BAGS, 15. SPACE FOR PACKING PLATE.

The graduation of pressure gauge hall be got calibrated first from recognised Istitution like an Engineering College, a Reserach station or a Research Institute in the presence of the Assistant Executive Engineer, concerned. The capacity of hose pipe and jack to withstand the high pressure of liquid at the higest test load shall also be got tested in the same institution along with pressure gauge calibartion. This ascertain is quite essential as otherwise, the hose pipe would often burst and halt the test abruptly causing repetition of the test from the start.

Further it is preferable to resort to caliberation a few days before the actual load test every time. The dial gauges will also be got tested for the accuracy and for their full range.

This caliberation process must be repeated for every load test without fail.

(*b*) *Test pit.*—The test pit shall have sufficient space for four persons to sit and record four dial gauges reading preferably It shall contain two escapes, ONE for entry and the other for an emergency exist. The floor of the pit shall be 10 cm. clear below the pile cap. The mudmat can be avoided preferably and the pile cap can be cast with bottom centering in addition to side shutterings Even if the sand filling is resorted to for the floor of the pit, the clearanc clearance of 10 cm. shall be maintained at any cost especially around the peripery of the pile below the pile cap.

The top of the pile cap shall be finished even and truly to plane Glass plates on grease base or any other suitable base (i.e.) plaster of paris, etc., will be fixed at four corners of pile cap equidistantly rom the centre of the pile cap to recieve the tip of the dial gauges.

Magnetic based dial gauges shall be employed in the test to suspened from the datum bars. This is again quite esstential, sin ordinary dial gauges suspended with holt and nut arrangement neither provide vertically at the start of the test nor maintain it during the test.

Both datum bars should be of equal length and of identical angles or channels and should be held in position to masonry cr concrete supports at either ends placed 5(*d*) away from the periphery of pile where d is the diamter of pile. These bars should be straight and stiffended transversely with cross plates, so that the datum bars are not distrurbed even inadvertently.

The loading for the test is normally achieved by sand bags (Lead blocks also) Stacked on a platform supported by R.S. Joists. This platform shall be kept at least 6.0" above GL to have sufficient head-room to move. The static load for the test excluding the weight of R.S. Joists will be normally not more than 20 per cent and hence a limit of 20 per cent higher than the highest test load may be followed. If this is not followed, the reaction load is not achieveed and that the Roller Steel Joists (R.S.I.S.) will be lifted or even tilts at the highest test load.

(*C*) *Testing*.—The load test on pile shall commence only when the above arrangements are completed to the satisfication of the Executive Engineer concerned and after obtaining his approval. In case of cyclic load test the following procedure shall be observed

(i) *Cyclic load test* (based on ISS 2911-1964) The test shall conform to I.S.S. 2911 (Pt. I) 1964 The procedural details of test shall on form to the above I.S.S. and to the following specifications After noting down the initial readings on the dial gauges, a load increment equal to 1/5 of the safe load shall be applied and the readings in the dial gauges noted down immediately. Note again the dial gauges readings after 30 minutes. Allow the load to remain for an hour. If there is drop in pressure in this period, this can be restored by jacking. Note down the readings of dial gauges then. If the rate of difference between the two mean readings of the dial gauges at the end of 30th and 90th minute is less than 0.02 mm. then release the load very slowly, and uniformly. If the rate of difference is more than 0.02 mm. the dial gauges readings will be observed continuously at one hour intervals till the rate of difference fails below 0.02 mm. After release of load in the I cycle, observe the readings for about 30 miniutes. If they are stable, note down the readings and proceed to the next cycle of loading. Next apply 2/5 th of safe load steadly and note sdown the dial gauges readings. Observe after 30 minutes and record the readings. Find out the readings after another 60 minutes. If the difference between the mean readings of the dial gauges at the end of 30th and 90th minutes is less than 0.02 mm proceed to release the load; If not continue the observation of readings This cycle of loading and unloading will continue till the test load (150 per cent of the safe load on pile as per I.S.S.) is reached. This test load shall be kept on there till the progressive settlement of pile stops and remains unaltered at its highest value i.e. the needles of dial gauges will then stop moving indicating that the total settlement has been reached and that there will be no further settlement. This condition should remain unaltered atleast for 24 hours consecutively under the test load. This test condition will be obtained normally in 3 or 4 days time (not governed by the I.S.S.) The test is correct and accetable only when this 24 hours condition is obtained (not governed by I.S.S.) If this 24 hours condition is not obtained within the stipulated time, the test shall be rejected and fresh test conducted at contractor's cost. The releasing of the test load to Zero-shall be carried out slowly and steadily by dropping down the load stage after stage, (7.55, 7/5, 6/5, 5/5, 4/5 etc.) and noting down the rebound. The net settlement at zero load shall be noted. The next settlement shall also be noted after 24 hours after release of test load (not goeverned by I.S.S.)

466-3—34A

The assessment of safe load on the pile will be made as follows for the "driven" piles.

(i) Two thirds of the final load at which the total settlement attains a value of 12 mm, unless it is established that a total settlement different from 12 mm is permissible in a given case on the basis of nature and type of the structure in the latter case the actual tota settlement permissble shall be used for assessing the safe load insteadl of 12 mm.

(2) Two thirds of the final load at which the net settlemen-increases to 6 mm. unless more settlement is permissible" I.SS.2911t (Part I) 1964. Assessment of safe load in the case of bored piles is made as follows (as per I.SS. 2911-1954) (Part 1).

(1) Two thirds of the minimum load causing a net settlement of 2 percent of diameter, subject to the maximum net settlement being 25 mm. may be taken as the allowable working load. The total settlement should, however, be restricted to 4 per cent of the diameter. For this purpose load increment should be put at equal time intervals

(ii) *Initial test* :—(based on I.S. 2911-Part I) 1964. All the above procedure will remain unaltered for initial test also except that the test load shall be 300 per cent of the safe load of pile as pe tender's design.

Assessment of safe load in the case of driven piles will be as follows :

(i) Two thirds of the final load at which the total settlement attains a value of 12 mm, unless it is established that a total settlement different from 12 mm. is permissible in a given case on the basis of nature and type of structure, in the latter case, the actual total settlement permissible shall be used for assessing the safe load instead of 12 mm.

(ii) Two thirds of the final load at which the net settlement attains a value of 6 mm.

(iii) 50 per cent of the final load at which the total settlement equals one-tenth of the diamter.

Assessment of safe load in the case of bored piles will be as in routine test.

Precautions : The load test on a pile shall not be carried out earlier then four weeks from the time of costing of the pile. In the case of precast driven piles in coarse grained sandy soils, the time when the load tests on the pile foundations are carried out shall not be earlier then one week from the time of driving of the piles.

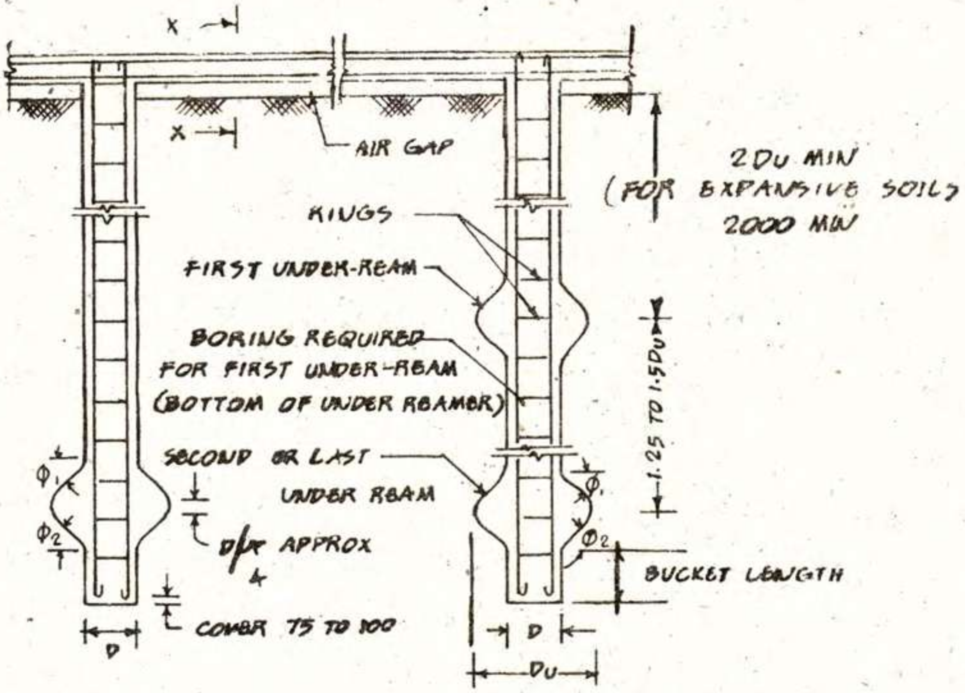
In practice piles will offen be driven into a succession of different strata. In such cases, the nature and thickness of the stratum in which the point of the pile rests will largely influence the load carrying capacity. The characteristics, thickness and inclination of the strata underlying the pile points have a preponderant influence on the settlement of the structure as a whole. In such soils care should be taken in estimating the overall settlement. The possibility of settlement due to the consolidation, the soil below the he pile point should be investigated and taken into account.

Factor of safety for assessing the safe load on piles from load test data should be increased in unfavourable conditions where.

(*a*) Settlement must be limitted as in the case of accurately aligned machinery or a superstructure with fragile finishings.

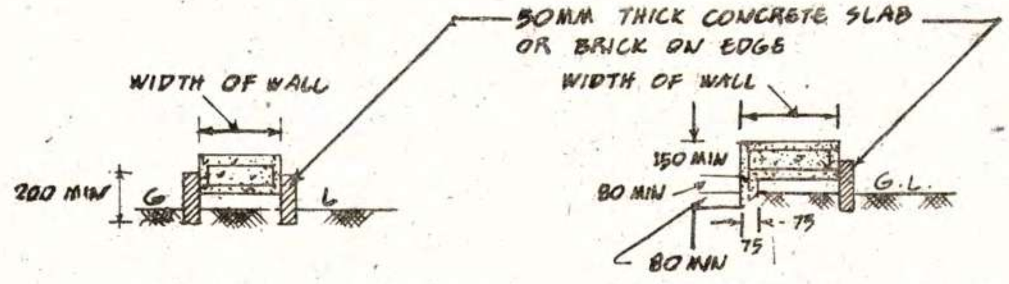
(*b*) large impact loads are expected.

(*c*) the properties of the soil may be expected to deteriorate with time.



SINGLE UNDER-REAMED PILE

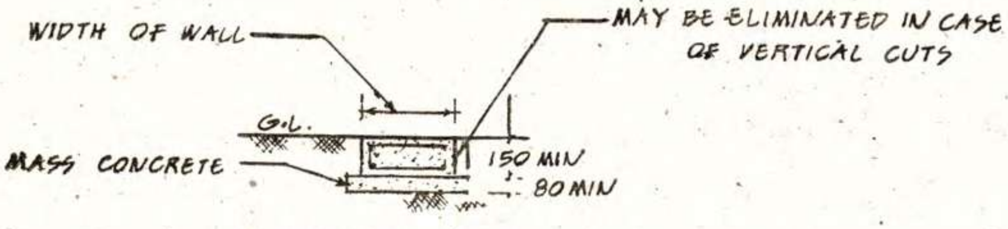
MULTI UNDER-REAMED PILE



INTERIOR BEAM

EXTERIOR BEAM

SECTION X-X
(FOR EXPANSIVE SOILS)



BEAM IN NON-EXPANSIVE SOILS

θ_1 = 45° APPROX, θ_2 = 30° APPROX, Du = 2.5D APPROX, G.L. : GROUND LEVEL

ALL DIMENSIONS ARE IN MILLIMETRES

SECTION V

BRICK MASONRY

SECTION V.

BRICK MASONRY.

CONTENTS

SECTION V.

BRICK MASONRY.

INDIAN STANDARDS EXTRACTS.

SECTION V.
BRICK MASONRY.

SPECIFICATION No. 31.

Brick Masonry General.

1. *Wall bricks* :—

1·1. Specification for building bricks and classification are covered by I.S. 1077/1970 and 3102/1971.

N.B.—Vide descriptive specification sheet to be attached to agreement regarding kilns from which bricks are to be obtained.

2. Bricks are to be well soaked in water before use. For further instructions regarding soaking and size of bricks to be used I.S. 2212/1962, and I.S. 1200 Part III/1970 shall apply.

3. Regarding making of bricks I.S. 2117/1967 shall apply. Where a large number of brick has to be manufactured it would be prudent to mould and burn a small number on trial to ensure the certainty of the output before starting operations on a large scale.

3·1. All fuel for brick burning should be dry and used when comparatively fresh. Decayed timber should not be used as fuel. Tamarind or babul is the best wood to use in burning. Specification for facing brick is covered by I.S. 2691/1972.

4. *Mortar*:—Specification is covered by I.S. 2212/62. Should the mortar perish, i.e., become dry white or powdery through neglect of watering, the work shall be pulled down and rebuilt at the contractor's expense, or should the contractor fail to watch the work to the satisfaction of the officer in-charge of the work the latter may supply the requisite men to water the work properly and charge the cost to the contractor.

4·1. All masonry shall be washed down on completion and all stains—lime or otherwise—removed from the face.

5. *Bats*:—No bats or cut bricks shall be used except where absolutely required for obtaining the dimensions of the differnt courses for obtaining the specified bond and where in the opinion of the Executive Engineer the work is of too petty a nature to warrant the special moulding of bricks of the shape required.

Setting bricks in mortar, bond and raking of joints are covered by I.S. 2212/1962.

7. *Non-plastered face work*:—Finishing joints is discussed in para 5.5 of I.S. 2212/1962. Where there is no specification superseding the standard specification "Pointing—Remarks on" non-schedule provision made for extra payment for pointing, the exposed joint shall be finished as described under clauses 1 to 4 of "Pointing remarks on" and shall be well rubbed with a piece of 10 mm rod suitably bent.

7·1. No extra payment will be made for this manner of finishing brick work face joints and it shall be included by the contractor in his unit rate for brick work.

8. *Racking back*:—When circumstances render it necessary to carry on the same section of the building in uneven course the bricks shall be raked back so as to maintain an uniform and effectual bond.

9. Iron, stone, concrete and other fixtures, buttresses, etc., *vide* clause 16 under standard specification for stone masonry general which is to be complied with.

10. *Wet foundations.—Vide* clause 17 under stone masonry general which is to be complied with.

11. *Openings*.—This is covered by paras 10·2, 10·4 of I·S· 2212/1962.

11·1. The contract unit rates for brick work are inclusive of quoin and jambs.

12. *Treating*.—This is covered by paras 5·12 and 5·13 of I.S. 2212/1962.

466-3—35

13. *Treatment at ends of beams and joists*.—The ends of all wooden beams wooden roof trusses, etc., shall rest in recess having 40 mm space for the free circulation of air all-round them and provided with perforated zinc sheeting.

14. Measurement of brick work is covered by I.S. 1200 Part III of 1970.

Measurements—

(i) Brickwork shall generally be measured in cubic metres unless other-wise specified.

(ii) Walls half brick in width and less shall be measured separately in square metres stating thickness.

(iii) Brick walls of width over half brick shall be measured in multiples of half brick which shall be deemed to be inclusive of mortar joints, irrespective of excess of executed width.

(iv) The following shall be taken as half brick measurement.
For bricks 19×9×9 cm—10 cm.
For bricks 19×9×5·7 cm—10 cm.

15. *Wooden bricks*.—No extra price will be paid for wooden bricks and plugs built into masonry, the wooden bricks and plugs themselves are to be supplied free of charge. Clause 14 under stone masonry "General" is to be complied with.

16. *Stacking*.—This is dealt with in I.S. 4082/1977.

17. *Handling bricks*.—Bricks shall not be handled in baskets or in other manner which will destroy the sharpness of their edges.

18. *Checking of levels*.—The Sub-Divisional Officer will personally verify all levels with a levelling instrument when the work reaches the level of the plinth and again at floor and roof levels.

19. *Rounding corners*.—(*a*) Corners of rooms or pillars whether interior or projecting shall not be rounded but in exceptional cases where it is so desired to round the corners shall be done in plaster for the re-entrant corners but will require chiselling of projecting angles before plastering.

(*b*) A separate addendum specification will be issued in case specially moulded rouded corner bricks are to be used in jambs aches and projecting and re-entrant corners so as to eliminate the sharp angles.

(c) The rate tendered for plastering and brick work in the case (a) and (b) above shall be held to cover the cost of labour and materials for complying with this clause.

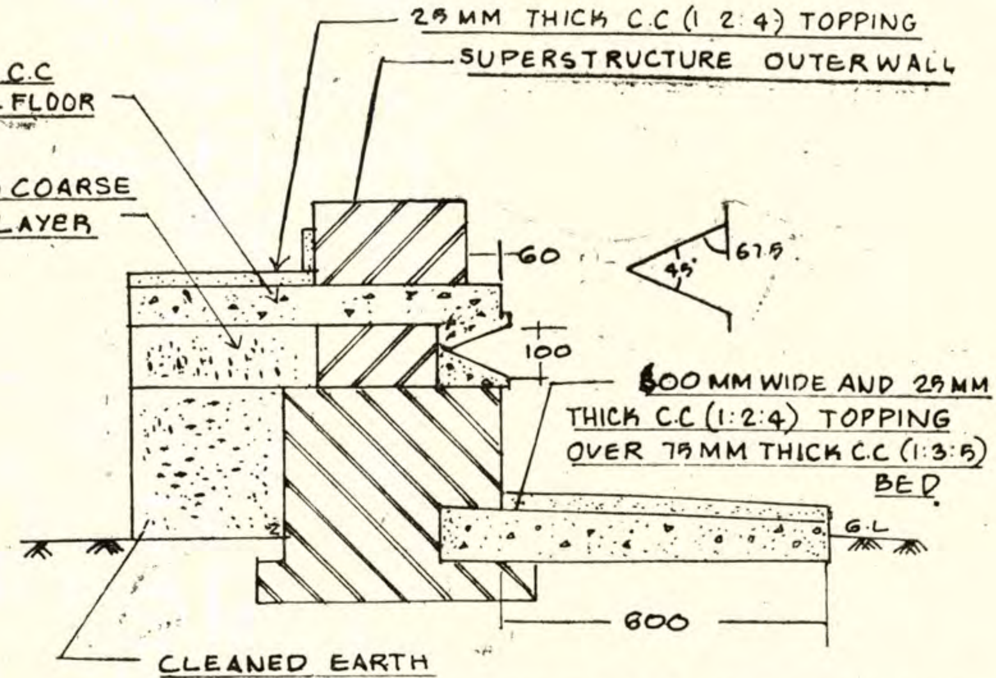
20. *Brick on edge coping, etc* : Para 10.1 of I.S. 2212/1962 shall apply, No extra payment will be made for this work, over the contract rate for brick work. The contract rate for brick work shall include the same.

21. *Plinth off-sets* : Plinth off-sets on the interior faces only should be kept 15 cm below floor level (unless finished thickness of floor to be laid will determine, instead of the 15 cm) to allow for the floor paving which is done subsequently coming upto the face of the superstructure. Similarly retaining walls of verandahs, etc., must be built with due regard to the slope allowed for the floors.

22. *Parapets* : All parapets will be measured under the masonry below them and with which they are continuous in a floor, the parapet has to be reckoned with the lower floor (Circular Memo. 6105/A8/53-2, dated 2nd December 1953).

23. *Anti-termite constructional methods* : At places of foundation where the existence of colonies of subterraneon termites are found the probability of internal attack of termites through floor and plinth tiillings is great. In such places the constructional practices for protection against subterranean termites originating both internally from within the plinth and externally from the area surrounding the building as laid down in I.S 6313 (Part I)—1971 shall be followed.

24. *Applicability of general specification*: General clauses shall apply to all the following sub-specification of brick masonry.



FINAL RECOMMENDATIONS FOR ANTI-TERMITE CONSTRUCTION

SPECIFICATION No. 31-A.

BRICK IN LIME MORTAR.

SPECIFICATION No. 31-B.

BRICK IN SURKI MORTAR.

SPECIFICATION No. 31-C.

BRICK IN CEMENT MORTAR 1:3

SPECIFICATION No. 31-D.

BRICK ARCHWORK.

Clacses Additional to General "Proceding"

1. If bricks, specially moulded to the radial lines of the arch, are demanded for archwork it will be so specified. If any case, the bricks shall be specially selected and shall be free from defects of any sort.

N.B. Specially moulded bricks are always preferable as cutting and rubbing of bricks to give proper radial joints remove the hard surfaces skin which protects the bricks from decay and weathering. The cost of labour, required for rubbing the bricks, will in important works come to as much as providing specially moulded bricks, in which casess it will be advisable for the contractor to provide, the same whether specified or left to his option in supply.

2. The bricks shall be laid in concentric half-brick rings. The voussoir joints shall be properly summered. The thickness of joints shall be the same as that specified in the standard specifications for the same class of brickwork in mortar. In all arches, the voussoir ioints shall be truly perpendicular to the tangent of the curve at those points. In setting the bricks in arches, they shall be well pressed into their beds so as to compress the mortar to full bearing and leave the joint thin.

3. Bricks forming skew-back joints shall be specially mould or cut, so as to radiate truly, and defects in this particular shall not be remedied by the extravagant use of mortar, nor shall patching up by chips, etc., be permitted.

4. Great care shall be taken that the rings are bonded together properly wherever the joints of any of the rings come to a summering or plane face. Joints in two consecutive rings shall not come in the same radial plane. The arch work shall be evenly and quickly done and kept thoroughly moist so that no portion of the arch hardens or sets before the whole arch is completed.

5. Centres shall comply with clause 4 for "Centres" under the standared specifications for "Ashlar Arching".

6. Archwork over doors and windows shall be built to this specification, segmental arches being given the rise indicated in the following table :—

AREA OF SEGMENTS AND MEAN LENGTHS OF ARCH RINGS OF DIFFERENT THICKNESS FOR SEGMENTAL OPENINGS OF 60° OVER DOORS WINDOWS, ETC.

Span in metre.	*Rise in metre.*	*Area of segment in m^2*	*Mean length of arch rings of different thicknesses.*				
			10 cm	*20 cm.*	*30 cm.*	*40 cm.*	*50 cm.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1.0	0.13	0.09	1.10	1.15	1.20	1.26	1.31
1.5	0.20	0.20	1.62	1.68	1.73	1.78	1.83
2.0	0.27	0.36	2.15	2.20	2.25	2.30	2.36
2.5	0.34	0.57	2.67	2.72	2.77	2.83	2.88
3.0	0.40	0.82	3.19	3.25	3.30	3.35	3.40
3.5	0.47	1.11	3.72	3.77	3.82	3.87	3.93
4.0	0.54	1.46	4.24	4.20	4.20	4.30	4.45

Area of segment of 60° = $(\text{Span})^2 \times 0.091$.

Length of intrados = Span $\times$ 1.047

Length of Extrados = (Span + arch thickness) $\times$ 1.047.

Mean length of the arch .. Average of length of intrados and length of extrados

$$\text{Rise} = \frac{\text{Span}}{7 \cdot 4641}$$

7. When flat arches are specified, a relieving arch is to be built over the flat arch. The chamber for the flat arch will be 10 mm per metre of span. The relieving arch must first be built with above precautions regarding centres, etc. and not simply built into the wall over the masonry laid to the segmental shape. Skew-back of relieving arch will be kept in the same radial alignment with the skew-back of the flat arch. The space between a relieving arch and a flat arch or lintel is not to be filled in until the wall has been completed, unless specially ordered by the Executive Engineer. Flat arches will be formed of carefully rubbed brick in header and stretcher bond with all voussior joints converging to the apex of an equilateral triangle described on and below the soffit of the arch. Flat arches will usually only be used for pointed face work.

SPECIFICATION No. 31-E.

BRICK WORK IN CLAY.

1. Mud mortar of the same specification as described in the standard specification "Random Rubble in Clay" shall be used. The bricks shall be the best of the class specified.

2. Work shall be carried out to the Standard Specification with the exception that clay replaces mortar. Joint thickness should not exceed 1.25 cm. The bricks also require comparatively little wetting prior to use nor need they be subsequently kept damp as specified for brick in lime mortar. As the brick work will usually be plastered less labour will be required for finishing off joints of the brickwork.

N.B.—It is customary with this class of masonry in Buildings, to execute the top 30 cm. of walls and 30 cm alround doors and windows with brick in lime mortar or cement mortar.

466-3—35A

SPECIFICATION No. 32.

HONEYCOMB WORK WITH BRICKS AND PLASTERED ONE COAT 10 MM LIME MOTAR INCLUDING WHITE WASHING TWO COATS.

1. Modular bricks shall be used unless other class of bricks are expressly specified in the schedule item description. The bricks shall be thoroughly bedded with lime mortar and have a bearing of 20 mm. on each side.

2. The wall shall be 20 cm. thick. The bond used shall be a heading bond throughout the wall with rectangular shaped holes.

3. The faces and sides of the holes shall be plastered with lime mortar one coat to that standard specification only with thickness 10 mm, and the rate is to include plastering, All joints and edges shall be struck flush to give even surface on all sides.

4. Watering shall be done for one week after completion of the masonry and prior to white washing.

5. Two coat of white wash shall be finally applied to both faces of the work and also to the interior of the heles. This included in the unit rates. The wall shall be carried up regularly course by course.

Note.—Cement mortar can also be used instead of lime mortar.

SPECIFICATION No. 33.

HONEYCOMB WORK WITH WASHED PAN TILES.

1. Standard specification pan tiles are to be used or such other size as may be specified or instructed to be used by the Executive Engineer. In no case tiles of different dimensions be used on the same work.

2. The tiles shall be soaked in water for 24 hours and allowed to dry, After they are quite dry they shall be dipped in standared specification white wash of the consistency of cream and again allowed to dry.

3. The tiles should then be laid in regular rows with concave surface downwards with sufficient mortar at the joints to prevent the tiles from displacement. The tiles in each row shall be built in so that each tile covers the joint between two tiles in the row immediately below. Broken tiles shall never be used on the work.

SPECIFICATION No. 34.

Reinforced Brick Work Walls.

1. The walls shall be built of modular bricks in Standard Specification cement mortar being in the proportion of 1 of cement to 3 of sand. The reinforcement shall consist of hoop iron 40 mm wide and 15 gauge or such other size as may be specified laid flat in the middle of the brickwork. (The bond of the hoop iron with the brickwork will be greatly improved if the hoop iron is punched at intervals of say 15 cm. so as to form burrs on both sides of the reinforcement. The punch hole shall be 6 mm diameter).

2. The strip of hoop iron shall be continuous and if it is not available for the full length it shall be revert-jointed with an overlap of not less than 8 cm. At the ends the strips shall be folded over at the junction to atleast half the depth of the course. It shall be placed at every alternate course or as may be otherwise specified or as shown in the drawing. Before laying the hoop iron it should be exposed to the weather to remove its bluish smooth surface and hereby increase its adhesion to the mortar.

3. Two slots at least 10 cms. deep should be cut in the walls between which the partition has to be built and the partition shall be built into these slots, the slots being flushed full joint with cement mortar 1:3 as the work proceeds.

4. The thickness of the wall will be the width of a standard specification size brick, unless other size brick is permitted by the Executive Engineer to be used—plus the plaster thickness for the two faces.

5. The joints should not be more than 6 mm., except where the hoop iron is to be laid, where the joint should be 25 mm., thick to ensure at least a cover of 12 mm between the reinforcement and the bricks. The face joints shall be raked out to 12 mm. depth before the mortar [illegible] completely.

6. The wall shall be finished with standard specification cement plastering 1 : 5, 12 mm thick on both faces and watered for three weeks.

7. Two coats of standard specification 'white washing' shall then be applied.

8. The rate shall be for 10 square metres inclusive of reinforcement cutting slots in end walls, plastering, white washing etc., completely finished in place.

Note.—(1) These walls are intended to be introduced in places where there are no walls or beams or such other foundation underneath and they are generally expected to act as a beam by themselves and to be held up by the side walls.

(2) For purposes of correct reinforecement it is necessary to lay most of the iron in the bottom courses farthest from the neutral axis of the wall treating it as a beam and to reduce the reinforecement proportionately upto the neutral axis and to have no iron in the compression courses above the neutral axis but to render the wall safe against any lateral shock of stress, reinforcement is taken upto be top.

Note on protection against X-Rays in Institutions—

9. *General.*—The following instructions shall be followed in the construction of all radiological institutions where it is necessary to provide adequate protection to the operators and other personnel engaged in the X-ray work from the harmful effects of X-Rays. In view of the danger to the health of occupants, if any mistakes are committed in applying the protective measures, it is specially warned that the precautions should be carefully studied and put into effect. The extent of protection that is required will depend upon the potentiality of the equipment to be housed. Requirements of various forms of X-Ray work are laid down in terms of thicknesses of lead in millimetres in the report of the X-ray and Radium Protection Committee. These requirements are as follows :—

	X-ray generated by peak voltage in KV.	*Minimum equivalent thickness of lead.* In millimetres.
Not exceeding	75	1·0
,,	100	1·5
,,	125	2·0
,,	150	2·5
,,	175	3·0
,,	200	4·0
,,	250	6·0
,,	300	9·0
,,	350	13·0
,,	400	17·0
,,	500	26·0
,	600	35·0
,,	700	44·0
,,	800	53·0
,,	900	62·0
,,	1000	70·0

9·1. These requirements shall be met by special requirements in construction as detailed below :—

9.1.1. *Walls.*—Walls shall be constructed of special barium impregnated bricks. These bricks shall be made by mixing dry 8 parts by volume of clay absolutely free from any pebbles and vegetable matter and one part by volume of barium sulphate. In order to ensure proper mixing, not more than 0·5 m^3 of clay shall be taken up in a heap for mixing at a time. All such heads are then collected together into a big heap and a pit formed in it. The requisite quantity of water shall then be poured in the pit slowly and the whole allowed to remain for 12 hours after which the mixture shall be thoroughly pugged. Bricks shall then be moulded in a mould of standard size but having special arrangements to leave V-shaped grooves, at least 3 mm. deep on all the four edges of the bricks to distinguish them from ordinary bricks. The bricks so prepared shall be burnt as ordinary bricks and shall be laid in lime mortar to which barium sulphate is added in the proportion of 8 : 1 by volume. The thickness of barium-impregnated brick walls shall be as required by the graph appended to this specification. For wall 30 cm thick barium impregnated bricks will be used for the full thickness and in walls of more than 30 cm. thicnkess. barium-impregnated bricks will be used for 30 cm. and 40 cm. widths, in alternate courses and the balance in thickness will be built with ordinary bricks in ordinary mortar.

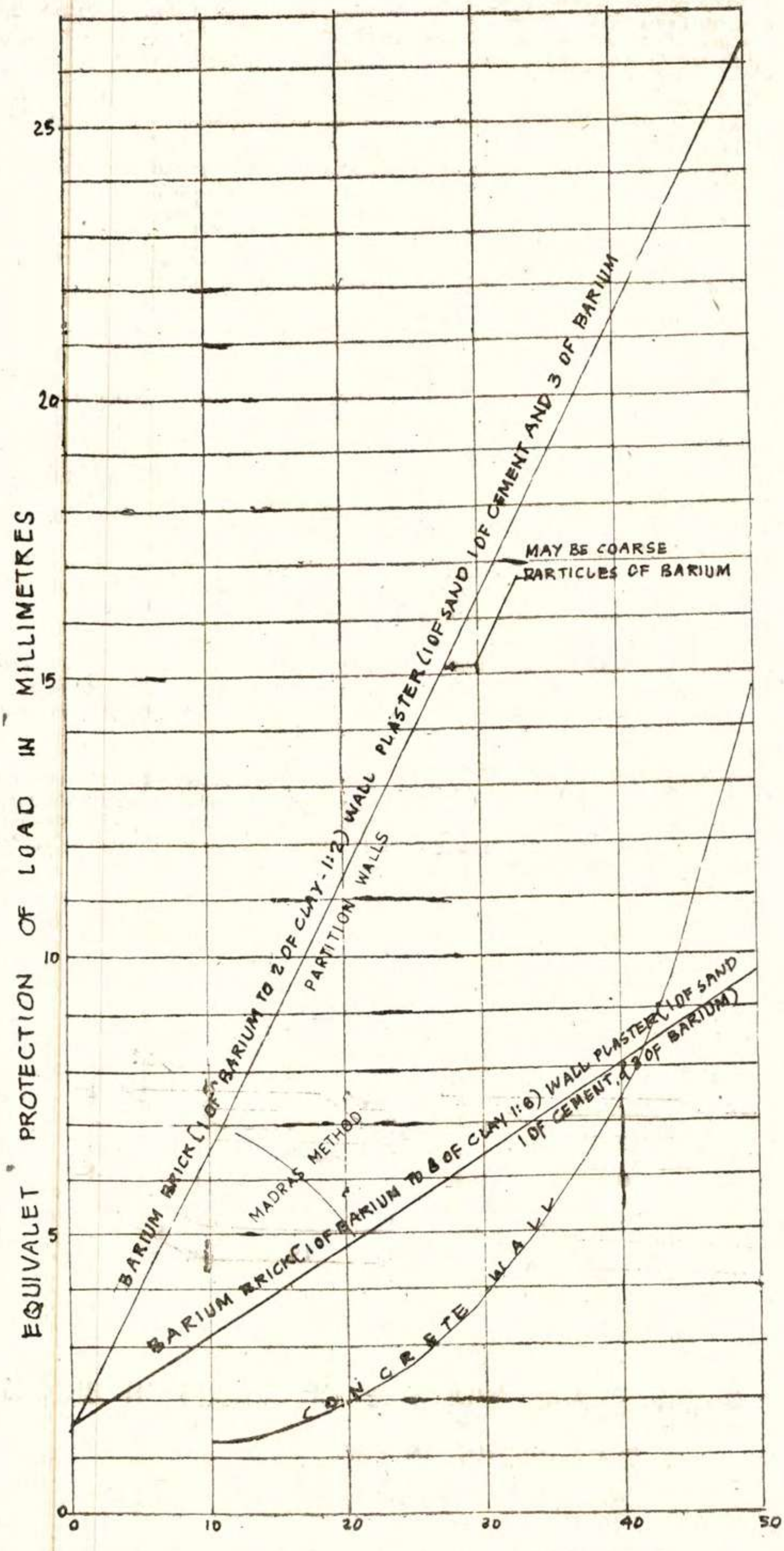

EQUIVALET PROTECTION OF LOAD IN MILLIMETRES
THICKNESS OF WALLS IN CENTIMETRES
0
5
10
15
20
25
0
10
20
30
40
50
BARIUM BRICK (1 OF BARIUM TO 2 OF CLAY - 1:2) WALL PLASTER (1 OF SAND 1 OF CEMENT AND 3 OF BARIUM
PARTITION WALLS
MAY BE COARSE PARTICLES OF BARIUM
BARIUM BRICK (1 OF BARIUM TO 6 OF CLAY 1:6) WALL PLASTER (1 OF SAND 1 OF CEMENT & 3 OF BARIUM)
MADRAS METHOD
CONCRETE WALL

PLATE 5.1

9.1.2. *Wall plastering.*—All the walls of barium impregnated bricks shall be plastered with special mortar of the following mix, viz., cement 1, sand 1, barium sulphate 3, by volume. The thickness of plaster shall be 15 mm to 20 mm lid in the same manner as two coats of ordinary lime plastering.

9.1.3. *Floor and ceiling.*—Floor projection shall be given by paving with barium bricks laid flat in cement barium mortar (1 cement, 1 sand and 3 barium sulphate by volume). The top of the floor shall be finished in good wood, rubber, linolium or any other non-conducting material. Protection in ceiling may be given by finishing with 25 mm thickness of cement barium mortar and painted over with white glossy paint.

9.1.4. *Partitions.*—Partitions shall be built in special partition bricks moulded in the proportion of 2 cla y and 1 of barium sulphate by volume and provided with a groove to accommodate reinforcement of mild steel rods. The protection afforded by these bricks against X-rays is given in the graph appended. The partitions shall be finished with cement barium plaster 15 mm to 20 mm thickness laid in two coats.

9.1.5. *Protection in doors, windows and shutters.*—Full protection shall always be provided for in all openings like doors, windows and shutters, etc. In the sides of door frames the lining of the barium impregnated bricks shall be done to the full thickness of the wall. Door frames shall be wrapped round with 28·3 kg/m2 (i.e., 2·5 mm thick) lead sheet before being fixed in masonry,. Protection in door-shutters shall be given by sand wiching a 56·7 kg/m2 (5·0 mm thick) sheet lead between the door proper and a covering panel of wood. Similar protection shall be given in all windows and shu tters except observation windows which shall have lead-glass shutters. Windows shall also be placed at a height of about 1·5 metres from floor level so that no direct radiation will pass out of the room.

EXTRACT FROM I.S. 4082-1977
Recommendations on stacking and storage of construction Materials at site (first revision).

3.4. *Bricks* :

3·4·1. Brick shall not be dumped at site. They shall be stacked n regular tiers as and when they are unloaded to minimise breakage and defacement of bricks.

3.4.2. In the case of bricks made from clays containing lime *KANKAR*, the bricks in stack should be thoroughly soaked in water (docked) to prevent lime bursting.

3.4.3. Brick stacks shall be placed close to the site of work so that least efforts is required to unload and transport the bricks again by loading on pallets or in barrows. Building bricks shall be loaded or unloaded a pair at a time unless palletised. Unloading of building bricks or handling in any other way likely to damage the corners or edges or other parts of bricks shall not be permitted.

3.4.4. Bricks shall be stacked on dry firm ground. For proper inspection of quality and ease in counting. The stacks shall be 50 bricks long and 10 bricks high, the bricks being placed on edge and preferably, the width of each stack shall be two bricks. Clear distance between adjacent stacks shall not be less than 0·8 m.

3.4.5. Bricks of different types and classification shall be stacked separately.

EXTRACT FROM I.S. : 1077—1970
Specification for common burnt clay building Bricks.

3. *Classification*

3.1. The common burnt clay bricks shall be classified on the basis of their minimum compressive strength. The brick of compressive strength 50 kg./cm.² shall be classified as 50.

3.1.1. Each class of bricks shall be further divided into two sub-classes A and B based on tolerances and shape. The brick of classification 50 shall have sub-classification 50 A and 50 B.

NOTE.—For convenience, detailed classification of bricks covered by this standard as well as in IS : 2180-1970 (Specification for heavy duty burnt clay building bricks) (first revision) has been prescribed in IS : 3102 classification of burnt clay building bricks, (First revision).

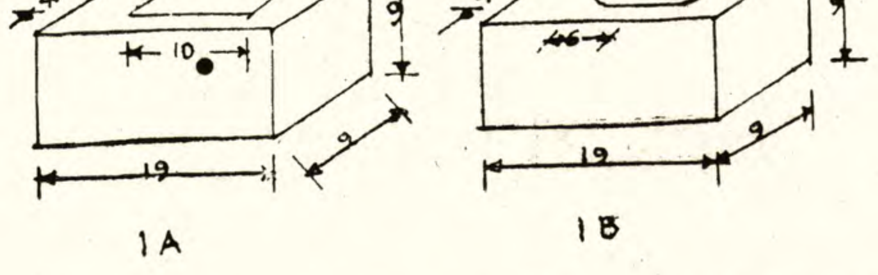


FIG. 1. SHAPE AND SIZE OF FROGS IN BRICKS
ALL DIMENSIONS IN C.M

4. *General quality.*

4·1. Bricks shall be hand-or machine-moulded they shall be free from cracks and flaws and nodules of free lime. Bricks of 9 cm. height shall be moulded with a frog 1 or 2 cm. deep on one of its flat sides ; the shape and size of the frog shall conform to either Fig. 1A or Fig. 1B. Bricks of 4 cm. height and those made by an extrusion process may not be provided with frogs.

4·2. The bricks of sub-class A shall have smooth rectangular faces with sharp corners and emit clear ringing sound when struck. The bricks of Sub-class B may be permitted to have slight distorted and rounded edges provided no difficulty shall arise on this account. in laying of uniform courses.

5. *Dimension and tolerances.*

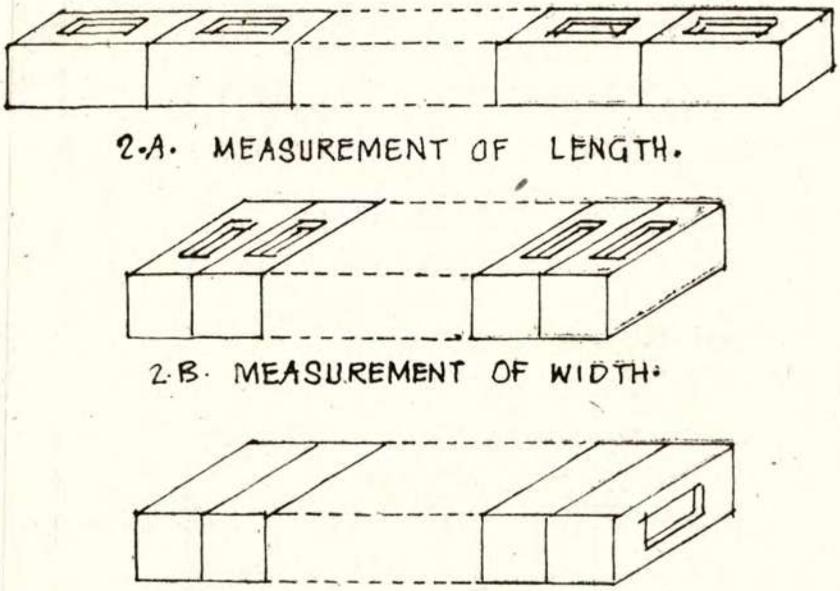
5·1. The standard sizes of common building bricks shall be as follows:

Length. *cm.*	*Width.* *cm.*	*Height.* *cm.*
19	9	9
19	9	4

5·2. *Tolerances*—The dimensions of bricks when tested in accordance with 5·2·1 shall be within the following limits:—

Sub-Class A.	a. Length.	368 to 392 cm.
	b. Width.	174 to 186 cm.
	c. Height.	174 to 186 cm. (in the case of 9 cm. high bricks). 77 to 83 cm. (in the case of 4 cm. high bricks).
Sub-Class B.	a. Length.	350 to 410 cm.
	b. Width.	165 to 195 cm.
	c. Height.	165 to 195 cm. (in the case of 9 cm. high bricks.) 74 to 86 cm. (in the case of 4 cm. high bricks).

5·2·1. Twenty (or more according to the size of stack) whole bricks shall be selected at random from the sample selected under 7. All blisters, loose particles of clay and small projects shall be removed They shall then be arranged upon a level surface successively as indicated in Figure 2A, 2B and 2C in contact with each other and in a straight line. The overall length of the assembled bricks shall be measured with a steel tape or other suitable in extensible measure sufficiently long to measure the whole row at one stretch. Measurements by repeated application of a short rule or measure shall not be permitted. If for any reason it is found inpracticable to measure bricks in one row, the sample may be divided into all the rows of 10 bricks, which shall be measured separately to the nearest millimetre. All these dimensions shall be added together.



2·A· MEASUREMENT OF LENGTH.

2·B· MEASUREMENT OF WIDTH·

2·C· MEASUREMENT OF HEIGHT

FIG 2. MEASUREMENT OF TOLERENCE OF BURNT CLAY BUILDING BRICKS.

6. *Physical properties.*

6.1. Compressive strength: Common building bricks shall have a minimum compressive strength of 50 kg./cm.^{2} when tested in accordance with the procedure laid down in table 1 of IS: 3495—1966 (See also note under 1·1).

6·1·1. The compressive strength of any individual brick shall no fall below the average compressive strength specified for the corresponding class of brick by more than 20 per cent.

6·2· *Water absorption.*—When tested in accordance with the procedure laid down in Table 2 of IS : 3495—1966 (Method of sampling and testing of clay building bricks) the average water absorption of common building Bricks shall not be more than 20 percnet upto class 125 (see 3·1) and 15 per cent for higher class, by weight after immersion in cold water for 24 hours.

6·3. *Efflorescent.*—When common building bricks are tested in accordance with the procedure laid down in Table 3 of IS: 3495—1966 (Method of sampling and testing of clay building bricks the rating of efflorescence shall not be more than "moderate" upto Class 125 and "slight" for higher classes.

EXTRACT FROM I.S. : 3102—1971

Classification of burnt clay solid bricks.

3. *Classification.*

3·1. The classes and sub-classes of burnt clay solid bricks shall be as given in Table I.

TABLE-I. CLASSES OF BURNT CLAY SOLID BRICKS AND THEIR PRINCIPAL REQUIREMENTS.

Type of brick.	*Class designation (see note below).*	*Compressive strength kg/cm^2 Min.*	*Water absorption (24 hr. Immersion percentage) max.*	*Efflorescence.*
(1)	(2)	(3)	(4)	(5)
Heavy duty (see IS: 2180—1970).	450	450	10	Nil.
	400	400	10	Do.
Common burnt clay building bricks (*see* IS:1077—1970).	350	350	15	Slight.
	300	300	15	Do.
	250	250	15	Do.
	200	200	15	Do.
	175	175	15	Do.
	150	150	15	Do.
	125	125	20	Moderate.
	100	100	20	Do.
	75	75	20	Do.
	50	50	20	Do.

NOTE.—Each class of bricks shall further be divided into sub-Classes A, B, etc., based on the following :—

Sub-class A—Tolerance limit shall be ± 3 percent and shall have smooth rectangular faces with sharp corners and emit clear ringing sound.

Sub-class B—Tolerance limit shall be ± 8 percent and shall be permitted to have slight distortion and rounded edges, provided no difficulty shall arise in laying of uniform courses.

EXTRACT OF I.S. : 2691-1972

Specification for burnt clay facing bricks (First Revision.)

3. *Classification.*

3·1. The facing bricks shall be of two classes—

(*a*) Class I ; and
(*b*) Class II.

4. *General quality.*

4·1. The facing bricks shall be made of clay, shale or mixture of these materials with or without admixtures and burnt to meet the requirements of this standard. The colouring material added to the clay shall be of suitable ceramic materials and shall be well distributed throughout the body. The brick shall be of uniform colour.

4·2. The bricks shall be free from cracks, flaws and nodules of free lime and of even texture. These shall be thoroughly burnt and shall have plane rectangular faces with parallel sides and sharp straight right angled edges.

5. *Dimensions and tolerances.*

5·1. The standard sizes of the facing bricks shall be 19 × 9 × 9 cm. nd 19 × 9 × 4 cm.

5·2. The permissible tolerances shall be as under :—

Dimension.	*Tolerance.*	
	Class I.	*Class II.*
cm.	*mm.*	*mm.*
19	±3	±5
9	±2	±3
4	±1·5	±2

6. *Physical requirements.*

6·1. The average compressive strength obtained in accordance with the procedure laid down in Table I of IS: 3495—1966 (Method of sampling and testing clay building bricks) shall not be less than 75 kg./cm.^{2} for Class II and 100 kg./cm^2 for Class I.

6·2. The water absorption requirement when tested in accordance with the procedure laid down in Table 2 of IS: 3495—1966 for 24 *h* immersion shall not exceed 15 per cent.

6·3. When tested in accordance with the method specified in Table 3 of IS: 3495—1966 efflorescence requirements shall be 'Nil' for both classes.

6·4. When measured in accordance with the method specified in Table 4 of IS: 3495—1966 the warpage for both classes shall not exceed 2·5 mm.

EXTRACT OF IS: 2212—1962.
Code of Practice for Brick Work.

Nominal thickness of a wall.—This is the thickness of wall that is stated in the estimates for calculation of quantities. It is a 'fictitious' dimension, which is neither the actual thickness of wall excluding surfaces finishes like plaster, rendering, etc., nor necessarily the overall thickness including such finishes. The following example will illustrate this point :—

	Nominal thickness.	Actual thickness.
For traditional brick of		
9 in. length (with allowance of 1/4 in. for mortar joint)—		
One brick wall ..	9 in.	$8\frac{1}{2}$ to $8\frac{3}{4}$ in.
$1\frac{1}{2}$ brick wall ..	$13\frac{1}{4}$ in.	13 to $13\frac{1}{4}$ in.
2 brick wall	18 in.	$17\frac{1}{2}$ to $17\frac{3}{4}$ in.
For modular brick		
(With allowance of 1 cm. for mortar joint)—		
One brick wall ..	20 cm.	19 c.m
$1\frac{1}{2}$ Brick wall	30 cm.	29 cm.
2 Brick wall ..	40 cm.	39 cm.

4·1. *Bricks.*—Unless otherwise specified, burnt-clay bricks shall conform to the requirements of IS: 1077–1957 specification for common burnt clay building bricks, and shall be of the specfied class.

4·2. *Mortars.*—Mortars for masonry shall be prepared in accordance wth IS: 2250 Code of Practice for preparation and use of masonry mortars.

The materials used for mortar shall conform to the requirements specified in 4·2·1 to 4·2·4·

4·2·1. *Cement.*—Cement used for brick masonry shall be ordinary or rapid—hardening portland cement conforming to IS: 269—1958 Specification for ordinary, Rapid—hardening and Low Heat Portland Cement (Revised) or blast furnace slag cement conforming to IS:455—1962,specification for port land Blast-furnace slag Cement (Revised.)

4·2.2 *Lime.*—Lime used for brick masonry shall conform to the requirements of IS 712—1956, Specification for Building Limes This may be used in the form of either hydrated lime or lime putty Field slaking of lime shall be done in accordance withIS: 1635—1960. Code of Practice for Field slaking of lime and preparation of Putty,

4·2·3 *Fine aggregate.*—Sand shall conform to IS: 2116 Specification for sand for masonry Mortar.

4·2.4. *Water.*—Water used for masonry mortar shall be clean and free from injurious amounts of deleterious materials.

5. *Design consideration.*

5.1. *Selection of bricks.*

5·1·1. For use in various situations of brick masonry, the brick shall be selected in accordance with Table 1.

5·1.2. When the requirements for strength of masonry predominate in the particular situation of use, the bricks shall be of such grade (*see* IS: 1077—1957) as to give the required strength for masonry and shall be selected in accordance with their relevant provisions of IS: 1905—1961, Code of Practice for Structural Safety of buildings Masonry walls.

5·2. *Selection of mortars.*

5·2·1. Mortars used for Brick Masonry shall conform generally to IS: 2250—1965—Code of Practice for Preparation and use of Masonry Mortars.

TABLE I : SELECTION OF BUILDING BRICKS.

(*Clause* 5·1·1·)

Serial number and situation of use.	*Type of brick to be used.*	*Special consideration.*	*Remarks.*
(1)	(2)	(3)	(4)
1. Facing	Class I Common bricks (*See* IS: 1077—1957).	Bricks shall be free from minor defects such as chips at the edge of corners. Colour and texture may also be specified. if so required.	....
2a. Subject to very heavy loadihg.	Heavy duty (*See* IS: 2180—1962).	....	....
(*b*) Requiring a high resistance to water penetration.	Do.	....	....
3 (*a*) Plinths and foundations below damp-proof course—ground well drained and no chance of continual wetting in foundations.	Class I or class II common bricks (*see* IS: 1077—1957).	....	
(*b*) Plinths and foundations below damp-proof course subsoil water table at a high level.	Do.	The bricks shall be free from efflorescence. These shall also not have any salt content which will affect the mortar of the masonry. The bricks may prefereably be the densest available with the minimum water absorption.	

TABLE I; SELECTION OF BUILDING BRICKS.

Clause (5·1·1)

Serial number and situation of use.	*Type of brick to be used.*	*Special consideration.*	*Remarks.*
(1)	(2)	(3)	(4)
4. (*a*) External walls neither plastered nor rendered on the outer face.	Class I common bricks (*see* IS: 1077—1957).	The bricks shall preferably be of uniform colour.	The exposed joints shall be pointed with a dense water tight mortar.
(*b*) External walls finished on both faces with a water-tight plaster or rendering.	Class II or better quality common bricks (*see* IS: 1077—1957).	....	For situations exposed to severe weather (*see* Table III only class I common bricks shall be used as in 4a.
5. Internal walls	Class II common bricks (*see* IS: 1077—1957).	....	Class III common bricks also may be considered for use, provided they satisfy the requirements for strength (*see* IS: 1077—1957). For walls which are liable to be frequently in contact with water such as in bathrooms only Class II or better bricks shall be used.
6. Free standing walls, parapets.	Class I common bricks (*see* IS: 1077—1957).	....	A dense water tight mortar shall be used for the masonry. Parapets shall preferably be finished on all sides with a water tight plaster.

5·2·2. The selection of mortar will alsobe governed bythe strength required for masonry and reference may be made to IS: 1905—1961 Code of Practice for Structural Safety of Buildings; Masonry walls for knowing the suitability of combination of various types of mortars and grades of bricks for different strengths required for the masonry.

5·3. *Types of bonds and their suitability.*

5·3·1. The primary object of bond is to give strength to masonry but it may also be employed to create artistic effects when the brick work is exposed to view.

5·3·2. In brickwork the cross joints in any course shall not be nearer than a quarter of a brick length from those in the course below or above it.

5·4. *Thickness of joints.*

5·4·1. The thickness of bed joints shall be such that four courses and three joints taken consecutively shall measure as follows:—

(*a*) In the case of traditional brick.	Equal to four times the actual thickness of the brick plus 3 cm.
(*b*) In the case of modular brick conforming to I.S: 1077—1957, specification for Common Burnt Clay Building Bricks (*see* also 0·3).	Equal to 39 cm.

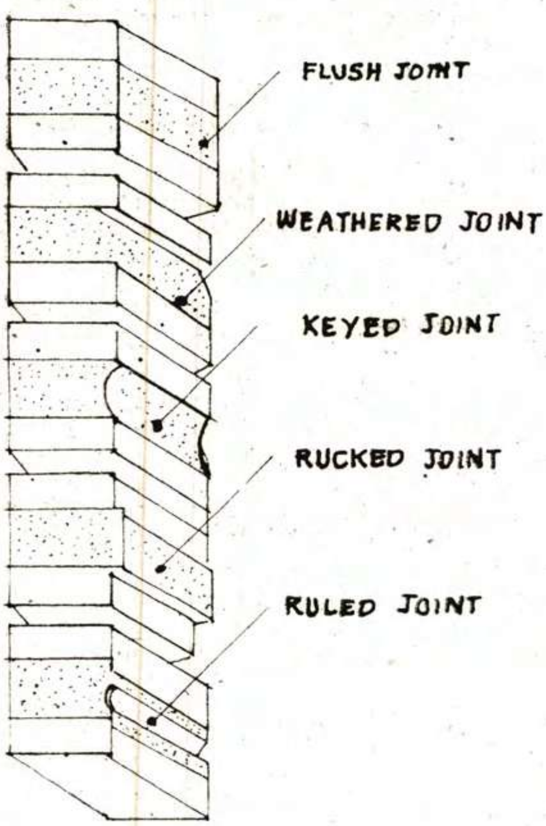
5·5. *Finishing of joints.*

5·5·1. The face joints of brick work may be finished by "Jointing or by "pointing."

5·5·2. In jointing, either the face joints of the mortar shall be worked out while still green to give a finished surface flush with the face of the brickwork, or the joints shall be squarely raked out to a depth of 1 cm. while the mortar is still green for subsequent plastering. The faces of brickwork shall be cleaned with wire brush so as to remove any splashes of mortar during the course of raising the brickwork.

5·5·3. In pointing, the joints shall be squarely raked out to a depth of 1·5 cm. while the mortar is still green and the raked joint shall be well brushed to remove dust and loose particles and well wetted, and shall be later refilled with mortar to give the required finish. Some such finishes are "flush" "weathered" "tucked". "ruled," etc. (*see* fig.).

NOTE:- POINTING WILL OFFER FACILITIES FOR INTRODUCING IN THE FACE JOINTS A MORTAR SPECIALLY PREPARED WITH REGARD TO COMPOSITION, COLOUR, ETC



DIFFERENT TYPES OF POINTING FINISHES FOR BRICK WORK

5·6·2. *Resustance to moisture penetration.*

5·6·2.1. Rain-water penetrates solidbrickwork eitherthrough cracks or through the body of the bricks of mortar. Unrendered walls permit more water to pass through than rendered walls, and there fore shall not be relied on to give protection from rain except under sheltered or moderate conditions.

5·6·2.2. Resistance to rain penetration will be increased by rendering which prevents the access of water through the joints of brickwork except in small quantities passed through by capilarly action. Rendered walls are, therefore, suitable for severe conditions provided other requirements, such as sufficient thickness, use of satsifactory materials, and workmanship are also satisfied.

5·6·2.3. A hollow wall willprovide a perfect barrier torain penetration. Even when the outer part of the wall gets wet, the inner one will remain absolutely dry.

5·6·2·4. Table III. indicates the suitability of various walls under different conditions of exposure.

TABLE III. SUITABLE OF WALLS FOR VARIOUS EXPOSURES.

Serial number.	Construction.	Exposure.		
		Sheltered.	Moderate.	Severe.
(1)	(2)	(3)	(4)	(5)
1	Unrendered ½ brick thick wall ..	N	N	N
2	Unrendered 1 brick thick solid wall.	R	N	N
3	Unrendered 1½ brick thick solid wall.	R	R	N
4	Rendered solid wall	R	R	N
5	Hollow walls	R	R	R

R=Recommended. N=Not Recommended.

NOTE.—Exposure conditions to wind and rain may be broadly divided into sheltered, moderate and severe locations.

Sheltered conditions are, for example, regions of low rainfall (below 750 mm. per annum) and where brickwork is protected by the proximity of buildings of similar or greater heights. Brickwork in the lower two storeys of buildings of such locations will fall in this group.

Moderate conditions obtain where the exposure is neither sheltered nor severe.

Severe conditions obtain where the brick work is exposed to a moderate gale accompanied by a persistent rain, Brick work that projects well above the surrounding buildings will, especially be severely exposed.

5.6.4.1. When bricks which have a drying shrinkage of not more than 0·02 per cent are used, fine hair cracks appear in the joints. These may usually be ignored. With bricks of higher shirnkage values, major cracks may appear through the brick work. To confine cracks to the joints and to dissipate these into a large number of fine joints, it is desirable that the mortar used shall be weaker than the bricks.

5.6.4.2. Cracking due to shrinkage normally will occur at openings or other points where the vertical or horizontal section of a wall changes. A long wall with a few openings will tend to show wider cracks above and below the openings than a similar wall with many openings. Metal reinforcement may be embedded in brickwork at points where cracking is likely to occur.

5.10. *Bearing of floors and roofs.*

5.10.1. *Timber floors and roofs.*—It is not desirable to embed any structural timber in brickwork as it is liable to be affected by dry rot. Timber wall plates shall be protected with preservative if they have to be embedded in wall. The ends of timber joints shall preferably rest on corbels or brackets but when built into a wall they shall be treated with preservative and, in addition, space shall be left around them for free circulation of air. The ends of beams carrying heavy loads, and of trusses shall be supported on templates of concrete or stone to distribute the load over a greater area of brick wall.

5.10.2. *Steel beams.*—The ends of steel beams embedded in masonry shall be built—in with space all round for repainting or shall be protected with a thick bituminous coat, or shall be encased in rich concrete of mix 1 : 2 : 4. The ends shall generally be supported on templates of plain or reinforced cement concrete of mix. 1 : 2 :4 or stone.

5.10.3. *RCC floors and roofs.*

5.10. 3.1. Reinforced cement concrete floor and roof slabs resting on the wall shall have a width of bearing not less than the effective teeth of slab, subject to a minimum of 10 cm.

5.10.3.2. Where the bottom of the slab does not coincide with the level of a brick course, the level shall not be made up with cut bricks but the thickness of the slab at bearing shall be increased so that the bearing is directly on the brick course immediately below its level.

5.10.3.3. Ends of RCC beams shall generally be placed on template of plain or reinforced cement concrete or stone.

5.10.3.4. The ends of RCC slabs may bear on a layer of cement mortar (1: 4 mix) 12 to 20 mm. thick. Its top surface shall be white-washed or otherwise suitably treated so as to minimize the friction to movement of the concrete slab over the bearing.

5.11. *Brick work round openings.*

5.11.1. Opening shall be of such a size and so spaced in walls as to reduce cutting of bricks to the minimum. The width of opening shall, as far as possible be a multiple or the width of a brick.

5.11.2. In external walls, it is desirable to rebate the sills, jambs and heads of openings so as to form a barrier for rain-water. The sill shall be slopped slightly so as to allow rain water to drain off.

5.12. *Parapets and copings.*

5.12.1. The thickness of parapets shall be such that their base covers the junction of roof slab and wall which shall be further effectively treated against possible leakage of rain water (*see* relevant Indian Standards on roof finishing.)

5.12.2. Copings may be of stone, concrete, brick or terracotta and throated on the underside of the projection, The top of the coping shall be slightly slopped so as to allow rain water to drain off.

5.13. *Architectural features.*

5.13.1. All Projecting architectural features, such as plinth projections, string courses or cornices, shall be effectively bonded by tailing into the brickwork to ensure stability. Such architectural features shall be set straight and tune with the finished joints as far as possible.

5.13.2. When such features are not to be plastered over, they shall be built with bricks which have high durability, resistance to abrasion and moisture penetration, Bricks specially made to required shape for this purpose shall be used, if possible ; otherwise, selected bricks rubbed and ground to correct shape and size may be used.

5.13.3. Sunshades and such projecting features which depend on the weight of Brick masonry over them for their stability shall be kept supported till such time when the brick masonry above is built and hardened sufficiently.

6.4. *Mortars.*

6.4.1. The problem of storage of mortar does not arise in the case of cement and cement-lime mortars or lime mortars with hydraulic limes, as these have to be used immediately. Lime mortars using semi-hydraulic limes which sometimes require to be used after a day or two after their grinding, shall be prevented from drying out by protective covering and by occasional sprinkling of water.

6.4.2. Mortars shall be well mixed and shall be transported from the mixing platform to the site of work in such a manner as to prevent formation of laitance or segregation.

9. *Soaking of bricks.*

9.1. Bricks shall be soaked in water before use for a period that is sufficient for the water to just penetrate the whole depth of the bricks (see Notes.) Wetting the bricks assists in removing the dirt, sand and dust from them. Further, it prevents the suction of water from the wet mortar, as otherwise the mortar is likely to dry out soon and crumble before attaining any strength. The bricks shall not be too wet at the time of use, as they are likely to slip on the mortar bed and there will be difficulty in ensuring plumb ness of the wall, Moreover, proper adhesion of bricks to mortar will not bc possible if the bricks are too wct.

NOTE 1.—The period of soaking may be easily found at site by a field test in which the bricks are soaked in water for different periods and then broken tofind the extent of waterpenetration. The least period that corresponds to complete soaking will be the one to be allowed for in the construction work.

NOTE 2.—If the bricks are soaked for the required time in water that is frequently changed, the soluble salts in the brick will be leached out, and subsequent efflorescence will be reduced.

9.2. When bricks are soaked they shall be removed from the tank sufficiently early so that at the time of laying they are skindry. Such soaked bricks shall be stacked on a clear place, where they are not again spoilt by dirt, earth,etc.

10. *Laying of brickwork.*

10.1. *General.*

10.1.1. Bricks shall be laid on a full bed of mortar. When laying the bricks shall be slightly, pressed so that the mortar can get into all the pores of the brick surface to ensure proper adhesion. Cross joints and wall joints shall be properly flushed and packed with mortar so that no hollow spaces are left. Properly filled joints ensure maximum strength and resistance to penetration of moisture which takes place mainly through joints.

In the case of thick walls (two-brick thick and over), the joints shall be grouted at every course in addition to bedding and flushing with mortar.

The courses at the top of the plinth and sills at the top of the wall just below the roof slab or floor slab and at the top of the parapet, shall be laid with bricks on edge (applicable only in the case of traditional bricks); and at corners and deadends the bricks shall be properly radiated and heyed into position by using cut-bricks (also known as 'punja' bricks or 'maruconas'). Typical shape and arrangement of these bricks are shown in Fig.

A TYPICAL ARRANGEMENT OF CUT-BRICKS IN A CORNER.

10. 1. 2. Bricks with 2 cm. deep frog shall be used frog-down Bricks with 1 cm. deep frog shall be used either frog up or frog-down.

10. 1. 3. The courses shall be aligned and care shall be taken to keep the perpends.

10. 1. 4. The brick work shall be built in uniform layers; corners and other advanced work shall be racked back. No part of a wall during its construction shall rise more than one metre abovethe genera construction levels, to avoid unequal settlement and also improper jointing.

10.1. 5. The face joints shall be furnished either by jointing or by pointing as specified, in accordance with 5.5.

10.1.6. Toothing may be done where future extention is contemplated but shall not be used as an alternative to racking back.

10·2. *Walls.*

10·2.1. All quoins shall be accurately constructed and the height of the courses checked with storey rods as the work proceeds. In general, quoin-bricks shall be headers and strerchers in alternative courses, the bond being established by placing a quoin closer next to the queen header.

10.2.2. Acute and obtuse quoins shall be bonded. Where practicable, in the same way as square quoins. Obtuse quoins shall be formed with squints showing a three-quarter brick on one face and a quarter brick on the other.

10.3. *Pilasters.*—These shall be so set out as to avoid broken bond

10.4. *Openings.*

10.4.1. The depth of reveals and rebates shall, where practicable, conform to standard brick sizes in order to avoid cutting of bricks and thereby weakening the work.

10.4. 2. The arrangement of bond at quoins at Jambs of openings shall be symetrical.

10.5. *Partitions.*—For half brick partitions to be keyed into main walls, indents shall be left in the latter.

10.6. *Arches.*—Arches shall be turned with ordinary bricks over timber centres, generally in rings of half-brick length. For face work, the bricks shall be either specially manufactured bricks or ordinary bricks cut and rubbed to shape in order to obtain uniform radial joints.

10.6.1. Flat arches may be used for the sake of appearance, but for purposes of carrying loads of the wall above they shall be used in conjunction with relieving arches, or with lintels palced behind.

10.6.2. In the construction of a flat arch, through the extrados is perfectly level, the intrades is given a slight camber to allow for any slight settlement or to correct the apparent sagging of a horizontal line, the usual allowance being about 1 mm. rise at the centre for every decimetre of span.

10.6.3. Large acrhes in masonry shall be constructed in accordance with the relevant Indian Standards on construction of masonry arches.

10.7. *Fixing of frames.*

10.7.1. Where door or window frames of timber are fixed in the openings, the fixing shall be done generally with hold-fasts of adequate size and strength securely embedded in the brickwork or in chases later filled up by cement mortar or concrete. Hold-fasts shall be fixed in the brick-work for a sufficient length and then turned up at end into a cross joint, thus avoiding indiscriminate cutting of bricks. Iron hold-fasts shall be given a protective coat of bitumen to avoid rusting. Wood-workfaces in contact with brickwork shall be treated with wood preservative to prevent attack from insects and termites.

10.7.2. Fixing of steel doors and windows shall be done in accordance with IS : 1081—1960, Code of Practice for Fixing and Glazing of Metal (Steel and Aluminium) Doors, Windows and Ventilators.

10.7.3. Fixing of timber doors and windows shall be done in accordance with the relevent Indian Standard on fixing of timber doors and windows.

10.7.4. The frames shall preferably be fixed simultaneously and the masonry work proceeds, as this construction will ensure proper bond without gaps between the masonry and the frames.

10.8. *Reinforced brick-work.*

10.8.1. Reinforcement in half-brick partition walls may be in the form of mild steel flats or hoop iron, expanded mesh or mild steel bars or fabric. These are generally used in every third or fourth courses of the brick-work. They shall be securely anchored at their ends where the partitions bond.

10.8.2. In the case of round bars used as reinforcement, the diameter shall not exceed 8 mm. Flat bars and similar reinforcement shall not have a thickness exceeding 8 mm.

10.8.3. The thickness of reinforced brick wall shall be not less than 10 cm.

10.8.4. The crushing strength of the bricks used in reinforced brick work shall be not less than 140 kg/cm².

10.8.5. The mortar used for reinforced brickwork shall generally be rich, dense, cement mortar of mix about 1 : 3. Lime mortars shall not be used.

10.8.6. The inlaid steel reinforcement shall be completely embedded in mortar. Overlaps in the reinforcement, if any, shall not be less than 30 cm.

10.8.6.1. The mortar covering in the direction of joints shall be not less than 15 mm.

10.8.6.2. The mortar interposed between the reinforcement bars and the brick shall be not less than 5 mm. thick.

10.8.7. In the case where the reinforcements cross inside a joint, the diameter of the reinforcement shall not exceed 5 mm. Unless specially shapped bricks are used to permit larger reinforcement.

10.10. *Curing*—In hot and dry weather, the mortar is likely to dry up before it has attained its final set and crumble. This shall be prevented by keeping the brick work constantly wet for atleast seven days, except in the case of brick work with mud mortar for which no such curing shall be done.

11.3. *Inspection of workmanship.*—A close supervision while the work is in progress will ensure a better quality work with he materials available for use. The following shall be observed at the time of inspection:—

(*a*) All loose materials, dirt and set lumps of mortar which may be lying over the surface over which brickwork is to be freshly started, shall be removed with a wire brush.

(*b*) All the bricks shall be thoroughly soaked in clean water immediately before use.

(*c*) The surface over which the brickwork is to be started shall be slightly wetted.

(*d*) The first course itself shall be made horizontal by providing enough mortar in the bed joint to fill up any undulations in the bed course.

(*e*) Plastic mortar results in thorough bedding of the brick and more complete filling of the joints which ensure greater strength. Care shall be taken to see that the required quantity of water is added to the mortar at the mixing platform itself and not over the courses.

(*f*) All the joints shall, as far as possible, be thin and the specifications mentioned in 5·4 in this regard shall be strictly adhered to.

(*g*) Care shall be taken to see that there is no through joints and the lap is not less than half the width of the brick, and that all the vertical joints are properly filled with mortar.

(*h*) The verticality of the walls and horizontality of the courses shall be checked very often with plumb bob and spritlevel, respectively.

(*j*) No portion of the work shall be left more than 1 m. lower than the other. Where the masonry of one part has to be delayed work shall be 'raked back' suitably at an angle not exceeding 45° according to bond, and not toothed.

(*k*) Where plastering is required to be done all the vertical as well as horizontal joints shall be raked to a depth of about 1 cm. while the mortar is wet, and this will ensure satisfactory adhesion between the plaster and brick work.

(*m*) Care shall be taken to ensure that the brickwork is kept wet for seven days commencing from 24 hours after the course is laid.

EXTRACT FROM THE I.S. 1905—1969
(CODE OF PRACTICE FOR STRUCTURAL SAFETY OF BUILDINGS : MASONRY WALLS (FIRST REVISION))

6; *Permissible stresses and design of walls.*—

6.1. *General* :—The permissible stresses recommended in this code apply to masonry walls consisting of squared units built to horizontal courses, with broken vertical joints (*See* 1 : 1, 3 and 4.6). In addition to the requirements given in 6.2 to 6.7, the recommendations given in 6.1.1, 6.1.2. and 6.1.3 shall apply to cavity walls faced walls and veneered walls respectively.

6.1.1. *Cavity wall.*—Where the load is carried by both leaves of a wall of a cavity construction, the permissible stress should be based onthe slenderness ratio derived from the effective thickness of the wall given in 5.8.3. or5.8.4. The eccentricity of the load shall be considered with respect to the centre of gravity of the cross-section of the wall. Where the load is carried by one leaf only, the permissible stress may be arrived at by one of the following two alternative methods.

(*a*) The slenderness ratio is based on the effective thickness of the cavity wall as a whole as given in 5.8.3 or 5.8.4 and on the eccentricity of the load with respect to the centre of gravity of the cross-section of the whole wall (both leaves). This is the same method as where the load is carried by both the leaves but the eccentricity will be more when the load is carried by one leaf only.

(*b*) The slenderness ratio is based on the effective thickness of the loaded leaf only using 5.8.1. or 5.8.2 and the eccentricity of the load will also be with respect to the centre of gravity of the loaded leaf only. In this method, the effective thickness is reduced (thus increasing the slenderness ratio) but the eccentricity is also reduced at the same time. In some cases, method (*a*) may give a higher stress factor and in this way allowance is made for the stiffening effect of the other leaf. In either case, only the actual thickness of the load bearing leaf should be used in arriving at the cross-sectional area resisting the load (*see* 5.3.2).

6.1.2. *Faced wall.*—The permissible load per unit length of wall shall be taken as the product of the total thickness of the wall and the permissible stress in the weaker of the two materials. The permissible stress shall be found by using the total thickness of the wall when calculating the slenderness ratio.

6.1.3. *Veneered wall*.—The facing shall be entirely neglected in calculations of strength and stability. For the purpose of determining the permissible stress in the backing, the slenderness ratio shall be based on the thickness of the backing alone.

6.1.4. *Wall panels* :—Where a wall is subdivided into panels by adequate horizontal or vertical (or both) supports, the recommendations for the structural design as given in this code will apply to individual panels.

6.2. *Permissible compressive stresses.*

6.2.1. The permissible compressive stresses in masonry shall depend upon the following factors :—

(*a*) Eccentricity of loading.

(*b*) Slenderness ratio of masonry.

(*c*) Strength of the masonry units.

(*d*) Mix of mortar.

(*e*) Cross-sectional area of masonry, and

(*f*) Shape of the masonry unit.

6.2.2. *Basic stress.*—All permissible stress shall be related to basic stress as given in Table 5 depending upon the crushing strength of the masonry unit and the mix of mortar used.

6.2.3. Where the cross-sectional area of a wall or column does not exceed 3000 cm^2, the basic stress shall be multiplied by a reduction factor equal to $(0{\cdot}75 + \frac{A}{12000})$ Where A is the area (in sq.cm.) of the horizontal cross-section of the wall or column.

6.2.4. *Axially loaded members.*—The stress in an axially loaded member shall not exceed the product of the appropriate basic stress and the reduction factor given in Table 6 corresponding to the applicable slenderness ratio and zero eccentrictly.

6.2.5. *Members subjected to eccentric loading and/or lateral forces.*

6.2.5.1. In a wall or columns subjected to compression and bending, the vertical and bending forces shall be combined by regarding the vertical force as acting at a statically equivalent effective eccentricity.

6.2.5.2. The maximum compressive stress in a wall or columns subjected to eccentric vertical loads or vertical loads plus lateral loads shall not exceed the product of the appropriate basic stress and the reduction factor given in Table 6, subject to increase as in 6.2.5.3 corresponding to the applicable slenderness ratio and equivalent eccentricity of vertical loads to be considered in the design.

6.2.5.3. Where there are additional stresses due to eccentricity of loading and lateral forces, the maximum stress resulting from the combination of these with the stress due to axial loading may exceed the product of the basic stress and the reduction factor or slenderness and eccentricity given in Table 6 by not more than 25 per cent provided that such excess is solely due to eccentricity of loading and or lateral forces.

Note 1.—In no case shall the stress due to axial load only exceed the values given in Tables 5 and 6.

TABLE 5.—BASIC COMPRESSIVE STRESSES FOR MASONRY MEMBERS (AT AND AFTER THE STATED TIMES).

(*Clause* 6.2.2.)

Serial number and description of mortar.	*Maximum (Parts by volume).* Cement.	Lime (*see note* 3).	Lime Pozzolana mixture (*see note* 4).	Pozzolana (*see note* 3).	Sand.	*Compressive strength of mortar at 28 days kg/cm^2 (see note 5).*	*Hardening time after completion of work days*.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1 Cement	1	0–¼C †	..	..	3	50 and above	7
2 Cement	1	½C †	..	..	4½	50 and above	14
3 Cement Lime	1	1C	..	..	6	30 to 50 ..	14
4 Cement Lime	1	2B	..	..	9	20 to 30 ..	
5 Cement	1	..	..	..	6	30 to 50 ..	14
6 Lime Pozzolana mixture ..	..	..	1	..	1·5	30 to 50 ..	
7 Cement Lime	1	3 B or C.	..	..	12	7 to 15 ..	14
8 Hydraulic Lime	..	1A	..	..	2	..	14
9 Lime Pozzolana	..	1C	..	1	2	7 to 15 ..	
10 Lime	..	1B	..	..	3	5 to 7 ..	28

Serial number and description of mortar.	Basic stress in kg/cm² corresponding to units whose crushing strength in kg/cm² is 35	70	105	140	175	210	280	350	440
(1)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
1 Cement	3·5	7·0	10·5	12·5	14·5	16·5	21·0	25·0	30·5
2 Cement	3·5	7·0	10·0	11·5	13·0	14·5	17·5	21·0	25·0
3 Cement Lime	3·5	7·0	10·0	11·0	12·0	13·0	16·0	19·0	22·0
4 Cement Lime .. .. .. 5 Cement .. .. .. 6 Lime Pozzolana mixture ..	3·5	5·5	8·5	10·0	11·0	12·0	14·5	16·5	19·0
7 Cement Lime	2·5	5·0	7·0	8·0	9·0	10·0	12·0	14·0	16·0
8 Hydraulic Lime .. .. 9 Lime Pozzolana	2·5	5·0	7·0	8·0	9·0	10·0	12·0	14·0	16·0
10 Lime	2·5	4·0	5·5	6·0	6·5	7·0	7·5	8·5	9·5

NOTE 1.—The table is valid for slenderness ratio 6 and the loading with zero eccentricity.

NOTE 2.—Linear interpolation is permissible for units whose crushing strengths are intermediate between those given in the table.

NOTE 3.—Lime shall conform to IS : 712—1964 "Specification for building limes". A, B and C denote the classes of limes as in IS : 712—1964. Pozzolana shall conform to IS : 1344 –1968 "Specification for burnt clay pozzolana (First revision)" or IS : 3812 (Part I)—1966 "Specification for fly ash : Part I For use as Pozzolana".

NOTE 4.—For mortar in Serial No. 6, Lime pozzolana mixture shall be of Grade LP 40 conforming to IS : 4098—1967 "Specification for Lime pozzolana mxture".

NOTE 5.—Mortar strength value are for information only and have been reproduced from IS : 2250—1965 ·· Code of practice for preparation and use of masonry mortars.

NOTE 6.—It is advisable to use plasticizers for cement mortars in order to improve properties of the mortar such as flow and water retentivity. Plasticizers should be used according to manufacturer's instructions.

NOTE 7.—Masonry cement mortars are also advisable and shall be used according to manufacturer's instructions. The mix proportions of masonry cement ; sand shall be such as to give comparable mortars crushing strengths with the cement : lime : sand mortar or cement : sand mortar of the particular grade.

* These periods should be increased by the full amount of any time during which the air termperature remains below 4.5 ° C plus half the amount of any time during which the temperature is between 4.5 ° C and 10° C.

† The inclusion of lime in cement mortars is optional.

Case (1) *Axial load only* :—		
Permissible compressive (axial) stress.	appropriate basic stress (from Table 5) multiplied by the appropriate stress factor for slenderness ratio and zero eccentricity (from Table 6).	
Case (2) *Eccentric load* :—		
Permissible compressive (axial compression + bending compression) stress.	appropriate basic stress multiplied by appropriate stress factor for the slenderness ratio and eccentricity multiplied by 1·25.	

The axial compressive stress component shall not exceed the value of the appropriate basic stress multiplied by the appropriate reduction factor for the slenderness ratio and the eccentricity (not for zero eccentricity).

Note 2.—Except for equivalent eccentricities smaller than 1/24 of the wall thickness, the design case of the eccentric loading with a 25 per cent increase in stress will always control rathar than the concentric loading with no stress increase. For equivalent eccentricities close to but smaller than 1/24 of the wall thickness, the 25 per cent stress increase may or may not be permitted, depending on the values of the reduction factors for the two cases of eccentric and concentric loading.

TABLE 6—REDUCTION FACTORS FOR SLENDERNESS RATIO AND ECCENTRICITY OF LOADING.

(*Clauses* 6.2.4. *and* 6.2.5.2.).

Slenderness ratio.	*Reduction factor.*						
	Equivalent eccentricity of loading divided by the thickness of the member.						
	0	0·04	0·1	0·2	0·3	0·33	0·50
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
6	1·000	1·000	1·000	0·996	0·984	0·980	0·970
8	0·920	0·920	0·920	0·910	0·880	0·870	0·850
10	0·840	0·835	0·830	0·810	0·770	0·760	0·730
12	0·760	0·750	0·740	0·706	0·664	0·650	0·600
14	0·670	0·660	0·640	0·604	0·556	0·540	0·480
16	0·580	0·565	0·545	0·500	0·440	0·420	0·350
18	0·500	0·480	0·450	0·396	0·324	0·300	0·230
21	0·470	0·448	0·420	0·354	0·276	0·250	0.170
24	0·440	0·415	0·380	0·310	0·220	0·190	0·110

Note 1.—Linear interpolation between values for the stress factors is permissible.

Note 2.—For unreinforced masonry, the values in column 8 are for purposes of interpolation only.

6.2.6. *Members subjected to concentrated loads* :—Additional stresses of a purely local nature, as at girder bearings, column bases, lintels or other concentrated loads, shall be calculated and the maximum stress resulting from a combination of these local stresses with stresses resulting from the general analysis of the members as provided for in 6.2.4. or 6.2.5., shall not exceed the permissible stresses given in 6.2.4. by more than 50 per cent, provided such excess is due solely to the local stresses. When the loading is transmitted through masonry, the angle of dispersion of the loading shall be taken as not more than 45° from the direction of such loading.

6.2.7. Where indeterminate but very high stresses occur such as at the outer edge of a wall supporting a cantilever, a spreader or bed block shall be provided.

6.2.8. The reduction factor for slenderness ratio need not be applied for sections within one-eighth of the height of the member above or below positions of lateral support. For such sections the slenderness ratio may be taken as 6.

6.2.9. *Allowance for shape factor* :—The values of basic stresses are suitable when the masonry units are of common brick shape, but may be unnecessarily low for masonry units whose ratio of height to thickness is greater than that of the common brick. For units of crushing strength not greater than 55 kg/cm^2 and with a ratio of height to thickness (as laid) greater than 0·75 but not greater than 3, the basic stress may be modified by the factor specified in Table 7.

TABLE 7—MODIFICATION FACTOR FOR SHAPE OF MASONRY UNIT.

Ratio of height to thickness of brick or block.	0·75	1·0	1·5	2·0 to 3·0
Factor	1·0	1·2	1·6	2·0

6.2.9.1. Linear interpolation between values for the reduction factors is permissible.

6.2.10. Where a type of masonry unit or a mortar mix are not provided for in this code, are used and provided the materials and the methods of construction comply with the requirements of relevant Indian Standards the basic compressive stresses for the masonry may be determined by strength tests as described in **Appendix A.**

6.2.10.1. For materials and wall constructions complying with this code and where tests on panels are made, a permissible stress related to the strength of the panels as obtained according to Appendix A may, at the discretion of the designer, be considered as an alternative to the permissible stress obtained from 6.2.2.

6.3. *Tensile stresses in masonry.*—In general no reliance should be placed on the tensile strength of brickwork in the calculations. The designer should assume that part of the section will be inactive and the remainder will carry compressive stress only.

6.3.1. No tension shall be relied upon at a damp-proof course or where water is present at the back of a wall.

6.3.2. In some types of walls, tensile stresses in bending may be taken into account at the discretion of the designer. For mortar not weaker than a 1:1:6. (cement : lime : sand) mix or its equivalent the permissible tensile stress in bending should not exceed 1 kg./cm.^{2}

6.4. *Permissible shear stress.*—In the case of walls built in mortar not weaker than 1 : 1 : 6 (cement : lime: sand) mix and resisting horizontal forces in the plane of the wall, the permissible shear stress, calculated on the area of the horizontal mortar bed joint should not exceed as 1.5 kg./cm^2.

6.5. *Arching of masonry.*—Account may be taken of the arching action of well-bonded masonry walls supported on beams, in accordance with established practice. Where arching of masonry is taken into account the increased axial stresses in the brick work associated with such arching shall not exceed the permissible stresses in 6.2, 6.3 and 6.4.

6.6. *Lintels.*—Lintels and other elements that support masonry construction shall be designed to carry the loads from the masonry (allowing for arching where applicable) and the loads received from any other part of the structure. The length of bearing of lintel at each end shall not be less than 10 cm or 1/10 of the span whichever is more and the area of the bearing shall be sufficient to ensure that the stresses in the masonry (combination of wall stresses, stresses due to arching action and bearing stresses from the lintel) do not exceed the stresses permitted in 6.2, 6.3 and 6.4.

6.7. *Assessment of eccentricity.*—The assessment of eccentricity of vertical loading at a particular junction in a masonry wall shall be made considering the extent of the bearing. magnitude of loads rigidity of the inter-connected members and the geometry of the junction. In the absence of exact calculation the eccentricities of loading shall be taken as given below.

(*a*) where reinforced concrete and prestressed concrete roof and floor system of normal span bear on external masonry walls, the point of application of the vertical loading shall be at the centre of the bearing of the wall. When the span is more than 30 times the thickness of wall the point of application of the load shall be considered to be displaced from the centre of bearing towards the span of the floor to an extent of one-sixth of the bearing width.

(*b*) For timber and other light weight floors, irrespective of their spans, the displacement of application of the load shall be same as for long span concrete floors.

(*c*) Interior walls carrying continuous floors are assumed to be axially loaded except when carrying very flexible floor or roof system. The assumption is valid also for interior walls carrying independent floors spanning from both sides, provided that the span of the floor on one side does not exceed that on the other by more than 15 per cent. Where the difference is greater, the displacement of the point of application of each floor load shall be taken as one-sixth of its bearing width on the wall.

(*d*) For a wall corbelled out to support a floor or roof, the point of application of the load shall be assumed to be at the centre of the bearing on the corbelling. If the floor or roof is supported on a metal corbel or hanger. the load shall be assumed to be applied 2.5 cm. away from the face of the wall.

EXTRACT FROM I.S. : 1905–1980

Code of practice for structural safety of buildings : masonry walls.

The Indian Standard Institution has revised the " Code of Practice for Structutal Safety of Buildings : Masonry walls IS : 1905–1969 ", by incorporating many changes in the design of masonry walls, with reference to revised mix proportioms,compressive strength of mortars, provision of lateral supports, calculation of effective height of masonry walls and columns and their effective length, maximum allowable slenderness ratio, the angle of dispersion of point loads in masonry, values of permissible shear stress etc. Because of these changes and revisions, the design calculations in determining the stress in masonry, eccentricity of loadings ; slenderness ratio etc., will have to be as per the revised Code IS : 1905–1980 and the " Explanatory Hand Book on Masonry Code " published by the Indian Standards Institution.

The salient features of design are mentioned below for guidance to Departmental Engineers. In addition, the important Codal provisions for load bearing masonry for ensuring their structural safety, are extracted from the Code (IS : 1905–1980) and appended for guidance and adoption.

I. Salient features :

1. In a load bearing structure the actual stress induced due to the dead load and live load should not be more than the permissibly compressive stress. The permissible compressive stress in masonry depends on the following factors ;

(*a*) Type and strength of masonry units ;

(*b*) Mix of mortar ;

(*c*) Slenderness ratio of masonry element ;

(*d*) Eccentricity of loading ;

(*e*) Shape and size of masonry unit ; and

(*f*) Cross-sectional area of masonry.

2. Whenever Tee beams and slab system is adopted the load from the Tee beam should be transferred to the brick masonry through a concrete bed block without causing excessive stress in the masonry (vide clause 5.3.1.6.e). The design of such masonry piers/walls/ columns can be prepared by following the steps listed below :

(i) The load on pier/wall/column is calculated (p).

(ii) The actual area of cross section of masonry carrying the load is found (A).

(iii) Actual stress $= \dfrac{\text{Load}}{\text{Actual area of cross section}} \left(\dfrac{P}{A}\right)$

(iv) Determine whether the masonry unit is a wall, pier or a column (as per clause 2.3.1).

(v) Determine the effective height of masonry unit using.

(*a*) Table 5 for wall.

(*b*) Clause 4.5.3. for columns.

(vi) Determine the effective length of wall as per Table 6.

(vii) Determine effective thickness as per Table 7.

(viii) Slenderness ratio.

$$\frac{\text{Effective height or Effective length whichever is less.}}{\text{Effective thickness.}}$$

(ix) Determine eccentricity of loading with the guide lines given in clause 5.9. and 5.9.7.

(x) Determine the Stress factor from Table 11 for the slenderness ratio and eccentricity calculated as above.

(xi) Determine basic compressive stress from table 10 for the mix of mortar proposed, in conjunction with the crushing strength of bricks available for use, as per Table 2.

(xii) Determine the modified basic compressive stress by multiplying the basic compressive stress obtained in step (xi) by shape modification factor for masonry units (vide Table 12) and Area reduction factor (vide Clause 5.3.1.5.).

(xiii) The permissible stress in masonry is than got by multiplying stress factor obtained in step (x) and the modified basic compressive stress obtained in step (xii).

(xiv) The actual stress calculated in step (iii) should be less than the permissible stress obtained in step (xiii). A typical example is worked out and appended.

II. The following informations from the Code are furnished for use of the designers.

(1) When concentrated vertical load is transmitted through masonry, the angle of dispersion of loading shall be taken as not more than 30° from the direction of such loading.

(vide clause 5.3.1.6. (c) of IS : 1905–1980).

(2) The dispersion through concrete bed block is maintained at 45° without any change (vide clause 5.3.1.6. (e).

(3) The optimum mortar mixes for maximum masonry strength, with masonry units of various strength, are furnished in Table 2.

(4) It is essential that long walls (such as in Science hall laboratories in schools) should be stiffened by cross walls at specified intervals as stipulated in Table 3 and Figure of IS. 1905–1980.

(5) The minimum thickness of basement walls should be a given in Table 4 of IS : 1905–1980.

(6) The guide liness for assessing the eccentricity of vertical loading at supports in conjunction with span of slab/beam are furnished in clause 5.9 of IS : 1905–1980.

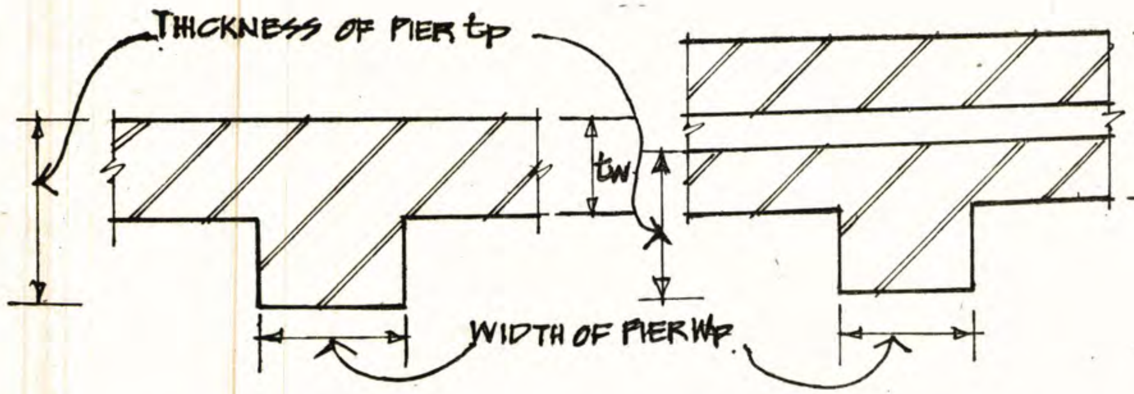
2. *Terminology* :

2.1. *Bed block.*— A block bedded on a wall, column or pier to dsiperse a concentrated load on a masonry element.

2.3.1. *Column.*—An isolated vertical load bearing member, with of which does not exceed four times the thickness.

2.3.2. *Pier.*— A thickened section forming integral part of a wall placed at intervals along the wall, to increase the stiffness of the wall or to carry a vertical concentrated load. Thickness of a pier is the overall thickness including the thickness of the wall or when Bonded into a leaf of a cavity wall, the thickness obtained by treating that leaf as an independent wall. (See Fig.).

2.3.3. *Buttress*: A pier of masonry built as an integral part of wall and projecting from either or both surfaces, decreasing in cross sectional area from base to top.



2.6. *Effective height* :—The height o a wall or column, to be considered for calculating the slenderness ratio.

2.7. *Effective length* :—The length of a wall to be considered for calculating the slenderness ratio.

2.8. *Effective thickness* :—The thickness of a wall or column to be considered for calculating the slenderness ratio.

2.20. *Slenderness ratio.*— : Ratio of the effective height or effective length to the effective thickness.

4.4. *Stability and lateral support* :

4.4.1. Lateral support for a masonry element, such as wall or column is required :

(*a*) to resist horizontal components of the forces so as to ensure stability of the structure against overturning ; and

(*b*) to limit slenderness of mosonry elements in order to prevent failure by buckling.

4.4.2. A wall or column may be considered to be provided with adequate lateral support if the construction providing the support is capable of resisting greater of the following lateral forces :

(*a*) The simple static reactions at the point of lateral support to the total applied horizontal forces ; or

(*b*) 2.5 per cent of the total vertical load, that the wall or column is designed to carry at the point of lateral support.

Lateral support may be in the vertical or horizontal direction, the former consisting of floor/roof acting as a horizontal girder capable of transmitting without execssive stresses the horizontal forces to cross walls acting as stiffening walls and the latter consisting of cross walls/piers/butteresses, capable of transmitting without excessive stresses the horizontal forces to foundation.

4.4.3. In case of load bearing buildings up to six storeys, stability requirements of 4.4.2 may be deemed to have been met with if :

(*a*) height to width ratio of building does not exceed 2 :

(*b*) Cross walls acting as stiffening walls continuous from outer wall to outer wall or outer wall to load bearing inner wall of thickness and spacings as given in Table 3 are provided. If stiffening wall or stiffening walls that are in a line, are interrupted by opening length of solid walls in the zone of the wall that is to be stiffened shall be at least one-fifth of height of the opening and

(*c*) Stiffening walls are built jointly with supported walls and jointly mortared, or the two inter-connected by toothing. Alternatively, stiffening walls may be anchored to walls to be supported by ties of non-corrodible metal of minimum section 6 x 35 mm and length 60 cm. with ends bent up at least 5 cm., maximum vertical spacing of ties being 1.2 m.

NOTE :—In case of halls, exceeding 8.0 m in length and non-residential buildings having trussed roofs, stability and adequacy of lateral supports should always be checked by structural analysis A trussed roof, unless special measures are adopted to brace and anchor it, may not provide adequate lateral support in the vertical directions.

4.4.3.2. *External walls of basement and plinth blocks* :
In case of external walls of basement and plinth blocks, stability requirement of 4.4.2. may be deemed to have been met with if :

(*a*) bricks used in basement and plinth have a minimum criushing of $5N/mm^2$ and mortar used in masonry is M1 type or better.

(*b*) Clear height of ceiling in basement does not exceed 2·6 cm.

(*c*) Walls are stiffened according to provisions of 4.4.3.

(*d*) In the zone of action of soil pressure on basement walls traffic load does not exceed 5 kN/m^2 and terrain does not rise ; and

(*e*) Minimum thickness of basement walls is in accordance with Table 4.

4.4.3.3. *Free standing walls* :—Since, in case of a free standing wall such as a compound wall or a parapet wall, there is no lateral support at the top and no cross wall to brace the same, stability shall be achieved by designing the wall as a gravity structure such that factor of safety against overturning is at least 1.5. As straight walls designed on this basis tend to be heavy, stability of free standing walls greater than 0.9 m in height should be achieved by staggering or provision of piers/butternesses. Even though a straight free standing wall may be stable with the stipulated factor of safety (that is 1.5), it will have some tension because condition of zero tension corresponds to a factor of safety of 3 against overturning. Mortar used for masonry of straight free standing wall should not normally be weaker than M1 type indicated in Table 1 unless walls are thick enough in relation to height, so as to be free from any tension.

Effective height :

4.5.3. *Openings in walls* :—When openings occurs in a wall such that the masonry between any two consecutive openings is by definition a column, effective height of this masonry shall be taken as 1.5 times the height of taller opening subject to a minimum of effective height of the wall, and maximum of effective height of column.

4.6. *Effective length* :—The effective length of wall shall be taken as given in Table 6.

4.7.1. For solid walls, faced walls, or column the effective thickness shall be the actual thickness.

4.7.2. For solid walls adequately bonded into piers or buttesses at intervals and provided the slenderness ratio is based upon the effective height, the effective thickness shall be the actual thickness of the solid wall multiplied by the appropriate stiffening coefficient as given in Table 7. No modification is, however, necessary if the slenderness ratio is based on the effective length of the wall.

4.8. *Slenderness ratio*:

4.8.1. *Wall*: For a wall, the slenderness ratio shall be the effective height divided by the effective thickness or the effective length divided by the effective thickness, whichever is less.

4.8.2 *Columns*: For a columns, the slenderness ratio shall be the greater of the ratios of respective effective heights to the respective effective thickness, in the two principal directions.

4.9.2 Slenderness ratio for a load bearing column shall not exceed 12.

Structural design:

5.3.1.4 *Allowance for shape factor*: The values of basic compressive stresses as given in Table 10, hold good when masonry units are of common brick shape, but these values may below for masonry units having ratio of height to thickness geater than that of the common brick. For units of crushing strength not greater than 15 N/mm^2, the basic compressive stress should be multiplied by the factor called shape modification factor (Kps specified in Table 12. For units of strength greater hen 15N/mm^2 effect of shape may be neglected.

NOTE :—The shape modifications factors as given above will not be applicable to the basic compressive stress values obtained by prism test.

5.3.1.5. *Effective of cross-sectional area* :—Where the cross-sectional area of a masonry element is less than 0.2 m^2, the basic tress shall be multiplied by a reduction factor called "area reduction factor (Ka) equal to (0.70×1.5A) where 'A' is the area (in m^2) of the horizontal cross section of the element.

5.3.1.6. *Members subjected to concentrated loads*. If bearing area under a load does not exceed one-third of the total cross-ctional area of the member supporting the load, the load may be termed as 'concentrated load'. For calculating stresses in members subjected to concentrated loads, the following points should be kept in mind :

(*a*) Masonry is capable of taking 50 per cent greater stress if load is of concentrated nature. This increase and the provision in Note under 5.3.1.2. should not be applied simultaneously ; but the one which permits higher stress should be applied.

(*b*) When masonry is stressed under a comabination of loads of different nature, namely, distributed load and concentrated load for reckoning the overall stress under concentrated load, equivalent distributed load in lieu of concentrated load may be taken as two-thirds of the concentrated load.

(*c*) When concentrated vertical load is transmitted through masonry, the angle of dispersion of the loading shall be taken as not more than 30° from the direction of such loading.

(*d*) Assuming that concentrated loads bear on full thickness of the masonry element and are concentirc, the length of the element to be considered as effective in resisting a concentrated load shall not exceed the centre to centre distance between the loads nor shall it exceed the width of bearing plus four times the thickness of the masonry element.

(*e*) Whenever there is a concentrated load on masonry, it should be checked whether bearing stress is within permissible limit or not. If it is not, conerete bed block should be introduced below the load to bring down stress in masonry to safe limits. An increase in stress of 50 per cent or not permitted for cross section of masonry below a bed block. It is assumed that angle of dispersion of load within the bed block is 45°.

NOTE.—When bearing area under a load is greater than one-third but less than full cross-sectional area of the member supporting the load, the permissible bearing stress may be interpolated between 1.0 and 1.5 times the allowable compressive stress.

5.9. *Assessment of eccentricity*.—Assessment of eccentricity of vertical loading at a particular junction in a masonry wall should depend upon the factors such as the extent of bearing, magnitude of loads, stiffness of slab or beam and fixity at the support, and the geometry of the junction. No exact calculations are possible to make accurate assessment of eccentricity. The extent of eccentricity under any particular circumstances has, therefore, to be decided according to the best judgement of the designer. Some guidance for deciding the extent of eccentricity is given in 5.9.1 to 5.9.7.

5.9.1. Where concrete roof and floor system of normal span bear on external masonry walls, the point of application of the vertical loading shall be at the centre of the bearing of the wall. When the span is more than 30 times the thickness of wall the point of application of the load shall be considered to be displaced from the centre of bearing towards the span of the floor to an extent of one-sixth of the bearing width.

5.9.2. In case of reinforced concrete slabs of normal span (that is less than 30 times the thickness of the wall), which do not bear on the full width of the wall and 'cover tiles or bricks' are provided, there is some eccentricity of load. This eccentricity may be assumed to be *one-twelfth of the thickness of the wall*.

5.9.4 Interior walls carrying continuous floors are assumed to be axially loaded except when carrying very flexible floor or roof systems. The assumption is valid also for interior walls carrying Independents floors spanning from both sides, provided that the span of the floor on one side does not exceed that on the other by more than 15 percent. Where the difference is greater the displacement of the point of application of each floor load shall be taken as one-sixth of its bearing width on the wall.

5.9.6. In multi-storeyed buildings, fixity and eccentricity have normally purely local effect and are not cumulative. They just form a constant ripple on the downward increasesing axial stress. If the ripple is large, it is likely to be more serious at upper levels where it can cause cracking of the walls than lower down where if may or may not cause local over-stressing.

NOTE.—The resultant eccentricity of the total loads on braced wall at any level may be calculated on the assumption that immediately above a lateral support, the resultant eccentricity of all the vertical loads above that level is zero.

5.9.7. For a wall corbelled out to support a floor or roof, the point of application of the load shall be assumed to be at the centre of the bearing on the corbelling.

TABLE 1. MIX PROPORTIONS AND STRENGTH OF COMMONLY USED MORTARS FOR MASONRY.

(*Clause* 3.3.1)

Serial number.	*Mix (by volume)* Cement.	Lime.	Sand.	*Minimum compressive strength.*	*Mortar type.*
(1)	(2)	(3)	(4)	(5)	(6)
				N/mm².	
1	1	0 to ¼C	3	10	H1
2 (*a*)	1	0	4	7.5	H2
(*b*)	1	½C	4½	6	
3 (*a*)	1	0	5	5	M1
(*b*)	1	1C	6	3	
4 (*a*)	1	0	6	3	M2
(*b*)	1	2C	9	2	
(*c*)	0	1A	2 to 3	2	
5 (*a*)	1	0	8	0.7	L1
(*b*)	1	3C	12	0.7	
6	0	1B or C	2 to 3	0.5	L2

NOTE 1.—Strength of mottor may vary appreciably, depending on angularity grading and fineness of sand. Quantity of sand in the mix may, therefore, be decreased where found necessary to attain the desired strength.

NOTE 2.—A, B and C denote eminently hydraulic lime, semi-hydraulic lime and fat lime respectively, as specified in Indian Standards.

NOTE 3.—When using plain cement sand mortars (Sl. No. 2 (*a*), 3(*a*), 4(*a*) and 5(*a*), it is desirable to include a plasticizer in the mix to improve workability.

NOTE 4.—For mortar at Sl. No. 6, if lime C is used, part of sand should be replaced by some pozzolanic materials, for example, burnt clay or fly ash, in order to obtain the requisite strength.

NOTE 5.—In this table, type classification of mortar as H1, H2, M1 M2, L1 and L2 have been given for concevenience for reference in design calculations, the letter 'H' standing for high strength, 'M' for medium strength and 'L' for low strength.

NOTE 6.—For mortar types H2, M1 and M2 though compressive strength of composite mortars (that is cement and line mortars) somewhat less than use of cement mortars, masonry strength may not be significantly effected.

TABLE 2. OPTIMUM MORTAR MIXES FOR MAXIMUM MASONRY STRENGTH WITH MASONRY UNITS OF VARIOUS STRENGTHS.

Masonry unit strength in N/mm²	*Mortar type.*
(1)	(2)
Below 5	M2
5 to 14.9	M1
15 to 24.9	H2
25 or above	H1

TABLE 3. THICKNESS AND SPACING OF STIFFENING WALLS.

(*Clause* 4.4.3)

Serial number.	*Thickness of load bearing wall to be stiffened.*	*Height* of storey not to exceed.*	*Stiffening Wall** *Thicknes not less than.* *1 to 3 storeys.*	*4 to 6 Storeys.*	*Maximum spacing*
(1)	(2)	(3)	(4)	(5)	(6)
	cm.	m.	cm.	cm.	m.
1.	10	3.2	10	..	4.5
2.	20	3.2	10	20	6.0
3.	30 and above.	3.4	10	20	8.0

* Storey height and maximum spacing as given are centre to centre dimensions.

TABLE 4. MINIMUM THICKNESS OF BASEMENT WALLS.

(*Clause* 4.4.3.2.)

Serial number.	*Minimum thickness of basement wall. (Nominal)*	*Height of the ground above basement floor level with wall loading (Permanent load).* *More than 50 kN/m.*	*Less than 50 kN/m.*
(1)	(2)	(3)	(4)
	cm.	m.	m.
1.	40	2.50	2.00
2.	30	1.75	1.40

TABLE 6. EFFECTIVE LENGTH OF THE WALLS.

(*Clause* 4.6)

Serial number.	*Condition of support.*	*Effective Length.*
(1)	(2)	(3)
1.	Where a wall is continuous and supported by cross walls/piers/buttresses and there is no opening* within a distance of H/8 from the face of cross wall, pier or buttress.	0.8 L
2.	Where a wall is supported by a cross wall/ pier/ buttress at one end and continuous with cross wall/pier/buttress supporting at the other end.	0.9 L

Serial number.	*Condition of support.*	*Effective Length.*
(1)	(2)	(3)
3.	Where a wall is supported at each end by a cross wall / pier / buttress	1.0 L
4.	Where a wall is free at one end and continuous with a cross wall/pier/buttress at the other end.	1.5 L
5.	Where a wall is free at one end and supported at the other end by a cross wall/pier/buttress.	2.0 L

Where

L—length of wall from or between centres of cross walls, piers or buttresses : and

H—the actual height of wall between centres of adequate lateral support.

* In case there is an opening taller than 0.75 H in a wall, the ends of the wall at the opening shall be considered as free.

TABLE 5—EFFECTIVE HEIGHT OF WALLS.

(*Clause* 4.5.1.)

Serial number.	*Condition of support.*	*Effective Height.*
(1)	(2)	(3)
1.	Lateral as well as rotational restraint (that is full restraint) at top and bottom. For example, when the floor/roof spans on the walls so that reaction to load of floor/roof is provided by the walls, or when an R.C.C. floor/roof has bearing on the wall (minumum 9 cm), irrespective of the direction of the span. (Foundation footings of a wall give lateral as well as rotational restraint)	0.75 H
2.	Lateral as well as rotational restraint (that is full restraint) at one end and only lateral restraint (that is partial restraint) at the other. For example, R.C.C. floor/roof at one end spanning or adequately bearing on the wall and timber floor/roof not spanning on wall, but adequately anchored to it, on the other end.	0.85 H

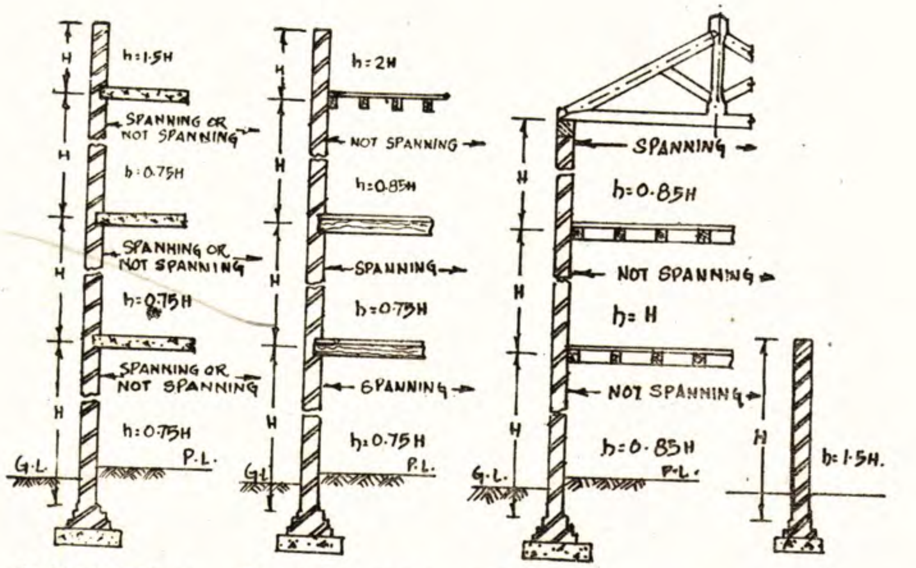
Serial number.	*Condition of support.*	*Effective Height.*
	(1)	(2)
3.	Lateral restraint, without rotational restraint (that is partial restraint) on both ends. For example, timber floor/roof, not spanning on the wall but adequately anchored to it on both ends of the wall, that is top and bottom.	1.00 H
4.	Lateral restraint as well as rotational restraint (that is full restraint) at bottom but having no restraint at the top. For example, parapet walls with R.C.C. roof having adequate bearing on the lower wall, or a compound wall with proper foundation on the soil.	1.50 H
5.	Lateral restraint, without any rotational restraint (that is partial restraint) at bottom and no restaint at the top. For example, parapet wall with timber roof not spanning on the wall below but adequately anchored to the wall.	2.00 H

Note 1 : H is the height of wall between centres of support in case of R.C.C. slabs and timber floors. In case of footings or foundation block, height (H) is measured from top of footing or foundation block. In case of roof truss, height (H) is measured upto bottom of the beam. In case of beam and slab construction height should be measured from Centre of bottom slab to centre of top beam. All these cases are illustrated by means of examples shown in Fig. 11.

Note 2 : Where membrane damp-proof course or termite shield causes a discontinuity in bond, H should be measured from the discontinuity, that is the top of D.P.C. or termite shield and the condition of support at the discontinuity should be treated as one with lateral restraint only.

Note 3 : When assessing effective height floors not adequately anchored to walls shall not be considered as providing lateral support to such walls.

Note 4 : When thickness of a wall bonded to a pier is at least two-thirds of the thickness of the pier measured in the same direction the wall and pier may be deemed to act as one structural element.



11A. RCC FLOOR/ROOF BEING ON WALL IRRESPECTIVE OF DIRECTION OF SPAN.

11B. TIMBER FLOOR OR ROOF

11C. TIMBER FLOOR AND TROSSED ROOF

11D. FREE STANDING WALL

TABLE 7.—STIFFENING COEFFICIENT FOR WALLS STIFFENED BY PIERS, BUTTRESSES OR CROSS WALLS.

(*Clauses* 4.7.2. aud 4.7.2.1)

Serial Number.	Ratio $\frac{S_p}{W_p}$	Stiffening Coefficient $\frac{t_p}{t_w}=1$	$\frac{t_p}{t_w}=2$	$\frac{t_p}{t_w}=3$ or more
(1)	(2)	(3)	(4)	(5)
1	6	1.0	1.4	2.0
2	8	1.0	1.3	1.7
3	10	1.0	1.2	1.4
4	15	1.0	1.1	1.2
5	20 or more	1.0	1.0	1.0

where

S_p — centre to centre spacing of the pier or cross wall.

t_p — the thickness of pier as defined in 2.3.2.

t_w — actual, thickness of the wall proper, and

w_p — Width of the pier in the direction of the wall or the actual thickness of the cross wall.

Note :—Linear interpollation between the values given in this Table is permissible but not extrapollation outside the limits given.

Table 8—MAXIMUM SLENDERNESS RATIO FOR A LOAD BEARING WALL.

(*Clause* 4.9)

Nnmber of Storeys.	Maximum Slenderness Ratio. Using Portland Cement or Portland Pozzolana Cement in Mortar.	Using Lime Mortar.
(1)	(2)	(3)
Not exceeding 2 ..	27	20
Exceeding 2 ..	27	13

TABLE 10—BASIC COMPRESSIVE STRESSES FOR MASONRY MEMBERS (AFTER 28 DAYS)

(*Clause* 5.3.1.1.)

Basic Compressive Stresses in N/mm² Corresponding to Masonry Units of which Hight to Width Ratio does not exceed 0.75 and crushing strength, in N/mm², is not less than

Sl. No.	Mortar Type Ref. Table.	3.5	5.0	7.5	10	1.25	15	17.5	20	25	30	35	40
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10	(11)	(12)	(13)	(14)
1	H1	0.35	0.50	0.75	1.00	1.16	1.31	1.45	1.59	1.91	2.21	2.50	3.05
2	H2	0.35	0.50	0 74	0.96	1.09	1.19	1.30	1.41	1.62	1.85	2.10	2.50
3	M1	0.35	0.50	0.74	0.96	1.06	1.13	1.20	1.27	1.47	1.69	1.80	2.20
4	M2	0.35	0.44	0.59	0.81	0.94	1.03	1.10	1.17	1.34	1.51	1.65	1 90
5	L1	0.25	0.36	0.53	0.67	0.76	0.83	0.90	0.91	1.11	1.26	1.40	1.60
6	L2	0.25	0.31	0.42	0.53	0.58	0.61	0.65	0.69	0.73	0.78	0.85	0.95

NOTE—(1) The table is valid for slenderness ratio upto 6 and loading with zero eccentricity.

(2) The values given for basic compressive stress are applicable only when the members are properly cured.

(3) Linear interpollation is permissible for units whose crushing strength are intermediate between those given in the table.

(4) In case of ashlar stone masonry and coarsed stone masonry the values of basic compressive stress given in this table shall be multiplied by factors 1.25 and 0.75 respectively.

TABLE 11—STRESS FACTORS FOR SLENDERNESS RATIO AND ECCENTRICITY OF LOADING.

(*Clauses* 5.3.1.2. and 5.3.1.3.)

Stress Factor (K) for Equivalent Eccentricity of loading Divided by the thickness of the Members.

Slenderness Ratio.	0	0.04	0.1	0.2	0.3	0.33	0.50 (See Note 2)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
6	1.000	1.000	1.000	0.996	0.984	0.980	0.970
8	0.920	0.920	0.920	0.910	0.880	0.870	0.850
10	0.840	0.835	0.830	0.810	0.770	0.760	0.730
12	0.760	0.750	0.740	0.706	0.664	0.650	0.600
14	0.670	0.660	0.640	0.604	0.556	0.540	0.480
16	0.580	0.565	0.545	0.500	0.440	0.420	0.350
18	0.500	0.480	0.450	0.396	0.324	0.300	0.230
21	0.470	0.448	0.420	0.354	0.276	0.250	0.170
24	0.440	0.415	0.480	0.310	0.220	0.190	0.310

NOTE—(1) Linear interpollation between values for the stress factors is permissible.

(2) For unreinforced masonry, the values in column 8 or only for purposes of interpollation between eccentricities of 0.33 and 0.50.

TABLE 12. SHAPE MODIFICATION FACTOR FOR MASONRY UNITS.

Height to width ratio of units. (As Laid)	Shape Modification Factors (Kps) For Units Whose crushing Strength in N/mm^2 is			
	3.0	7.5	10.0	15.0
(1)	(2)	(3)	(4)	(5)
Upto 0.75 ..	1.0	1.0	1.0	1.0
1.0 ..	1.2	1.1	1.1	1.0
1.5 ..	1.5	1.3	1.2	1.1
2.0 to 4.0 ..	1.8	1.5	1.3	1.2

NOTE : — Linear Interpolation between values is permissible.

SECONDARY SCHOOL BUILDING LOAD BEARING WALL.

C.A. JOB No. 2123/DRG/39—R

STRESS CALCULATION.

Data :

1 Three storeys .. .. Ultimate.

2 C/C of Tee beams .... 3.00 m.

3 C/C of Windows .. .. 3.00 m.

4 Span of Tee beams .. .. 9.00 m.

5 Woindow Size .. .. 1.5 m × 1.3m.

6 Window sill above floor .. .. .. + 0.80 m.

7 Width of piers .. .. 1.50 m.

8 Crushing strength of Brick (Min) .. .. 75 kg/cm2.

9 Access not provided to the roof .. ..

loadings :—

(a) *Roof slab*—

Self wt of slab	240 kg/m^2.
Roof finish	225 kg/m^2.
Live load (access not provided)	75 kg/m^2.
Total	540 kg/m^2.

(b) *Floor Slab*—

Self wt. of slab	240 kg/m^2.
Floor finish	75 kg/m2.
Live load (School Building)	400 kg/m2.
Total ..	715 kg/m2.

Second Floor Window Sill Level.

(a) *Calculation of actual stress.—*

Load from roof slab $540 \times 9.60 \times 3 \times \frac{1}{2}$ = 7,776 kg.
20 cm. wall.

Wt. of 20 cm. wall $0.2 \times 3.0 \times 2.4 \times 1920$ .. 2,765 kg.

Self wt. of beam $0.3 \times 0.6 \times 9.6 \times 2{,}400$ .. 2,074 kg.

2

D/F Window and Ventilators $(1.5 \times 1.3 + 1.5 \times 0.6) \times 0.2 \times 1920$ = (—) 1094 kg.

Add for sunshade etc. .. .. .. 279 kg.

Total .. 11,800 kg.

Load at S.F. Window sill level. .. .. 11,800 kg.,

Actual stress at F.S. window sill level.

$$\frac{\text{Load}}{\text{Thickness} \times \text{length of masonry Pier.}}$$

$$\frac{11.80\text{ t}}{0.2 \times 1.5} = \text{L} \quad 39.33\text{ t/m2.}$$

(b) *Calculation of allowanble stress.*

Ref 1/Clause 2.3.1 Since the length of pier is greater than four times thickness, the slenderness ratio is calculated as that of wall.

$$\text{Slenderness ratio} = \frac{\text{Eff ht/or Eff length which ever is least}}{\text{Eff thickness.}}$$

Eff ht. of wall = 0.75 × (Floor to floor height (—) half the depth of beam + half the slab thickness.)
(Table 5)

$$= 0{\cdot}75 \times \left(3.30 - \frac{0.70}{2} + \frac{0.10}{2}\right)$$

$$= 0.75 \times 3.00 = 2.25\text{ m.}$$

Eff thickness = 0.20 m.

Slenderness ratio $= \frac{2.25}{0.2} = 11.25$

Ref 1/Clause 5.9.1 Eccentricity 1.6 ∵ span >30 times. thickness.

Ref 1/ Table 11 Stress factor = 0.7715.

Allowable Stress = Stress factor × Basic comp. sress.

= 0.7715 X 59.*

= 45.51 t/m2.

> Actual stress (39.33 t/m2).

Hence safe.

Ref 1/table 10* For brick work in C.M. 1 : 6 (M2 Mortor type) using bricks having a minimum crushing strength of 75 kg/cm2,. Basic compressive stress equal to 54 t/m2.

Result.—

Thickness of wall 20 cm.

Brick — Minimum crushing strength 75 kg/cm2.

Mortar — M2 type (CM 1 : 6).

First floor window sill level—

(a) *Calculation of actual stress—*

Load at S.F. window sill level	11,800 kg.
Wt. of wall below sill level upto S.F. Slab level $0.2 \times 3.0 \times 0{\cdot}8 \times 1920$.	922 kg.
Load from floor slab $715 \times 9.60 \times 3 \times 1/2$. ..	10,296 kg.
Self wt. of beam .. .. $0.3 \times 0.6 \times 9.6 \times 2{,}400$	2,074 kg.

2

		Kg.
Wt. of wall above lintel 0.2X1.50X1.100X1920.	.. .. ..	634
d/f ventilators etc. 0.20X1.50X0.60X1920.	.. ..	(—) 346
Wt. of wall bet windows 0.3X1.50X2.4X1920.	.. .. ..	2,074
Total	..	27,445
Load at F.F. Window sill level	.. ..	27,454 Kg.

Actual stress at F.F. window sill level .. $\dfrac{27.454 \text{ Kg./m}^2}{1.5X0.3}$

$= 61.00$ t/m2.

(b) *Calculation of allowable stress.*

Ref. 1 clause 2.3.1 Since the length of pier is greater than four times thickness the slenderness ratio is calculated as that of wall

Effective ht. of wall.. .. ..$=0.75\left(3.3-\dfrac{0.70}{2}+\dfrac{0.10}{2}\right)$

(Table-5) $=2.25$ m.

Slenderness ratio .. .. $= \dfrac{2.25}{0.30}$

$= 7.50$

Eccentricity .. .. 1/6 ∵ span ≯ 30X30

Eccentricity bet the centre line of S.F. and F.F. walls is equal to (—) 5 cm.

Load at S.F. slab level .. .. 13,292 kg. (inclusive of slab load).

Taking mement about face of wall.

Eccentricity .. .. $=15-\dfrac{(12370\times20+12722\times10)}{25092}$

$= 15-14.93.$

$= 0.07$ negligible.

Ref 1/Table 11 Stress factor .. 0.856

Ref 1/Table 12 Allowable stress .. 0.856 X 74.*

$= 63.34$t /m².

≯Actual stress (61.00 t/m²)

* Basic Comp stress for Brick work in CM 1 : 5 (M1 Mortor type)using brick having a minimum crushing strength of 75 kg/cm² is 74 t/m².

Portion above window between piers.

The load dispersion from bottom edge of 70 cm depth T-beam at 45° in bed block and at 30° to vertical in masonry will not stress the brick work above window opening for 3 m C/C of Piers and 3.30 m floor height for a window size of 1.5 m×1.3 m and a sill height of 0.8 m.

Portion below window sill between Piers.

The actual stress .. .. 62.44 t/m² (as that of pier).

Effective length of panel wall .. .. .. 150 cm Ref 1 Fig. 13.

Effective ht of panel wall .. .. 1.5×80=120 cm

Slenderness ratio .. .. $\dfrac{120}{20}$ $=6$

Stress factor .. .. $=1$

Slowable stress .. .. $=1\times74$

$=74$ t/m²

≯Actual stress (61.00 t/m²)

Result.

Wall thickness above window opening between piers = 20 cm.

Wall thickness below window opening between piers 20 cm.

Wall thickness pier portion 30 cm.

Brick—Minimum Crushing Strength 75 kg/cm²

Mortor—M1 type (CM 1 : 5) for pier and below window sill M2 type (CM 1 : 6) for masonry above window opening between piers.

Ground Floor Window Sill Level.

(a) *Calculation of actual stress*

		Kg.
Load at F.F. window sill level	.. .. ..	27,454
wt of wall below sill level of F.F. slab level		
0.3×1.5×0.8×1920	.. ..	691
0.2×1.5×0.8×1920	.. ..	461
Load from slab 715×9.6×3.0×½	.. ..	10,296
Self wt of beam $\dfrac{0.3\times0.6\times9.6\times2,400}{2}$	.. ..	2,074
Wt of wall above lintel 0.2×1.5×1.10×1.920	.. ..	634
Wt of wall in pier portion 0.4×1.5×2.40×1,920	.. ..	2,764
D/f Ventilator etc. 0.2×1.5×0.6×1,920	.. .. ..	..(—) 346
Add for lintel etc. ..	.. ..	450
Total	.. .. ..	44,478 Kg.

Actual stress.. $\dfrac{44,478}{1.5\times0.4} = 74.13$ t/m2

(*b*) *Calculation of allowable stress.*

Ref 1/clause 2.3.1. Since the length of pier is less than four times thickness, the slenderness ratio is calculated as that of column

Effective ht .. .. 1.5×ht of opening (*Clayse* 4.5-3) 1.5×1.3 =1.95 m

Slenderness ratio .. .. $\dfrac{1.95}{0.4}$ =4.875

Eccentricity .. .. =5.5 cm. from difference in wall thickness of F.F. and G.F.

1/t .. .. $\dfrac{5.5}{40}$ 0.138

Stress factor 0.9996

Ref 1/Table 12 Allowable stress .. .. .. 0.9996×74 73.97 t/m2 <Actual stress (74.13 t/m2).

Hence provide 40×10 cm. plaster projection on inside

Actual stress..	44,708* / (1.5×0.4+0.4×0.1) =69.90 t/m2 < Allowable stress (73.97 t/m2)

* inclusive of plaster weight.

Portion above window between Piers.

Since the size of window in G.F. is same as that of F.F. and floor height is also same as that of F. F. the load dispersion does not stress the brick work above window opening between piers.

Portion below window sill between Piers.

Actual stress..	69.90 t/m²
Effective length of panel wall	150 cm.
Effective ht of panel wall	1.5×80 120 cm.
Slenderness ratio	120 / 20 =6
Stress factor	1
Allowable stress	1×74 74 t/m2 >69.90 t/m2

Result.

Wall thickness above and below window Openings 20 cm	
Wall thickness of pier portion	40 cm.
Plaster projection (inside)	40 cm×10 cm.

Brick.—Minimum crushing strength 75 kg/cm2

Mortar— M1 type (CM 1 : 5) for pier portion and wall portion below window opening, M2 type (CM 1 : 6) for wall portion above window opening.

General note— Proper designed bed blocks should be provided for beams in all floors.

Reference— 1. IS 1905—1980—Code of practice for Structural safety of Buildings Masonry Walls

EXTRACT FROM EXPLANATORY HAND BOOK ON MANSONRY CODE (*I.S.* 1905-1980). SP :20 (S & T)—1981.

Part 2 *Commentary on mansonry code.*

4.8.3.2. *Non-load bearing walls.*—On detailed examination, the existing provisions have been found to be incorrect and require modifications as explained below :—

(i) *Panel and curtain walls.*—These are external walls and are subject to wind loading. As explained in 3.2.1. of the British Standard CP 121, these walls may be considered, for the purpose of stability, as vertical slabs spanning one or two ways (or sometime and intermediate arrangement) and thus laterally supported on two, three or four edges. The choice of method of laternal support and the detailing of the edges depend upon consideration of laternal loads to be resisted, type of main supporting structure and differential movements expected between the panel wall and the structure. Panel and curtain walls with adequate edge restraints which are subjected to wind loands, should be designed on engineering principles (*see* 5.3.4.). A general guidance is regard to thickness of panel walls could be had from London County Council (L.C.C.) Byelaws which provide for a minimum thickness of 8½ and a maximum hieght of 25 ft. such that actual thickness is at least ₁¹ of the height or the length which ever is more. This provision in case of a solid 20 cm. wall of normal storey height permits a panel of 3.6 M. length.

(ii) *Partition walls.*—These are internal panels, usually subject to much smaller lateral forces. The comments as follow are based on the consideration that the walls are not subjected to any seismic force. When seismic force has to be catered for design of non-load bearing walls including partition walls should be based on engineering principles.

The behavious of such panels may be similar to external panels, an empirical approach to design is usually sufficient. In accordance with the American Code (3) (Clause 6.3.2.) distance between lateral supports should not exceed 36 times the thickness of partition including plaster, the laternal supports being either vertical or horizontal. A more comprehensive guidance in this regard could be had from the British Standard CP 121 (8) relevant provisions of which are reproduced below :

(1) Walls with adequate lateral restraint at both ends but not at the top :

(*a*) The panel may be of any height provided the length does not exceed 40 times the thickness ; or

(*b*) The panel may be any length provided the height does not exceed 15 times the thickness (that is, it may be considered as a free standing wall) ; or

(*c*) Where the length of the panel is over 40 times and less, than 59 times the thickness, the height plus twice the length may not exceed 133 times the thickness.

(2) Walls with adequate lateral restraint at both ends and at the top :

(*a*) The panel may be of any height provided the length does not exceed 40 times the thickness ; or

(*b*) The panel may be of any length provided the height does not exceed 30 times the thickness ; or

(*c*) Where the length of the panel is over 40 times and less than 110 times the thickness, the length plus three times the height should not exceed 200 times the thickness.

(3) Walls with adequate lateral restraint at the top but not at the ends. The panel may be of any length provided the height does not exceed 30 times the thickness ;

NOTE.—Attention is drawn to he possibility of substantial wind-loading on internal partitions where there are openings in the external envelop of a building. Guidance is given in BRS Digest No. 119* and CP 3, Chapter V.

(iii) Free standing and parapet walls.

(*a*) Clause 312 of the British standard CP III (1) reads as follows :

" Parapet walls and balustrades—Parapet walls and balustrades should have sufficient strength and stability to carry the lateral loads given in CP 3, Chapter V.

(*b*) There is similar provision in the Australian Standard 1640-1974 (2) (Paragraph 4.25).

(*c*) According to the American Code (3) height of a parapet wall should not exceed 3 times the thickness (paragraph 6.5).

* BRS Digest No. 119 ' The assessment of wind loands ' Published by HMSO.

' CO. 3 ' Code of basic data for the design of buildings ' Chapter V. Wind lands, Part I. ' Dead and Imposed Loads ' (*d*) Clause 3.2.2.2.1. of the British Standard CP 121 (8) reads as under :

"Free standing walls—Straight non-load bearing free standing walls, whether external or internal, subject to wind pressures, should, unless stability calculations are carried out, have height to thickness ratio not exceeding those given in Table 1 (reproduced as Table 5 below) if there is no horizontal damp-proof course or if there is a horizontal damp-proof course which can develop tension vertically across it.

TABLE 5—HEIGHT TO THICKNESS RATIO RELATED TO WIND SPEED.

Designed wind speed. (1)	*Wind pressure.* (2)	*Height to thickness ratio.* (3)
m/s	N/m²	
Upto 20	Upto 285	Not exceeding 10
28	575	7
34	860	5
38	1150	4

(Intermediate values may be interpolated).

Note.—1 N/m2=1/10 Kg./m2 (approximately.)

If there is a horizontal damp-proof course near the base of the wall which is not capable of developing tension verticaly the minimum wall thickness should be the greater of that calculated from either :—

(1) the appropriate height/thickness ratio given in Table 1, (Table 5 above) reduced by 25 percent and the height from the level of the damp proof course (or.)

(2) the appropriat e height/thickness ratio given in Table 1 (Table 5 above) and the height from the lower level at which the wall is restrained laterally. Units weighing less than 960 Kg./m (60 lb/ft.3) are not normally used in external free standing walls however, if designers are certain that such units will be satisfactorily, it may be necessary to decrease the height to thickness ratio quoted in Table 1 (Table 5 above).

(v) It is suggested that designers may take help of the above provisions for proportioning of non-load bearing walls. For guidance in regard to design of a free standing wall, a reference is invited to comments on Clause 4.4. Suitable modifications in the Code will be made at the time of its revision.

4.10. *Veneered wall.*—The expression 'veneered wall' occuring the first line of the clause should have been 'Veneer of a wall'.

4.11. *Curtain wall.*—Refer to comments under 4.8.3.2.

EXTRACT FROM IS : 2117-1963

Code of practice for manufacture of hand-made common burnt—clay Building Bricks.)

4. *Soil.*

4.1. The soil used of making building bricks should be processed so as to be free from gravel, coarse sand (that is particle size greater than 2 mm.), lime and kankar particles vegetable matter, etc.

4.2. Regarding mechanical composition, the soil should preferably conform to the following requirements:—

Clay	20 to 30 per cent by weight.	
Silt	20 to 35	Do.
Sand	35 to 50	Do.

The total content of clay and silt shall not be less than 50 per cent by weight.

Note—(1) The limits for particle size grading specified in this clause are not applicable for black cotton soil and lateritic soils.

Note—(2) In special cases certain admixtures like rice husk may be incorporated if found by experience to be beneficial in manufacture.

4.3. Two or more soils may be mixed so as to conform to the requirements of 4.2. if a single soil does not so conform.

4.4. The soil, after weathering, shall be tested for moulding characteristics, such as liquid limit, plasticity index, etc. in accordance with the procedures laid down in the relevant Indian Standard on methods of test for soil. Test bricks of the same size as the properties in accordance with the relevant Indian Standard on methods of test for soil. Test bricks of the same size as the product-brick shall be manufactured and tested for the following properites in accordence with the relevant Indian Standards mentioned against them

(*a*) Drying shrinkage. *

(*b*) Fired shrinkage. *

*product brick shall be manufactured and tested for the following:

(*c*) Water absorption of burnt brick—Appendix A of IS : 1077-1957 Specification for Common Burnt Clay Building Bricks.

(*d*) Compressive strength of burnt brick—Appendix C of IS : 1077-1957.

(*e*) Optimum fixing schedule. **

(*f*) Efflorescence—Appendix B of IS : 1077-1957.

** Standard methods of test are yet to be established for these characteristics. However, a fairly satisfactory guidance may be obtained by the maufacturers by burning sample bricks in a poter's kiln and observing the characteristics of the product (*See* A-3).

4.4.1. For quick field observations and intermittent checks simple tests are as given in Appendix A may be found useful.

5. *Preperation of soil.*

5.1. *Weathering.*—The soil shall be left in heaps and exposed to weather for at least one month in cases where such weathering is considered necessary for the soil. The soil shall be turned atleast twice and it shall be ensured that the entire soil is wet throughout the period of weathering.

5.2. *Tempering.*

5.2.1. After weathering the required quantity of water shall be mixed with the soils so as to obtain the right consistency for moulding when it is tempered. Additions of sand and other materials, if necessary, may also be made at this stage to modify the composition of the soil. * The quantity of water may range from 1/4 to 1/3 by weight of the soil. The moistened soil shall be kneaded with spades or other manual or mechanical equipment into a plastic mass. Sandy soils require less water and clayey soils more water. But nature and degree of wetness of the soil at the stage of water addition shall also be duly considered in this respect and the observation made in preliminary test [*see* 4.4. (*a*)] may be useful for the judgement.

6.2. *Moulding procedure.*

6.2.1. Hand-made bricks may be either ground-moulded or table-moulded. A level, firm surface of ground shall be used in the former case.

6.2.2. Before moulding, the inside of the mould shall be cleaned and then sprinkled with sand or ash. If slope moulding is adopted the mould shall be dipped in water and cleaned. The mould shall then be set firmly on the level surface.

6.2.3. Quantity of clay slightly more than the volume of the mould, shall be taken rolled in sand, if found necessary then shaped suitably into a single lump and dashed firmly into the , mould with a force that is to be judged by the moulder by experience, so that the clay completely occupies the mould without air pockets and with the minimum surplus for removal.

6.2.4. The surplus soil shall be scraped off with a sharp straight edge or a stretched wire and the top surface levelled.

6.3. The whole assembly of mould shall then be lifted, given a slight jerk, and inverted to release the moulded brick on a pallette board in the case of table moulding or on dry level surface of the ground in the case of ground moulding. The ground may be advantageously sprinkled with sand before releasing the brick over it, so that the brick does not stick to the ground. When a frog is not needed a bottomless mould may be adopted in which case inversion to release the moulded bricks from the mould will not be necessary.

7. *Drying.*

7.1. The moulded bricks shall be allowed to dry till they become bone-dry.

7.1.1. The drying operations may be done in several stages as follows :—

(*a*) In the position as released from the mould.

(*b*) As turned to stand on edges, and

(*c*) As transported and arranged in rows in and hacks' with spaces of not less than one centimetre between the bricks.

NOTE—The duration of drying for each of the above stages may vary with the conditions of weather. Generally, stages (*a*) and (d) together will require two to three days and stage (*c*) about a week.

7.2. The moulded bricks shall be protected effectively against rain and dampness till they are stacked inside the kiln.

7.3. In the initial stages unequal drying shall be avoided.

8. *Handling and transport oj moulded bricks.*

8.1. During conveyance to the kiln, the moulded bricks shall be loaded or unloaded one at a time. Use of pallette boards will be advantageous in this respect.

11. *Control of burning.*

11.1. *Fuel—feed.*

11.1.1. The fuel shall conform to the specifications of the design of the kiln. Generally, lightly-slacking cearse slacks coal with a large proportion of pieces not more than 5 cm. size, will be preferable.

11.1.2. The fuel shall be fed directly to the chambers through feed-holes only when the bricks have been heated over 700 C. The fuel shall be fed in small quantities at regular inrervals. The feed-holes shall be covered tightly after every feed. It will be advantageous to use automatic feeders for fuel.

11.2 *Control of temperature and rate of fire travel.*

11.2.1 The temperature at which bricks are to be fired may range from 800 ° to 1000 ° C. depending upon the type of clay. The temperature shall preferably be observed frequently by means of suitable high temperature measuring devices, and the fire feed and draft adjusted for control.

12. *Unloading of bricks from the kiln and stacking.*

12.1. The bricks shall be unloaded from the kiln and conveyed to the storeyard with minimum breakage. They may be sorted into the various classes of quality as laid down in IS : 1077—1957.Specification fo Common Burnt-clay Building Bricks.

12.2. Bricks shall be stacked on dry surface effectively drained and in such a very to facilitate easy inspection and removal.

APPENDIX A.

(Clause 4.4.1.)

SIMPLE FIELD TESTS FOR SOIL FOR BRICK MANUFACTURE.

A.1. *Testing soil for drying shrinkage.*

A.1.1. The soil shall be ground to a fine powder and mixed withs sufficient water adding it in small quantities so that it becomes plastic and can be moulded with hands. Care shall be taken that not more than the correct quantity of water is added.

A.1.2. Take a handful of the soil prepared as in A.1.1 and form into a ball.

A.1.3. Keep the ball in the sun for drying. When dried, examine the ball for loss of shape and surface cracks, if any.

A'1.4. *Conclusions.*

A.1.4.1. If the ball had deformed on drying and crumbles easily, it may be inferred that the sand content is excessive.

A.1.4.2. If the ball is hard but shows cracks on the surface, then the sand content is insufficient.

A.1.5. If the soil is not found suitable as inferred in. A.1.4. the test shall be re-done after modyfing the composition of the soil such as by mixing different proportions of two soils or by addition of sand, etc. for checking the suitability.

A.2. *Testing soil for moulding characteristics.*

A.2.1. A quanity of soil as adjusted for composition shall be taken and water shall be added in just enough quantities and mix kneaded well so as to obtain a plastic consistency at which it is possible to roll threads of about 3mm. out of the soil.

A.2.2. Bricks of standard size shall be actually moulded from the soil as prepared in A.2.1. and examined for sharpness of edges and corners.

A.2.3.If edges and corners are not sharp, the test shall be repeated varying the quantity of water added, so that finally a satisfactory result is obtained.

A.2.4. The moulded bricks shall be left to dry for four days in the sun and examined for shrinkage cracks.

A.3. *Testing for shrinkage on burning.*

A.3.1. The sample bricks prepared in A-2 shall be burnt in an ordinary potter's kiln for three days and four nights or until the bricks become red hot, whichever is longer.

The following precautions shall be taken during the burning :

(*a*) Spaces of not less than 10mm. shall be left between the brick when arranging them in the kiln for burning, and

(*b*) The arrangements shall ensure that there is even burning of the bricks.

A.3.2. When the bricks are burnt, they shall be allowed to cool.

A.3.3. After cooling, the bricks shall be taken out of the kiln and examined for shrinkage and deformation generally.

A.3.4. Bricks of the lots that are found to have been brunt evenly without deformation and unequal shrinkage shall be reserved fo strength tests as described in A-5.

A.4. *testing for water absorption.*

A.4.1. The test shall be done in the same manner as described in Appendix A of IS : 1077— 1957 Specification for Common Burnt-Clay Building Bricks.

A.5. *Testing for strength.*

A.5.1. The test shall be done in the same manner as described in Appendix C of IS : 1077-1957 Specification for Common Burnt. Building Bricks.

EXTRACT OF I.S : 1200 (Part III)—1960

Method of Measurement of Building and Civil Engineering Works

Part III—Brick work.

4. *Measurement.*

4.1. Brickwork shall generally be measured in cubic metres, unless otherwise stated.

4.1.2. Walls exceeding one brick thick but not exceeding three bricks in thickness shall be measured in multiples of half brick which shall be deemed to be inclusive of the mortar joints. Where fractions of half-brick occur due to architectural or other reasons, the measurement shall be taken as follows :

(*a*) Upto ¼ brick—actual measurement, and
(*b*) Exceeding ¼ brick—full half-brick.

4.1.3. For walling which is more than three bricks in thickness the actual thickness of wall shall be measured.

4.1.4. No deductions or additions shall be made on any account for.—

(*a*) ends of dissimilar materials (that is, joints, beams, lintels posts, girders, rafters, purlins, trusses, corbels, steps, etc.,) upto 0·1 m^2 in section ;

(*b*) Opening upto 0·1 m^2 in area (*see* Note) ; and

(*c*) Wall plates and bed plates, and bearing of slabs *Chajjas* and the like, where the thickness does not exceed 10 cm and the bearing does not extend over the full thickness of the wall.

Note :—In calculating the area of openings, any separate lintel or sills shall be included with the size of the openings but the end portions of the lintels shall be excluded [*see* 4.1.4. (*a*)] and the extra width of rebated reveals, if any, shall also be excluded.

4.1.5. *Fire places, chimneys, etc.,*—Brickwork (excluding fire brick work) in chimney breasts, chimney stacks, smoke or air flues not exceeding 0·2 m^2 in sectional area shall be measured as solid and no extra measurement shall be made for pargeting and coring such flues. Where flues exceed 0.2 m^2 in sectional area, deduction shall be made for the same, and pargeting and coring flues measured in running metres, stating the size of the flue. Apertures for fire places shall not be deducted and extra labour shall not be measured, for splaying of jambs and throating.

4.1.6. *Pillars*—Pillars shall be fully described and measured in cubic metres. Where pillars of different sections and shapes are involved their numbers shall be stated in addition in each case Pillars shall be measured and kept separate under the two categories

(*a*) Rectangular or polygonal on plan, and

(*b*) Curved on plan to any radius.

5. *Brick work circular on plan.*

5.1. Brickwork circular on plan to a mean radius not exceed 6 m. shall be measured separately and shall include all cutting and waste and templates.

5.1.1. Brickwrok circular on plan to a mean radius exceeding 6 m. shall be measured net and included with the general brickwork.

6. *Backing to masonry.*

6.1. Brickwork in backing to masonry shall be measured separately stating the average thickness, the deseription shall include all cutting and waste for bonding.

7. *Honeycomb brick work.*

7.1. Honey comb brick walling shall be measured to square metres stating the thickness and the pattern of honey combing. Honeycomb opening shall not be deducted.

8. *Independent chimney shafts.*

8.1. Brickwork in independent chimney shafts (as for large steam boilers) shall be measured net inclusive of all cutting waste and templates and kept under following categories.—

(*a*) Rectangular on plan.
(*b*) Polygonal on plan, and
(*c*) Curved on plan to any radius.

8.1.1. The height of chimney from the ground/datum line shall be stated.

9. *Cavity walls.*

9.1. Forming of the cavity shall be measured in square metres stating the width of the cavity and shall include the ties and their number per square metre. The materials, size and shape of ties shall be described.

21. *Brickwork around steel joists (encasing).*

21.1. Extra labour in cutting and fitting brickwork round steel joists, stanchions, girders, etc., shall be measured in square metres for the finished surfaces.

22. *Sills, cornices, etc.*

22.1. Plain corbels, string courses, aprons, friezes, sills, cornices drip courses, oversailing courses, and other projections, etc., splayed, bullnosed or any other type of purposes made or cut-bricks shall be fully described and measured in running metres stating the depth and width of the projection. No deduction shall be made from the masonry of wall for the bearing portion of drip curve, bearing of moulding and cornices.

23. *Tile brick work .*

Tile brickwork shall be measured separately and the rule for measuring ordinary brickwork shall be followed.

24. *Chases, rebates, etc.*

24.1. Cutting chases, rebates, throatings, grooves, etc., in existing brickwork shall be measured in running metres stating the girth and classified according to the girth as follows :—

(*a*) Not exceeding 10 cm. girth, and

(*b*) Exceeding 10 cm. but not exceeding 20 cm. girth.

24.1.1. Chases, rebates, etc,. exceeding 20 cm. girth shall be measured in square metres (the girth X length).

25. *Cutting holes.*

25.1. Cutting holes through existing brickwork including making good be measured per centimetre of depth of cutting and shall be classified as follows :—

(*a*) Holes upto and including 400 cm^2 in area, and

(*b*) Holes exceeding 400 cm^2 and upto including 0·1 m^2 in area.

26. *Cutting openings.*

26.1. Cutting openings exceeding 0·1 m^2 in area in walls one brick thick and less shall be measured in square metres and in walls exceeding one brick thick shall be measured in cubic metres and the item shall include the provision for fixing and removal of the requisite shoring and temporary supports.

27. *Toothing aud bonding.*

27.1. Where new walls are bonded to existing walls, an item of labour and material in cutting, toothing and bonding shall be measured in square metres measured on the vertical face in contact with new work only.

SECTION VI
STONE MASONRY

SECTION No. VI

STONE MASONRY.

Contents.

466-3—39

SECTION VI.

STONE MASONRY.

SECTION VI.

STONE MASONRY.

SPECIFICATION No. 35.

STONE MASONRY.

1. *General.*—The following instructions are to be complied with for all classes of stone masonry.

1.1. *Requirements for building stone.*—Building stones shall comply with specification No. 3 and shall be obtained from the quarries defined in the agreement descriptive specification sheet—for detailed specification of stones I.S. 1597 Part I/1967 and I.S. 1123—1957 shall apply. Stone not suited for the particular class of works defined in the schedule items shall be rejected and rejected stone shall be removed at once by the contractor from the works spot *vide* "General conditions of contract ".

2. *Method of laying stone.*—Lay on broadest face which gives better opportunity to fill the spaces between stones. For detailed specification I.S. 1597 Part I/1967 shall apply.

3. *Bond.*—For detailed specification I.S. 1597—Part I—1967 shall apply.

4. *Watering.*—For detailed instructions I.S. 1597 Part I 1967 shall apply.

4.1. *Mortar.*—Should the mortar perish *i.e.,* become dry, white or pawderly through neglect of watering, the work shall be pulled down and rebuilt at the contractor's expense or should the contractor fail to water the work to the satisfaction of the officer in charge of the work, the latter may supply the requisites men to water the work properly and charge the cost to the contractor.

4.2. All masonry shall be washed down on completion and all stains—lime or otherwise—removed from the face.

5. *Moving stone after it has been placed upon the mortar bed.*—

5.1. If it is necessary to move a stone after it has been placed on the mortar bed, it should be lifted clear and be reset. Attempt must never be made to slide it over stone already laid. Care must be taken not to disturb joints already laid when handling or moving stone.

6. *Bed Plates.*—Bed plates are to be laid in all cases under the ends of beams, girders, roof trusses, etc. The bed plates are to be of sizes specified or ordered by the Executive Engineer. In all important cases cut stone or reinforced concrete blocks will be used and the size and quantity detailed and included under the relevant item of work. In all other cases where cut stone or reinforced concrete bed plates are not demanded, the contractor shall supply large stone of size and dressing as ordered by the Executive Engineer and he will not be paid any extra rate above the contract rate for the wall masonry for such bed plates.

7. *Recesses for ends of beams, girders, etc., corbels under heavy beams and cornice under joists.*—The ends of all beams, girders, roof trusses, etc., shall be situated in a recess having 40 mm. space alround them to permit free circulation of air and provided with perforated zinc sheeting.

7.1. Joists and rafters will usually be built in the masonry and tarred for that portion. When it is approved by the Executive Engineer to build the ends of steel joists or other steel work into masonry the masonry for atleast 15 cm. alround the embedded steel shall be in cement mortar. No extra payment will be made for this treatment.

8. *Stones which are not to be plastered over.*—All lintels and inside stones which are not to be plastered over should be to the full width of the walls in which they are placed including the thickness of the Plaster.

9. *Plinth off-sets.*—Plinth off-sets on the interior faces only should be kept 15 cm. below floor level (unless finished thickness of floor to be laid is less than 15 cm, in which case the actual thickness of the floor to be laid, will determine, instead of the 15 cm.), to allow the floor paving, which is done subsequently, coming up to the face of the superstructure. Similarly retaining walls of verandahs, etc. must be built with due regard to the slope allowed for the floors.

10. *Jambs for door and window openings.*–Jambs for door and window openings shall be formed with quoins of the full height of the course in the case of coursed masonry. The quoins shall be in breadth at least one and a half times the depth of the course and in length at least twice the depth. For each side of door openings three and for window openings two, of these quoins shall be stones of the full thickness of the walls. Unless rebating of the whole frame into the masonry is specially specified, chisel dressing to the width of door and window frames shall be done to secure a close fit between the frame and the masonry. A rebate shall be made in the frame where plastering is to join with the frame as shown in the standard designs for doors and windows and the plaster shall be keyed well into the rebate to form a neat joint. Jambs shall be played as described in the standard specification for "Brick Masonry—General" Contract rates for all classes of masonry are inclusive of quoins, jambs, and chisel dressing as demanded by the above and by the following masonry sub specifications.

11. *Contractor to supply sample stones when tendering his rates.*— In the case of cut stone masonry or rubble masonry of any kind, the contractor shall supply a sample stone when tendering his rates, showing the class of dressing and face finish that he will execute for each rate and these sample stones will be initialled and kept by the Executive Engineer. Failure of the contractor to execute all work of the particular clause up to the standard of his sample supplied, will be dealt with as contractor's violation of the contract.

12. *Mortar and materials to conform to standard specifications.*— The mortar to be used for each class of masonry shall conform to the particular standard specification for that class of mortar and the standard specifications for the materials used therein. For example, for " Cuttone in cement mortar " the Portland cement, sand and cement mortar shall conform to the three respective standard specification for these items.

13. *Dowels and cramps.*—When so specified or instructed by the Executive Engineer, copings will be dowelled or cramped—and courses of pillars, skew-backs and similar work joggled to the stone below it using dowels and cramps of the hardest and toughest stone procurable or of copper and set in pure lime or cement as ordered Iron cramps are not to be used. Extra payment for such dowels or cramps will be fixed by prior agreement before execution of the work.

14. *Holes for passage of water, etc., to be left and wooden plugs and wooden bricks to be built in during construction.*—Care shall be taken to see that holes for passage of water wherever necessary as from terraces, bath rooms, recesses for downfall pipes, etc., are provided during construction and neatly finished off by pointing or plastering as ordered. Well-seasoned wooden plugs and bricks of sizes and quality approved by the Executive Engineer are to be built in as the work proceeds for fixing door and window shutter appliances coat hangers, picture rails, and for any other purpose decided necessary by the Executive Engineer. Holes are also to be cut in the sill-stones to receive the uprights of door-frames, in cases where there is no threshold plate to the frame. No extra payment will be made to the contractor for the supply and fixing of the wooden plugs and bricks forming holes, etc., as described in this clause, for any class

466-3—39A

masonry *vide* also relevant clauses in the standard " Preliminary specification ".

15. *Laterite*.—In districts where laterite is used as a building stone, the work shall be executed according to the relevant masonry sub-specification which will be described in the schedule item. The stone shall be the best procurable and free from any admixture of white earth. It shall be dug out from the quarry a sufficient time in advance, to harden well, before being placed in the work. The least thickness of stone shall be 17·5 cm. and other diamensions shall be as laid down in the relevant sub-specification, the stones being laid header and stretcher alternatively, breaking joints by at least 7·5 cm.

16. *Iron, stone, concrete or other fixtures and buttresses, etc.*—All iron, stone, concrete or other fixtures, returns buttresses, counterforts, etc., shall be built and bonded into the work as it proceeds and not inserted or joggled on after the masonry is advanced. No extra payment will be made for labour involved in building in any fixtures, holdfasts, etc., which are given to the contractor for fixing in place.

17. *Wet foundations*.—In wet foundations, the excavation shall be kept free of water by the contractor, while the masonry is in progress and until the Executive Engineer considers the mortar has sufficiently set.

18. *Scaffolding and tools and plant*.—*Vide* relevant clauses under the conditions of contract.

19. *Chisel drafting corners and rounding interior corners of rooms*.—The Vertical exterior corners of buildings and pillars of buildings in coursed rubble in mortar, first and second sort and random rubble in mortar (except for clay mortar masonry) shall be chisel drafted 40 mm. width on either side, or such other width as may be specified. At the entrance of doors, windows, archways and other openings, the corners against which doors and windows will open shall be chamfered 25 mm. width and chisel-drafted beyond the chamfer 40 mm. as above. (when parliamentary hinges are used chisel drafting only is necessary).

19·1. All interior corners of rooms and projecting angles shall be rounded to 25 mm. radius. The projecting angle will in such cases be chamfered as necessary and the rounding for both interior corners and projecting angels will then be done in the plaster, Similarly, rounded, chamfered and chisel drafted corners shall be done wherever else they may be shown on the drawings.

19.2. All chisel drafting and chamfering referred to under this clause shall be included by the contractor in the tender unit rate for masonry and rounding of corners in his tender unit rate for plastering. No extra allowance will be made for labour and materials invovled in compliance with this clause, unless it is so expressly stated in the agreement specification.

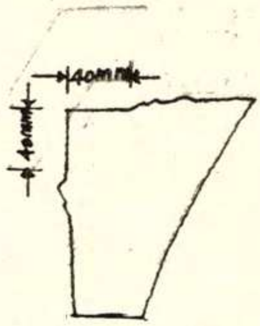
19.3. Sketches illustrative of the nature of work to be done under this clause and clause 10 preceding are appended.

20. *Pointing*.—Clause 10 of the standard specification for "Brick Masonry" "General" shall apply to this specification.

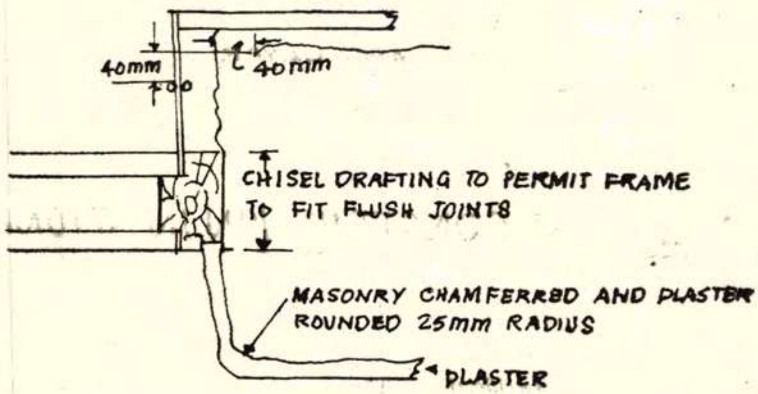
CHISEL DRAFTING

NOTE:-

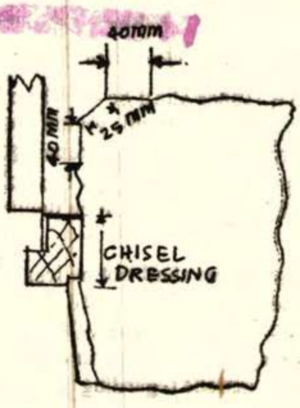
TO BE DONE TO STONE MASONRY BUILDINGS- COURSED AND RANDOM RUBBLE IN MORTAR- AND INCLUDED IN THE UNIT RATE FOR MASONRY



CORNERS OF BUILDINGS AND PILLARS

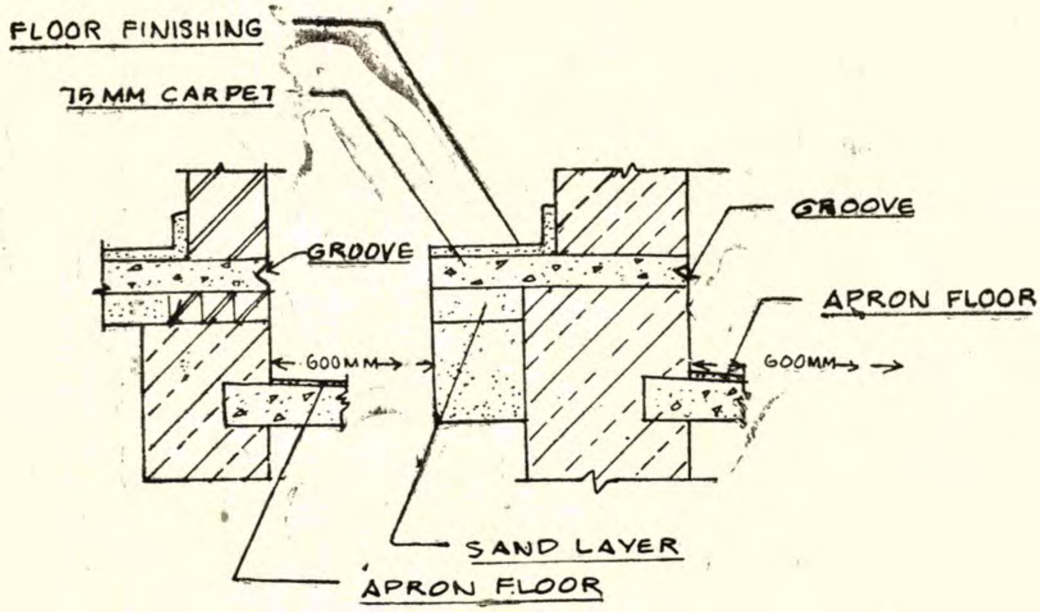


TYPICAL DRESSING FOR ENTRANCES DOORS, WINDOWS AND ARCHES.



TYPICAL DRESSING FOR CASES WHERE SHUTTERS OPEN AGAINST CORNERS AND ELSEWHERE, WHERE SPECIFIED.

21. ***Anti-termite constructional methods*** : At places of foundation where the existence of colonies of subterranean termites are found the probability of internal attack of termites through floors and plinth fittings is great. In such places the constructional practices for protection against subterranean termites orginating both internally from within the plinth and externally from the area surrounding the building as laid down in I.S. 6313 (Part I)—1971 shall be followed.



ANTI-TERMITE CONSTRUCTION IN STONE MASONRY WALL

22. *This general specification applicable to sub-specifications* : The clauses of this "General" specification shall be applicable in all pertinent points to the masonry sub-specifications following and the contract unit rate for each particular item of work is inclusive of compliance with all clauses of the "General" specification and relevant sub-specifications.

SPECIFICATION NO. 35-A.

CUT STONE IN MORTAR.

Additional clauses to "General" preceding.

Cut stone : I.S. 1597 Part II 1967 para 6.1.1 shall apply. By fine tooled dressing is meant the finest surface which can be given to a stone with a chisel and without rubbing.

1.1 In the absence of further definition cut stone masonry shall. be executed with a fine dressing for the face vide the accompanying figures.

1.2. Masonry shall be laid as per I.S. 1597 Part II-1967 and I.S. 1127-1970.

1.3. In walls 75 cm. thick and under the headers shall run right through the wall.

2. *Fixing measurement and payment for certain features*: Instructions in I.S. 1200 Part IV—1970 shall apply.

3. All fine dressed cut stone work shall be protected by means wood boxing immediately after fixing at the contractors expense.

SPECIFICATION NO. 35-B.

CUT STONE IN SURKI MORTAR.

1. The specification shall be the same as specification No. 35-A. The mortar shall be as per I.S. 2250-1965.

SPECIFICATION No. 35-C.

CUT STONE STRING COURSE BOND AND OTHER CORNICES ETC. IN MORTAR.

Para 6.5 of I.S. 1597 Part I-1967 and Para 6.5 of I.S. 1597 Part II 1967 shall apply.

SPECIFICATION No. 35-D.

ASHLAR ARCHING.

Additional clauses to "General" preceding.

1. The arch stones shall be closely of the same size and carefully and accurately wrought, giving the proper radiating joints, that is, the archs ones shall be dressed full and true to their proper shapes and shall be careuflly set in good fine mortar. Thickness of ring and class of mortar will be defined in the relevant schedule item.

1.1. The are stones shall not be iess than 25 cm. on their least dimension and header joints shall break joint at least 22.5 cm. In arches upto 60 cm. in thickness, the stones shall all be of the full thickness of ring. For deeper arch rings, the Executive Engineer will supply instructions regarding bond, face-stones and key stones

1.2. Exact uniformity will be required in the thickness of the arch ring, and in oblique or skew arches, great care is to be taken to dress the beds to the required winding.

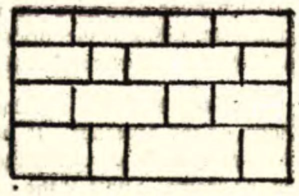
1.3. All archwork stones should be of special large stones. The breadth of each stone at top and bottom will be determined at the time of execution according to the span and number of stones.

2. *Dressing* : The header and side radial joints shall be fine tooled to exact fit on all beds; the keying course shall be accurately fitted in and driven into its place with heavy wooden beaters.

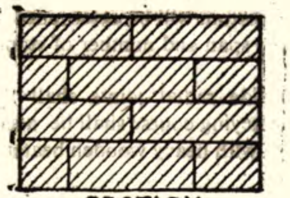
2.1. The side or radial joints shall be perpendicular to the tangent of the curve of the arch at each point and at right angles to the face. The soffit shall be dressed to the true curve of the arch and the back or upper surface of the arch stone shall be dressed to the true curve of the extrados or each stone shall have its upper surface dressed to a plane flat surface according as the drawing may indicate. The thickness of each joint shall not exceed 3 mm.

3. *Face stones* : The face stones shall be fine tooled, or rock faced as specified or shown on the drawings. It will also be separately as specified if chamfering is to be done to the exposed radial joints of face stones and horizontal joints of the soffit.

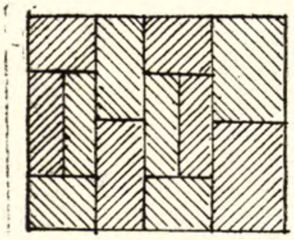
ASHLAR FINE



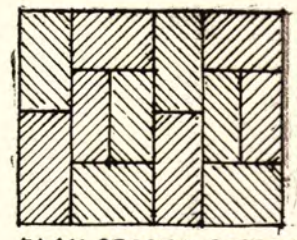
ELEVATION



SECTION

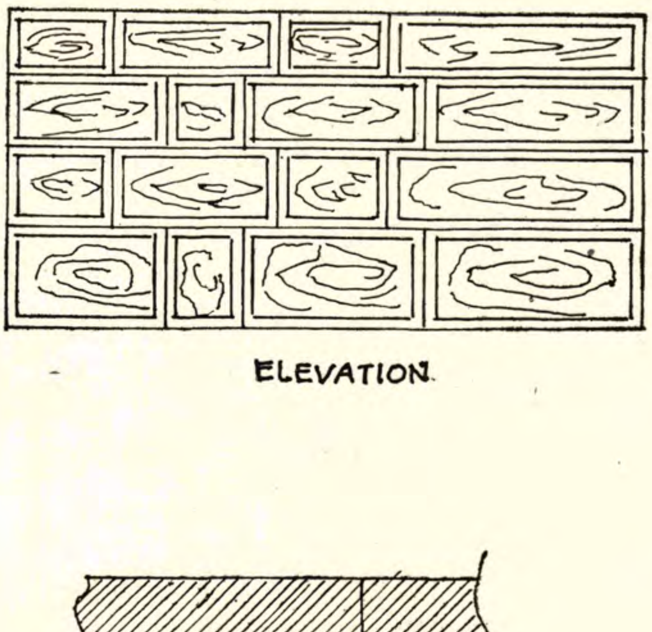


PLAN FIRST COURSE

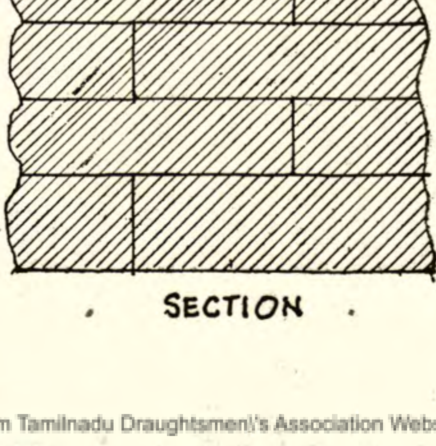


PLAN SECOND COURSE

ROCK OR RUSTIC ASHLAR WITH CHISEL DRAFT



ELEVATION



SECTION

4. *Centres.*—The contractor shall furnish for the approval of the Executive Engineer, plans for the centres of all arches up to 4.5 m· pan. For larger span arches, the Executive Engineer will prepare centering plans and furnish the same to the contractor, except in the case of lump sum contracts, where the contractor shall prepare and submit the plans of the centres proposed to be used for prior approval by the Executive Engineer. For spans larger than 1.8 m., timber centres are to be used and are to be provided with hardwood wedges for slackening, the centres-sand boxes shall be used for slackening, for spans over 6 m. In all centres the arrangement shall be such that the slackening can be effected without any vibration being transmitted to the arch and in the case of a series of arches that the centres can all be slackened simultaneously. If the centres are not of clear span, but rest on intermediate brick pillars, the brick pillars, shall be well and strongly built, the top of each pillar being capped with wood and connected up with other pillars by a continuous piece of timber from abutment to abutment.

4.1. In all centres, the upper bearing surface shall be very correctly formed to the curve of the intrados of the arch.

4.2. The contractor shall obtain instructions from the Executive Engineer, regarding the number of hours after completion of the arch that the centres shall be sufficiently slackened to compress the joints (re-tightening at once) and also the time for complete removal. When using a lime mortar centres will ordinarily be slackened within 24 hours after completion of the arch. Care shall be taken however that the centres are not slackened while the mortar in the last finished joints is still so soft that it will be squeezed out,but at the same time, the centres shall be slackened while the mortar is still moist, so as to allow the arch to compress itself and bring all the joints to fair bear, ing In the case of a segmental arch,care shall be taken to see that the skew backs are secure (they are better tobe given a week's time to set and in the case of semi-circular, elliptical, pointed or other arches springing from a horizontal joint, that the adjacent wall has been built up to two-thirds of the height of the arch, before slackening centres. With a quick-setting cement mortar, centres should be left till the mortar has finally set.

4.3. During the progress of the work, care must be taken to distribute the load on the centres in order to obtain a true curve at the completion of the work. Before turning arches exceeding 12m. span, the middle half of the centre shall be loaded with all the material which is to be used on that portion of the arch ring.

4.4. The rate for arch work is to include the provision of proper centres as described above—together with sand boxes setting up easing and removing the same irrespective of the size of the arch. (If centres or sand boxes are to be supplied by the department to the contractor, then such will be entered in the tender notice and the rates shall be tendered accordingly.)

5. *Removal of bad work.*—If any arch settles unduly or becomes unsightly through carelessness, bad workmanship, centering or bad material, it shall be removed or re-built at the contractor's expense.

6. *Measurement.*—Measurement of arch work shall be the mean of the lengths of extrades, the full breadth of the arch and the full thickness of the ring.

SPECIFICATION No. 35-E.

RUBBLE ARCHING

Additional clauses to "General" preceding.

1. Rubble arching shall consist of flat bedded slabs laid solidly and flush in mortar with their radial joints perpandicular to the tangent to the curve of the arch at each point and the arch stone shall properly break joint at heading joints. The mortar to be used shall be standard specification mortar of the class described in the Schedule item wording and the thickness of arch ring will be defined therein. Each slab shall be hammer dressed approximately to the proper shape, with the necessary summering so that the arch stone may bear fairly one upon another for the full thickness of the arch ring, and should parts for the full thickness of the arch ring, and should parts of the backs of the stones be open they shall be solidly wedged up with spalls and chips of stones set in mortar.The exposed faces of the face or quoin stone shall be bushed or plain dressed as specified with face perpendicular to the length inwards. The soffit shall be dressed to a plane surface, true at all points to the curve of the arch.

2. The joints on face and soffit shall not exceed 12 mm. in thickness.

3. The arch quoins shall be of the same thickness as the sheeting of the course, but they shall be superior selected stones, in all cases extending right through from intrados to extrados and alternately, not less than 37.5 cm. and 5.3 cm. long perpendicular to the face of the arch.

4. Interior arch stone in the sheeting shall not be less than 75 mm in least dimension, and the stones shall break joint with each other 150 mm. In arch rings 37.5cm. thick and under, all stones shall be of full thickness of the ring.

5. In arch rings more than 37.5 cm thick, the stones will be laid in alternate courses of headers and stretchers, unless otherwise specified. not more than two stones going to make up the thickness of the arch ring.

SPECIFICATION No. 35-F.

RUBBLE IN MORTAR (FIRST SORT).

1. I. S. 1597/Part I-1967 shall apply.

1.1. The stones shall be solidly bedded set full in mortar with joints not exceeding 12 mm thickness and with no pinning whatever on the face and shall extend well back into the hearting.

1.2. In all walls upto a width 60 cms. bond stones running through the wall shall be provided of intervals of 1.8 metres clear in every course. For walls thicker than 1.8 metres a line of headers each header overlapping the other by 30 cms. or more shall be provided from front to back at 1.8 metres interval in every course. Care shall be taken not to place the bond stones of successive courses over each other. The position of bond stones shall be marked on both the faces for identification and verification(Tar marking where plaster is to be applied will suffice.

2. No under-pinning of any description is to be allowed and hollow bedding and flushing such gaps with mortar are to be carefully avoided.

3. The work on the interior face shall be precisely the same as on the exterior face unless the work is to be plastered, in which case the side joints need not be vertical.

4. The rate per cubic metre shall be for finished work inclusive of all dressing, chisel drafting, etc. The contractor shall therefore tender his rate to cover the dressing required to comply with the specification.

SPECIFICATION No. 35-G.

RUBBLE IN MORTAR (SECOND SORT).

1. I.S. 1597/1967 Part I and I.S. 1127/1970 shall apply.

1·1. The whole width of the wall will be paid for as coursed rubble in mortar second sort unless it is specified that a certain thickness will be paid for as coursed rubble and the balance as randum rubble.

N.B.—In thick walls such as lock walls, etc., the Executive Engineer will determine and specify in the tender notice the width which will be paid for under each class of work.

SPECIFICATION No. 35-H.

Random Rubble in Mortar.

1. For details of random rubble work I.S. 1127/1970 and I.S. 1597 Part I/1967 shall apply.

2. No pinning whatever shall be used on the face "Bushings" shall not project beyond the face of the wall more than 12 mm. in faces proposed to be plastered.

3. Measurement of stone masonry is covered by I.S. 1200 Part IV/ 1970 shall apply.

SPECIFICATION No. 35-I.

Random Rubble in Clay.

1. The mud to be used for mortar shall be prepared from carefully selected earth of tenacious nature to which sand shall be added in such quantity that a dried lump of mixture shall not show signs of cracking. The mud shall be well trodden and worked into the consistency of a thick paste by the addition of sufficient water. The mixture thus made shall be kept for a week allowing water to stand on the top of the mud in a shallow pool. The mud thus stored up shall be well tamped with water by treading when it is to be used on the work, care being taken to remove all clods and stones.

2. The work shall be executed to the same specification as the standard specification for random rubble in mortar with the exception the clay of the above description is to be used instead of mortar.

N.B.—It is customary with this class of masonry in buildings to execute top 30 cm. of walls and 30 cm. around doors and windows with random rubble in mortar.

SPECIFICATION No. 35-J.

Prescast stone masonry block walling.

1·1. The concrete used for moulding the precast stone blocks shall be as specified in Specification No. 28.

1·2. The stones shall be of such variety conforming to the requirements of building stone as laid down in Specification No. 35.

1·3. The method of production, dimensions of blocks and moulds, casting of blocks shall be done as specified in Data Sheet No. 8 of C.B.R.I. Roorkee.

1·4. The average compressive strength for various mix proportions shall be as in Table 2 of Data sheet mentioned above.

1·5. The blocks shall be used for load bearing and non-load bearing walls. The permissible stresses in the masonry shall be taken from I.S. Code 1905-69 "Structural Safety of Buildings Masonry walls" depending upon the morter to be used for laying and the compressive strength of the blocks. Masonry bonds construction and curing shall be as laid down in the Data Sheet mentioned above.

1·6. The data furnished by the C.B.R.I. Roorkee shall be followed for guidance only.

SPECIFICATION No. 35-K.

Celcrete Block Masonry.

1. *Celcrete Blocks.*

1·1. *Materials.*—The celcrete is a light weight material of uniform porous structure obtained as a result of aerating the green concrete mix with gas. The main ingredients shall be sand quick lime, cement, flyash aluminium powder and gypsum.

1·2. Properties of celcrete shall be as given under.

Serial number and properties. (1)	*Value.* (2)
1. Density (dry)	2,750 kg/m.³
2. Specific gravity	0·75
3. Crushing stress	50 to 60 kg./cm.²
4. Tensile stress	4 kg./cm.²
5. Shear stress	7·5 kg./cm.²
6. Bond stress	4 kg./cm.²
7. Modulus of elasticity ..	1, 96 to 2·25 x 10^4 kg./cm.²
8. Absorption test	Not exceeding 45 per cent by volume in 48 hours.
9. Capillary action	3 cm. in 24 hours.
10. Shrinkage	0·30 mm./m. for variation of 80 per cent humidity.
11. Thermal conductivity ..	0·15 K. cal/sq. mh. (degree c/m.).
12. Fire resisting	Good.

1·3. *Block sizes and finish.*—The sizes of blocks used shall be as follows :—

For load bearing walls ..	(1) 59 cm. x 24 cm. x 19 cm. (2) 59 cm. x 15 cm. x 19 cm.
For partition walls	(1) 59 cm. x 12 cm. x 19 cm. (2) 59 cm. x 10 cm. x 19 cm.

Maximum variation in dimensions shall not be more than ± 2mm. for height and breadth and ± 3 mm. for length. The faces of the blocks shall be rectangular, opposite faces shall be parallel and all arrises shall be square and straight. The angles of the blocks shall be right angles and the edges shall be sharp unless otherwise specified.

Allowable compressive and tensile stress.—The maximum compressive stress shall be 50 to 60 kg./cm.². The tensile stress shall be 10 to 14 per cent of the allowable compressive stress.

1·4. *Stacking and handling.*—Celcrete blocks shall be stock-piled on planks or other supports free from contact with the ground. The blocks shall be handled with care and damaged units shall be rejected.

2. *Celcrete masonry :*

2·1. *Mortar.*—Cement mortar 1:6 (one cement and six sand) shall be used. For detailed specifications for cement mortar I.S. : 2250/65 shall apply.

2·2. *Strength and stability.*—Minimum thickness of load bearing walls shall be 15 cm. and minimum nominal thickness of non-load bearing partition wall shall be 10 cm. thick.

Celcrete masonry shall be designed in accordance with I.S. : 1905-1969.

2·3. *Laying.*—Laying of celcrete block masonry in superstructure shall be as in paragraph 10 of I.S. : 6042-69 (code of practice for construction of light weight concrete block masonry) (extract furnished).

2·4. *Finishing.*—External plastering shall be done if so specified. The specification No. 56 shall apply for plastering with cement mortar.

2·5. Celcrete masonry shall be constructed for superstructure only and shall not be used in foundation.

SPECIFICATION No. 36.

DRY STONE MASONRY.

(FOR RETAINING WALLS.)

1·1. The work shall be executed with bond according to standard specification for "random rubble in mortar" the mortar being omitted and chamfering and chisel drafting of corners not being required.

1·2. The largest rubble stone procurable from the quarries sspecified shall be used. The batter to such masonry for walls and parapets should not be less than 1 in 12 or such other batter as may be specified

SPECIFICATION No. 37.

ROUGH STONE DRY PACKING FOR APRON AND REVETMENT

(For detailed specification I.S. 4515-1967 shall apply).

1·1. The bed or slope to receive the packing will first be prepared as specified and passed by the Executive Engineer. In cases where the work of preparation of bed and slope such as cutting out high bund, filling in hollows, etc., or the digging of the wall foundations is rather extensive, separate items should usually be provided for such subsidiary kinds of work in the schedule to the agreement. But if the work involved in such subsidiary item is very little, no separate provision need be made and in the absence of such provision, the contractor shall understand that his tender rate is inclusive of all such work without extra charge. If the packing is to be laid on made ground-which is objectionable it shall, so far as possible, not be laid till the ground has completely settled. If a backing of gravel, quarry, rubbish or other material is to be given, it will be specified in a separate schedule item (15 cm. gravel or quarry rubbish backing well wetted and consolidated is desirable for loose soils).

2. The stones shall be perfectly sound, as regular in shape as possible, and with their lengths equal to the thickness of the required apron or revetment, and each stone shall not be less in size than, 0·014 $m.^3$ unless otherwise specified or ordered by the Executive Engineer, having regard to the nature of the stone being quarried. The smaller size stones required for filling in interstices and wedging shall only be supplied to the actual requirements for the works as defined in clause (4) below and shall not be used in two or more layers as a substitute for the full thickness stones specified in clause (3). The stones shall be obtained from the quarry defined in the Descriptive Specification Sheets.

3. The stones shall be laid closely in position on the prepared bed firmly set with their broadest end downwards, so that they may meet all round their bases and with the top of the stone, level with the finished surface of the packing. The stones shall be laid breaking joint so far as possible in the direction of the fiow of water, The stones are to be placed perpendicular to the finished surface, i.e., perpendicular to the slope for revetments.

4. The interstices between adjacent stones shall be filled in with stones of the proper size, well driven in with crowbars to ensure tight packing and complete filling of all interstices. Such filling shall be carried on simultaneously with the placing in position of the large stones and shall in no case be permitted to fall behind,. The final wedging shall be done, only after obtaing the orders of the Executive Engineer. The final wedging shall be done with the largest sized chip practicable each chip being well driven home with a hammer so that no chip is possible of being picked up or removed by hand.

5. Profiles of strings and pegs are to be put up to ensure that the pitching is done, true and to the proper slope throughout and revetments are in all cases to be built up from the foot of the bank to be revetted. Care is necessary that a strong toe wall or other protection is always given to the revetment-which protective measure will be shown on the plans.

6. On completion the surface presented by the apron or revetment shall be even throughout, free from irregularities, to the required length, breadth and slope as specified or shown on the plans.

N.B. If jeddy stone dry packing is required by the schedule item description the size of such stone will be described in the schedul item description or in a supplementary specification.

SPECIFICATION No. 37-A.

LATERITEOR ROUGH STONE PITCHING FOR RIVER CONSERVANCY WORKS

1.1. The stones shall conform to paragraph 2 of Specification No. 37.

2. Profile sections with strings and pegs shall be formed by the contractor at suitable intervals at his cost. The pitching shall be done true, straight and to the proper slope. The top layer of stones shall be 45 cm thick laid closely in position, and firmly set with the broadest faces next to the slope.

2.1. The interstices between the stones shall be filled with the large sized chips and each chip shall be well driven home with a hammer so that it cannot be removed by hand.

2.2. On completion, the surface shall be even throughout free from irregularities to the required dimensions and slope as specified or shown on plans.

3. The rate shall be for cubic metre of laterite or roughstone pitching and shall be for labour for removing stones from stacks, conveying to the river margin and making up the pitching as herein described unless otherwise specified.

SPECIFICATION No. 37-B.

GRAVEL BACKING TO ROUGH STONE DRY PACKING AND GRAVELLING TO TOP AND SIDE SLOPES OF BUNDS 15CM THICK.

1·1. The surface to receive the gravel coating shall be neatly trimmed to the proper slope, free from all roots and vegetation and profusely wetted before gravel is laid on.

2. Standard specification gravel shall then be mixed with wate and worked with mamoties till it can be formed into stiff plastic balls Gravel so mixed shall be carried in baskets, to where it is to be laid and placed a single layer to give 15 cm in finished thickness and shal be well rammed in position with flat wooden or iron rammers.

3. The finished surface of gravel should be left untouched until the gravel dries up and does not show signs of yielding.

4. Vide standard specification for gravel; regarding stack measurments.

5. If any thickness other than 15 cm is specified the work shall be executed to this specification; ramming in layers not exceeding 15 cm in thickness.

6. The rate will be per 10 m^2 (unless otherwise defined in the schedule) and will include compliance with watering and all other clauses of this specification.

SPECIFICATION No. 38.

DAMP PROOF COURSE IN CEMENT MORTAR 1:3 (ONE CEMENT AND THREE SAND) 20*mm* THICK.

The damp proof course in cement mortar 1:3 mixed with crude oil (5 precent of weight of cement used) shall be laid at level just below the undersurface of the floor.

EXTRACT FROM I.S. 1127—1970.

Recommendations for dimensions and workmanship of natural building stones for masonry work (First Revision).

3. *Dimensions and Tolerances.*

3.1. The recommended diamensions of natural building stones measured at edges shall be as given in Table 1.

3.1.1. The recommended dimensions given in Table 1 have been worked outon the basis that the thickness of the mortor joints are 3mm for ashlar masonry 6 mm, for block in course and 10 mm for square rubble.

3.2. Tolerances—The following tolerances shall be allowed on the dimensions :

(a) For stones required in ashlar masonry :

(1) Length and breadth.. .. . ±5 mm.

(2) Height .. .. ±3 mm.

(b) For stones required for other than ashlar masonry:

(1) Length and breadth .. .. +5 mm. / −10 mm.

(2) Height .. .. .. ±5 mm

4. *Workmanship.*

4.1. In the case of stratified rocks stones for building purposes shall be so quarried and dresesd that when set in the building the stones are laid along the plan of stratification.

TABLE 1 : DIMENSIONS OF NATURAL BUILDING STONES.

(*Clause* 3.1.)

Serial number and type of masonry.	*Length* mm.	*Breadth* mm.	*Height* mm.
(1)	(2)	(3)	(4)
1. Stones for ashlar ..	597 697 797	297 347 397	297 347 397
2. Stones for block in course	394 494	194 244	194 244
3. Stones for square rubble	90	90	90
	140	90, 140	90, 140
	190	90, 140, 190.	90, 140, 190.
	240	90, 140, 190.	90, 140, 190.
	290	90, 140, 190, 240.	90, 140, 190, 240, 290.
	390	90, 140, 190, 240 290.	90, 140, 190, 240, 290.
	440	90, 140, 190, 240, 290.	90, 140, 190, 240, 290.
	490	90, 140, 190, 240 290.	90, 140, 190, 240, 290.
	590	90, 140, 190.	90, 140, 190, 240, 290.
4. Stones for random rubble.	May be of any size and shape but not less than 150 mm. in any direction.		
5. Stones for sills and lintels	(a) 890, 990, 1090, 1190, 1290.	90, 190, 290, 390, 490.	90, 140, 190.
	(b) 1390, 1490, 1590, 1690, 1790.	190, 290, 390, 499 590.	140, 190, 240, 290.
6. Stones for arches, domes and circular moulded work.	The dimensions depend on the particular of the curve.		
7. Coping stones ..	190, 290, 390, 490, 590, 690, 790.	200, 300, 400, 500, 600.	100, 150, 200.
8. Kerb stones	390, 490, 590, 690, 790.	100, 200, 300.	300, 400, 500.

EXTRACT FROM I.S. 2250—1965.

Code of practice for preparation and use of masonry mortars.

Masonry mortar shall preferably be specified by the "Grade" in addition to mix proportions. As a guidance in this respect, the compressive strength (at the age of 28 days) for various types of masonry mortars normally used may be taken as in Table 1.

TABLE 1—COMPRESSIVE STRENGTH OF MASONRY MORTARS.

(*Clause* 5.1.)

Mortar mix (by volume).				*Compressive strength at 28 days in*
Cement. (1)	*Lime.* (2)	*Pozzolana.* (3)	*Sand.* (4)	*Kg. Cm²*. (5)
0	1B	0	3	5 to 7
0	1C	1	2	7 to 15
1/4	3/4 B to C	0	3	7 to 15
0	1C	2	0	15 to 20
0	1A	0	3	20 to 30
0	1C	3	0	Do.
1/2	2/3B	0	3	Do.
1/2	1/2C	0	3	30 to 50
1	0	0	6	Do.
2/3 to 4/5	1/3 to 1/5C	0	3	50 and above (depending upon the class and composition of lime used).
1	0	0	3	Do.

Note.—A, B and C denote the classes of limes to be used (*See* I.S. 712-1964*).

*Specification for building lime.

5.2. *Durability.*

5.2.1. The durability of masonry mortar will depend upon the following factors :

(*a*) Volumetric changes during the process of setting, hardening and later due to temperature variations or due to moisure movement in the surroundings, and the extent to which the mortar will internally accommodate the stresses induced by these volumetric changes before yielding.

(*b*) The nature and distribution of resulting cracks, whether as fine cracks well distributed throughout or large localized cracks.

(*c*) The extent to which the bond between the mortar and masonry units is ruptured by volumetric changes and structural movements resulting not only in reduction of strength of masonry but also in provision of channels of seepage for water and other solution into the masonry which would further the process of deterioration.

The selection of masonry mortars from durability considerations will, therefore, have to cover both the loading and exposure condition of the masonry, The requirement for masonry mortar shall generally be as specified in 5.2.2. to 5.2.4.

5.2.2. In the case of masonry exposed frequently to rains and where there is further protection by way of plastering or rendering or other finishes, the grade of mortar shall not be less than 10, but preferably, about 25 [1 : 3] lime (Class A): sand mortar or 1 : 2 : 9 cement, lime sand, mortar). Where no protection is provided the grade of mortar for external walls shall not be less than 25.

5.2.3. For masonry in internal walls—In the case of load bearing internal walls, the grade of mortar shall preferably be 10 or more for high durability but in no case less than 5. Lime cement mortar, or lime mortar (*see* I.S. 1625-1962) may be used.

5.2.4. For masonry below ground : In the case of masonry in foundations laid below damp-proof course the grades of mortar for use in masonry shall be as specified bleow :—

(*a*) Where the soil has little moisture, lime-cement mortar, or lime mortar of grade not less than 10 shall be used.

(*b*) Where the soil is very damp, mortar of grade preferably 25 or more [1 : 3] lime (Class A) : Sand mortar or 1 :2 :9 cement, lime, Sand mortar or stronger mortars) shall be used. But in no case shall the grade of mortar be less than 10.

(*c*) In the case where soil is saturated with water, cement mortar) or lime-cement mortar of grade preferably above 50 shall be usedr but in no case shall the grade of mortar be less than 25 (1 :3) lime Class A : Sand mortar or 1 :2 :9 cement, lime, sand mortar or stronger mortars].

5.2.5. For masonry in buildings subject to vibration of machinery the grade of mortar must not be less than 25 [1 :3] lime (Class A) Sand mortar or 1 :2 :9 cement, lime, sand mortar or stronger mortars.]

5.2.6. For parapets where the height is greater than thrice the thickness, the grade of mortar used in the masonry shall notbe less than 25 [1 :3] lime (Class A) : Sand mortar or 1 : 2 : 9 of low parapets, the grade of mortar shall be the same as used in the wall masonry below.

5.2.7. Only cement mortars shall be used in reinforced work. For use in reinforced masonry and as protective layer around reinforcement, the grade of mortar shall not be, less than 25 [1 :3] lime (Class A) : sand mortar or 1 : 2 : 9 cement, lime, sand mortar or stronger mortars] in the case of dry conditions exposure and not less than 50 (1 : 3] cement : Sand mortar or 2 : 1 :9 to 4 : 1 :15 cement, lime sand mortar or stronger mortars] under wet conditions.

5.2.8. The grade of mortar for bedding joints in masonry with large concrete blocks, shall not be less than 25 [1 :3] lime (Class A) : Sand mortar or 1 :2 : 9 cement, lime, sand, mortar].

6.3. *Preparation of cement mortar* : Mixing shall be done preferably in a mechnaical mixer. If done by hand-mixing, the operation shall be carried out on a clean watertight platform. Cement and sand shall be mixed dry in the required proportion to obtain a uniform colour. The required quantity of water shall than be added and the mortar mixed to produce workable consistency. In the case of mechanical mixing the mortar shall be mixed for atleast three minutes after addition of water ; in the case of hand mixing the mortar shall be head back and forth for 10 to 15 minutes with additions of water.

6.4. *Preparation of cement lime mortar.*

6.4.1. Where coarse sand is used, the lime putty and the sand in the required proportions shall, after preliminary mixing on a watertight platform with necessary addition of water, be ground in a mortar mill taking care to rake up continuously the mortar partiucalrly at the corners, and also adding water as and when required during grinding. This mix shall then be transferred to a mechnaical mixer to which the required quantity of cement is added and the content mixed for atleast three minutes.

6.4.2. Where fine sand is used the mixing operations shall be done in the same manner as in 6.4.1. except that grinding may be omitted for the preliminary mixing of lime putty and sand.

6.4.3. If the mixture of lime putty and sand is not used immediately for mixing with cement, it shall be kept protected from drying out till the time of use.

6.4.4. When adding water finally in the mortar during mixing operations it shall be ensured that it is added only to the extent necessary for obtaining working consistency for the mortar and not more.

6.4.5. Where dry hydrated lime is used, grinding of lime and sand in a mortar mill with required addition of water shall be done before addition of cement.

6.4.6. Where pozzolana is used in the mortar, the pozzolana shall first be mixed with the lime in the specified proportions and ground in a mortar mill with addition of required quantity of water. Sand shall then be added to the mix and the mixing and grinding repeated till every aggregate particle gets coated uniformly with the cementitious material. Mixing after addition of cement as ingredient shall be done in the same manner as described in 6.4.1· in a mechanical mixer.

7. *Controlling the consistency of masonry mortar.*

7.1. The working consistency of the mortar is usually judged by the worker during application. The water should be enough to maintain the fluidity of the mortar during application, but at the same time it shall not be excessive leading to segregation of aggregates from the cement. The quantity of water needed for maintaining consistency or fluiditiy will also depend upon the masonry to which the mortar is used ; for example, thinner joints will require greater fluidity; bed joints subject to heavy pressure may require stiffer mortar. Also the mortar should be able to hold the water against suction by the masonry unit particulary in the case of burnt clay and concrete products.

EXTRACT FROM I.S. 1597 (PART I)-1967.

Code of practice for construction of stone masonry.

Part–I *rubble stone masonry.*

4·1. *Stone.*

4·1·1. *Types.*—The common types of natural building stones which are generally used are, granits and other igneous rock, lime stone (including marble), sandstone, etc., For the properties of these ypes of stones reference may be made to I.S. 1123-1957.

4·1·2. *Quality.*—All stones used for building purposes shall be strong, hard and durable as indicated in 4·1·2·1· and 4·1·2·2·.

4·1·2·1. *Strength.*—The strength of building stones should be adequate to carry the loads imposed. For ashlar and coursed rubble masonry, the strength shall be as worked in accordance with I.S. 1905-1961, taken into account, the appropriate crushing strength of stone as given in Table 1, and also the type of mortar used. For random rubble masonry, the strength value shall be specified on the basis of local experience.

TABLE 1—CRUSHING STRENGTH OF STONES.

Serial number and type of stone.	*Minimum Crushing strength in kg./cm²* (*See Notes*).
(i) Granite	1,000
(ii) Basalt	400
(iii) Limestone (except very soft stone) ..	200
(iv) Sandstone	300
(v) Marble	500
(vi) Laterite	30

NOTE.—The sources of information are : for (i) I.S. 3316-1966 'Method of sampling and grading structural granite'; for (ii) Bombay P.W.D. Handbook ; for (iii) (iv) and (v) DIN 1053-1952· Wall masonry and design execution; and for (vi) I.S. 3620-1966 " Specification for laterite stone block for masonry ".

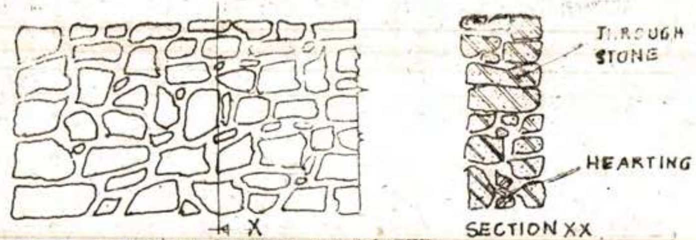
4·1·2·2. *Durability.*—The stone shall be free from defects like, cavities, cracks, flaws, sandholes, veins, patches of soft or loose materials, etc. The percentage of water absorption (see I.S. 1124 1957 for the method of test) shall generally not exceed 5 per cent. Generally the stone should not contain crypto crystalline silica or chert, mica or any other deleterious material like iron oxide, organic impurities, etc.

NOTE. 1.—The selection of stones for durability is generally based on experience. An examination of structures, at least half a century old, where the particular type of stone is used, will indicate the durability of the stone. If tool marks are visible, and the edges and corners are still aharp and true and the surface is hard and shows no signs of deterioration, the stone is durable.

NOTE 2.—Stone from quarries having stratification at regular intervals will be of uniform quality generally. Where there are variations in stratification, the stone shall be examined petrographically in accordance with I.S. 1123-1957.

4·1·2·3. *Size of stone.*—Normally stones used in rubble masonry should be small enough to be lifted and placed by hand. The length of the stone shall not exceed three times the height and the breadth on base shall not be greater than three-fourths of the thickness of wall nor less than 15 cm. The height of stone for rubble masonry may be upto 30 cm.

NOTE.—The selection and grading of stones for rubble masonry work is largely done at site and the smaller stones are used in the hearting of the wall. Large scale supply will be facilitated if, as far as possible. preferred standard sizes for building stone are used as covered in I.S. 1127-1957.



FIG·4· RANDOM BUBBLE UNCOVERED MASONRY

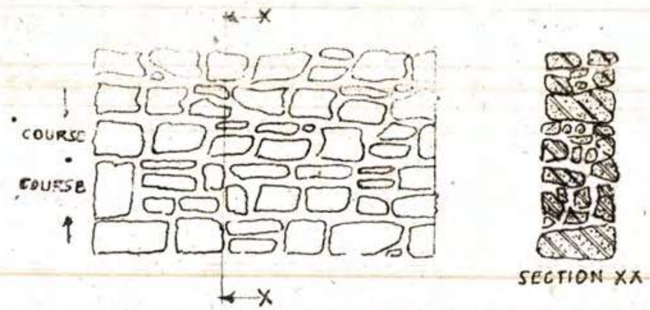
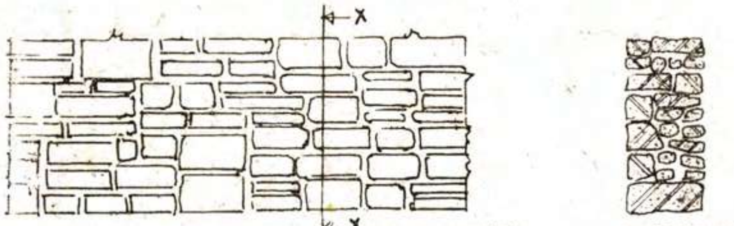
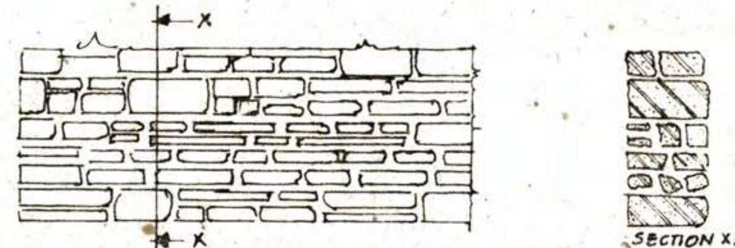


FIG 5· RANDOM RUBBLE MASONRY BROUGHT TO COURSE



1.G· SQUAREDRUBBLE UNCOVERED MASONRY



FIG·7· SQUARED RUBBLE MASONRY BROUGHT TO COURSE

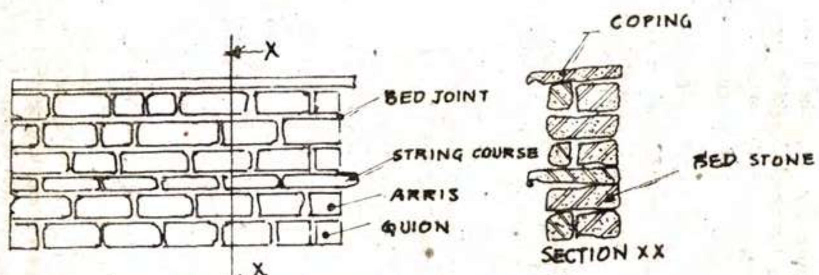
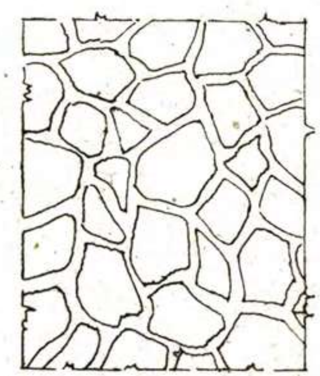


FIG 8· SQUARE RUBBLE COURSED MASONRY



FIG·9· POLYGONAL RUBBLE WALLING

6·1·1. *Random rubble.*—(*a*) *Uncoursed* (*See Fig*.4).—This type of masonry is constructed of stones as they come from the quarry. The mason or waller selects blocks of all shapes and sizes, more or less at random, and places them in position to obtain a good bond, while restricting cutting of the stones to the removal of inconvenient corners with a scabbling or spalling hammer.

(*b*) *Brought to courses* (*See Fig*. 5).—This walling is similar to uncoursed random rubble except that the work is roughly levelled upto courses at intervals varying from 30 cm. to 90 cm. in height, according to the locality and the type of stone used. The course heights usually correspond with the heights of the quion and jamb stones.

6·1·2. *Squared rubble.*—(*a*) *Uncoursed* (*See Fig*. 6).—In this type, the stones are roughly squared as risers or jumpers and stretchers with varying heights, and are laid uncoursed.

(*b*) *Brought to courses* (*See Fig*. 7.)—The stones are similar to those used for uncoursed rubble but the work is levelled upto course of varying depth from 30 cm. to 90 cm. according to the locality and the type of stone used.

(*c*) *Coursed* (*first and second sort*) (*See Fig*. 8).—Coursed walling is built in courses which may vary in height from 10 to 30 cm. but the stones in any one course are roughly squared to the same height. The faces of the stones may be pitched to give a rock face appearance or may be dressed smooth. A variant of this type of walling may be formed by the introduction of pinnings, that is, smaller stones in the same courses, at intervals, producing a chequered effect.

6·1·3. *Polygonal rubble walling* (*See Fig*. 9).—Stone with no pronounced stratification is roughly hammer pitched into irregular polygonal shapes. and bedded to show the face joints running irregularly in all directions.

6·5·1. All projecting architectural features, such as plinth projections, string courses, or cornices shall be effectively bonded by tailing into the stone work to ensure stability, Such architectural features shall be set straight and true into the finished joints as far as possible.

6·5·2. When such features are not to be plastered over, they shall be built with stone which have high durability and resistance to moisture penetration. [Stones specially made to required shape with the help of templates cut out of sheets, shall be used.

6·5·3. Sun shades and such projecting features which depend on the weight of masonry over them, for their stability shall be kept supported till such time when the masonry above is built and hardened sufficiently.

6·5·4. All coping shall be dowelled or cramped. String courses shall tail at least 25 cm. into the work and shall be throated on the underside.

7·6. *Watering.*—Stones shall be sufficiently wetted before laying to prevsnt absorption of water from mortar.

7·7. In all types of masonry, the particulars given in 7·7·1 to 7·7·12 shall be complied with.

7·7·1. The stone shall be laid so that the pressure is always perpendicular to the natural bed.

7·7·2. The courses (if any) shall be built perpendicular to the pressure which the masonry will bear. In case of battered walls, the base of stone and the plane of courses (if any) shall be at right angles to the bater.

Note.—In the case of a bridge pier having batter on both sides, the courses shall be horizontal.

7·7·3. In the case of coursed rubble masonry, if the heights of the courses vary the largest stone shall be placed in the lowest course, the thickness of courses shall also decrease gradually to the top.

7·7·4. Vertical joints shall be staggered as far as possible.

7·7·5. Bell shaped bond stones or headers shall not be used.

7·7·6. All necessary chases for joggles, dowels, and cramps should be formed in the stones before hand.

7·7·7. Sufficient transverse bonds shall be provided by the use of bond stone extended from the front to the back of the wall and from outside wall to the interior, of thick walls and in the latter case bond stones shall overlap each other in their arrangement.

7·7·8. At all angular junctions the stones at each alternate course shall be well bonded into the respective courses of the adjacent wall.

7·7·9. Where there is a break in masonry work the masonry shall be raked in sufficiently long steps for facilitating joining of old and new work. The stepping of the raking shall not be more than 45° with the horizontal.

7·7·10. Masonry construction with too thin faces, tied up with occasional through stones or filled up with dry packing or small size agregates shall be strictly prohibited.

7·7·11. The walls and pillars shall be carried up truly plumb or to specified batter,

7·7·12. Storey rods showing the heights of all doors and windows and other necessary information should be used at the time of construction of masonry.

7·8. *Fixing of frames.*—Where door or window frames of timber are fixed in the openings, the fixing shall be done generally with hold—fasts of adequate size and strength, securely embedded in the stone work preferably in chases filled up by cement concrete. Iron Hold-fast shall be given a protectivie coat of bitumen to avoid rusting Wood work faces in contact with stone work shall be treated with wood preservative to prevent attack from insects and termites. The frames shall preferably be fixed simultaneously as the masonry work proceeds as this construction will ensure proper bond without gaps between the masonry and the frames.

7·9. *Bearing of floors, roofs and joints.*—It is not desirable to embed any structural timber in stone work as it is liable to be affected by dry rot. The ends of timber joints shall preferably rest on corbels or brackets but when built into a wall this shall be treated with preservative and in addition, space shall be left around them for free circulation of air. The ends of beams carrying heavy loads and of trusses shall be supported on templates of concrete or stone. Bed blocks should set true to level and bedded in the same mortar as that used for walling. The ends of the steel beams or trusses embedded in masonry shall be built in with space all around for repainting or shall be protected with a thick bituminous coat or shall be encased in rich concrete of mix 1 : 2 : 4. The ends shall generally be supported on templates of plain or RCC of mix 1 : 2 : 4 or stone.

Note.—In case of timber ground floor, the ends of the open spaced timber joints supporting the floor boards should be nailed to wall plated on top of 12·5 cm. walling, built either as an offset to wall or as a separate sleeper wall.

7.10. *Jointing and pointing.*—All joints shall be full of mortar. Pointing shall be avoided as far as possible, but where unavoidable it shall be carried out as the work proceeds using the same mortar as for bedding. If carried out by raking out the joint later on after hardening, specially prepared mortars shall be used. The maximum thickness of joints shall be 20 m.m for random rubble and 10 mm. for square rubble. The various types of pointing are shown in Fig. 10 of I.S. : 2212—1962.

7.11. *Covering.*—Green work shall be protected from rain by suitable covering. Masonry work and cement of composite mortar shall be kept constantly moist on all the faces for a minimum period of seven days. The top of the masonry work shall be left flooded with water, with the close of the day. Watering shall be dcne caiefully so as not to disturb or wash out green mortar and use of perforated rose spout may be suitable. In the case of lime mortar, curing should commence two days after the laying of masonry and shall continue for seven days.

8. *Construction.*

8.1. *Random masonry (Uncoursed and brought to course).*

8.1.1. *Dressing.*—Stone shall be hammer—dressed on the face the sides and the beds to enable it to come in proxmity with the neihbouring stone. The bushing on the face shall not be more than 4 cm. on an exposed face.

8.1.2. *Insertion of chips.*—Chips and spalls of rtones shall be used wherever necessary to avoid thick mortatr beds or joints and it shall also be ensured that no hollow spaces are left any where in the masonry. The chips shall not be used below hearting stones to bring these upto the level of face stones. The use of chips shall be restricted to the filling of interstics between the adjacent stones in hearting and these shall not exceed 20 per cent of the quantity of a stone masonry.

8.1.3. *Hearting stones.*—The hearting or interior filling of a wall face shall consist of rubble stone not less than 15 cm. in any direction, carefully laid, hammered down with a wooden mallet into position and solidly beded in mortar. The hearing should be laid nearly level with facing and backing.

8.1.4. *Bond stones.*—Through bond stones shall be provided in walls upto 60 cm. thick and in case of walls above 60 c,m. thickness, a set of two or more bond stones ovarlapping each other by at least 15 cm. shall be provided in a line from face to back, In case of high absorbent types of stones (porous lime stone and sand stone, etc.) the bond stone shall extend about two-third into the wall, as through stones in such cases may give rise to damp penetration and, therefore for all thickness of such walls a set of two or more bond stones overlapping each other by at least 15 cm. shall be provided. Each bond stone or a set of bond stones shall be provided for every 0·5 m^2 of the wall surface.

8.1.5. *Quoin stone.*—Quoin stone shall not be less than 0·03 m^3 in volume.

8.1.6. *Plumb stone.*—The plumb stone at about 90 cm. interval shall be provided.

8.1.7. *Laying.*—The masonry shall be laid with or without courses as the case may be as per general requirement (see 7.7.) The Quoins shall be laid header and streatcher alternatively. Every stone shall be carefully fitted to the adjacent stone so as to form neat and close joint. Face stone shall extend and bond well in the back. These shall be arranged to break joints, as much as possible, and to avoid long vertical lines of joints.

8.2. *Square rubble.—Coursed rubble (first sort).*

8.2.1. *Dressing.*—Face stone shall be hammer—dressed on all beds and joints so as to give them approximately rectangular shape. These shall be square on all joints and beds. The bed joints shall be chisel drafted for at least 8 cm. back from the face and for the side joints at least 4 cm. No portion of the dressed surface shall show as depth of gap more than 6 mm. from a straight edge placed on it. The remaining unexposed portion of the stone shall not project beyond the surface of bed and side joints. The requirements regarding bushing shall be same as for random rubble masonry. (See 8.1.1)

8.2.2. *Hearting stones.*—The hearting or the interior filling of the wall shall consist of flat bedded stone carefully laid on their beds in mortar. The use of chips shall be restricted to the filling o interstics between the adjacent stones in hearting and these shall not exceed 10 per cent of the quantity of masonry. While using chips it shall be ensured that no hollow spaces are left anywhere in the masonry.

8.2.3. *Bond stones.*—The requirements regarding through or bond stone shall be same as for random rubble masonry but these shall be provided at 1.5.m. to 1.8m. apart clear in every course.

8.2.4. *Quoin stone.*—The quoins which shall be of the same height as the course in which these occur, shall not be less than 45 cm. in any direction.

8.2.5. *Face stone.*—Face stone shall tail into the work for not less than their heights and at least one thirds of the stones shall tail into the work for a length not less than twice their height. These should be laid headers and stretchers alternatively.

8.2.6. *Laying.*—All courses shall be laid truly, horizontal and all vertical joints shall be truly vertical. The quoin stones shall be laid stretches and headers alternatively and shall be laid square on their beds, which shall be rough chisel dressed to a depth of at least 10 cm.

EXTRACT FROM I.S.: 1597 (PART II)—1967.

Code of practice for construction of stone masonry.

Part II—Ashlar Masonry.

6.1.1. *Plain ashlar* (See Fig. 1)—Stone blocks of the same height in each course, are used and every stone is fine tooled on all beds, joints and faces, full and true.

6.1.2. *Sunk or moulded* (See Fig. 2-D)—The exposed faces of each stone block shall be gauged, cut, grooved, rebated, sunk or plain moulded as the case may be. Stone blocks of same height in each course are used.

6.1.3. *Rock (quarry) faced* (See Fig. 2-B)—The faces of each stone block exposed to view, shall have only chisel draft 25mm wide around the edges and between the drafts be left rough as the stone comes from the quarry.

6.1.3.1 *Chamfered* (See Fig. 2-C)—In the case of chamfered masonry, the edges are bevelled to 45° for a depth of about 2·5 cm., stone blocks of same height in each course are used.

6.1.4. *Rough tooled or punched* (See Fig. 2-A)—The faces of each stone block exposed to view, shall have a fine dressed chisel draft 2·5 cm. wide alround the edges and be rough tooled between the drafts and on all beds and joints. Stone blocks of same heigh in each course are used.

6.1.5. *Block-in-course.*—This is hammer-faced or pitch-faced regular coursed masonry in large blocks. It is a superior type of coursed rubble masonry.

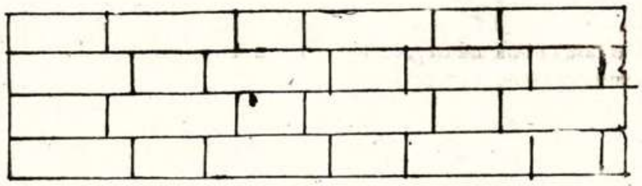


FIG 1. PLAIN ASHLAR

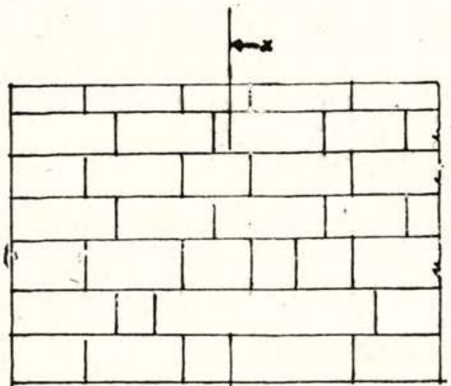
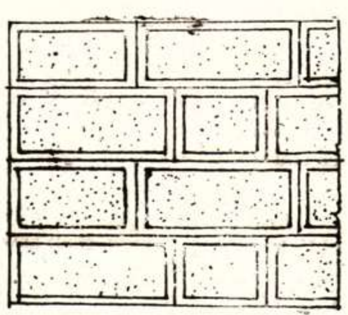
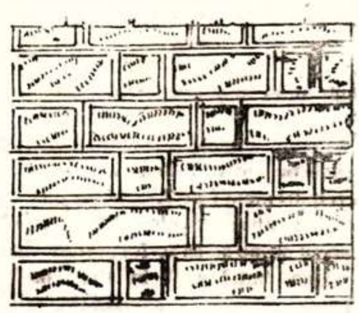


FIG 3. BLOCK-IN-COURSE ASHLAR MASONRY

SECTION XX

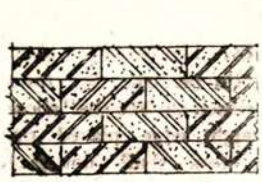


2A. ROUGH TOOLED OR PUNCHED



2 B. ROCK FOR QUARRY FACED

C C. CHAMFERED



2 D. SINK OR MOULDED

Fig. 2. ASHLAR MASONRY

6.2. *Weather protection.*—Generally ashlar masonry is not given any further protective rendering or finish.

7.6. *Watering.*—Stones shall be sufficiently wetted before laying to prevent absorption of water from mortar.

7.7. In all types of ashlar masonry, the following shall be complied with.

7.7.1. The natural bed of the stratified stone shall be so laid that the pressure is always perpendicular to the strata.

7.7.2. The courses shall be built perpendicular to the pressure which the masonry will bear. In case of battered walls, the beds of stone and the plane of courses shall be at right angle to the batter.

7.7.3. Where the depth of courses vary, the largest stone shall be placed in the lower course. The thickness of courses shall also decrease gradually to the top.

7.7.4. Stones shall break joint on the face for at least half the height of the course and the bond shall be carefully maintained throughout.

7.7.5. All connected masonry in a structure shall be carried up nearly at one uniform level throughout but when breaks are unavoidable, the joint shall be raked back at a maximum angle of 30° to the horizontal so as to prevent cracks developing between new and old work.

7.7.6. All necessary chases for joggles, dowels and cramps should be formed on the stone before-hand.

7.7.7. The walls, pillars shall be carried up truly plumb or to specified batter.

7.7.8. All courses shall be laid truly horizontal and all vertical joints shall be truly vertical.

7.7.9. Storey rods showing the heights of all doors and windows and other necessary information should be used at the time of construction of masonry.

7.10. *Jointing and pointing.*—All joints shall be full of mortar. Pointing shall be avoided as far as possible, but where unavoidable it shall be carried out as the work proceeds using the same mortar as for bedding. If carried out by raking out the joint, later on after hardening, specially prepared mortars shall be used. The maximum thickness of joints shall be 3 mm. except for block in course which shall be 6 mm. The vaious types of pointing are shown in Fig. 10 of I.S.: 2212—1962.

7.11. *Curing.*—Green work shall be protected from rain by suitable covering. Masonry work and cement of composite mortar shall be kept constantly moist in all the faces for a minimum period of seven days. The top of the masonry work shall be left flooded with water with the close of the day. Watering shall be done carefully, so as not to disturb or wash out green mortar and use of perforated rose spout may be suitable. In the case of lime mortar, curing should commence two days after laying of masonry and shall continue for seven days.

8. *Construction.*

8.1. *Plain ashlar.*

8.1.1. *Dressing.*—Every stone shall be cut to the required size and shape, chisel dressed on all beds and joints so as to be free from bushing dressed surface, shall not show a depth of gap of more than 3mm. from straight edge placed on it. The exposed faces and joints, 6mm. from the face shall be fine tooled so that a straight edge can be laid along the face of the stone in contact with every point. All visible angles and edges shall be true and square and free from chippings. The corner stones (quoins) shall be dressed square and corner shall be straight and vertical.

8.1.2. *Bond stones.*—Through bond stones shall be provided in walls upto 60 cm. thick and in case of walls above 60 cm. in thickness a set of two or more bond stones overlapping each other by at least 15 cm. shall be provided in a line from face to back. In case of highly absorbent type of stones (porous lime stone and sand stone etc.) the bond stone shall extend about two-third into the wall, as through stones in this case may give rise to damp penetration and hence for all thickness of such walls a set of two or more bond stones overlapping each other by at least 15cm. shall be provided. Each bond stone or a set of bond stones shall be provided at 1·5 m to 1·8 m. apart clear in every course.

8.1.3. *Laying.*—The faces stone shall be laid headers and stretchers alternatively. The headers shall be so arranged to come as nearby as possible in the middle of stretchers, above or below. Stones shall be laid in regular courses of not less than 30cm. in heght and all courses shall be of the same height unless otherwise specified. No stone shall be less in breadth than its height or less in length than twice its height, unless otherwise specified.

8.2. *Ashlar sunk or moulded.*

8.2.1. *Dressing.*—Dressing shall be done in the same manner as in plain ahslar. The faces shall then be gauged, cut, grooved, rebated, sunk or plain moulded as required for the work. For this purpose a full size layout of the moulding shall be prepared on plat forms for which sheet templates shall be cut and the stone dressed to the templates to a uniform and fine finish. The dressed surface shall not be more than 3mm. from straight edge placed on it. All visible angles and edges shall be true and free from chippings. The joints, 6mm. from the face shall also be fine tooled so that a straight edge placed on it is in contact with every point. It shall be finest surfacethat can be given to a stone with the chisel and with rubbing.

8.2.2. The requirements regarding bond stones and laying shall be the same as in plain ashlar (See 8.1.2).

8.3. *Dressing.*—The dressing of stone blocks in case of ashlar rock shall be similar to ashlar rough tooled (see 8.4.1.) except that the exposed faces of the stone between the drafts shall be left rough as the stone comes from the quarry but no rock face or " bushing shall project more than 7.5cm. from plane of drafts.

8.3.1. Stones required for ashlar chamfered masonry shall be dressed as above except that the edges round the exposed face of each stone shall be bevelled off to 45° for a depth of about 2·5cm. or more as specified.

8.3.2. The requirements regarding bond stones and laying shall be the same as in plain ashlar (See 8.1.2.)

8.4. *Ashlar rough tooled.*

8.4.1. *Dressing.*—The dressing of stone blocks shall be similar to plain ashlar except that face exposed in view shall have a fine chisel draft 2·5cm. wide round the edges and shall be rough tooled between the draft such that the dressed surface shall not deviate more than 3mm. from the straight edge placed over it.

8.4.2. The requirements regardirg bond stones laying shall be the same as on plain ashlar (See 8.1.2.)

8.5. *Ashlar block in course.*

8.5.1. *Dressing.*—The stones dressed all sqared and laid to fine joints (*see* 7.10) the faces usually being hammer dressed. The stone selected, may be of larger size than for plain ashlar.

8.5.2. The requirements regarding bond stone and laying shall be the same as in plain ashlar (*see* 8.1.2) except that the courses vary between 20 to 25 cm in the thickness. This type of masonry is, therefore, slightly superior to coursed rubble masonry.

8.6 Ashlar Masonry for special works.

8.6.1. *Arch dome or circular moulded work.*

8.6.1.2 *Dressing.*—The dressing shall be done in the same manner as for ashlar sunk moulded except that for arch or dome work, the stones shall be dressed to the required wedge shape so that the joints shall be truly radial.

8.6.1.2. The requirements regarding bond stone and laying shall be the same as in plain ashlar (*see* 8.1.2). Centering and shuttering required for this work should be of approved quality.

8.6.2. *Moulded and carved columns.*

8.6.2.1. *Dressing.*—The dressing shall be done in the same manner as for plain ashlar (*see* 8.1.1.). The joints with the adjoining stones shall be truly vertical, horizontal, radial and circular as the case may be. The face shall be dressed to uniform curves of planes as required for the work in accordance with the method prescribed for ashlar plane (*see* 8.1.).

86.2.2. Other details shall be the same as for plain ashlar.

EXTRACT FROM I.S. 4515—1967.

Code of practice for boulder lining for canals.

4. *Specifications for stone for lining.*

4·1. Stones used for lining shall be rounded or sub-angular river cobbles or blasted rock pieces with sufficient base area to be stable.

4.2. All the stones shall have reasonably uniform size with dimensions as given in Table I depending upon the canal capacity.

4·3. Individual stones shall be sound, hard and durable and shall be such that they will be able to sustain weathering and water action. They shall be free from laminations, soft spots, cracks, seams and other defects.

TABLE–I DIMENSIONS OF STONES AND THICKNESS OF LINING.

(*Clasue* 4·2.)

Serial number and canal capacity.	*Thickness of lining.*	*Average dimension along the longest axis.*	*Minimum dimension at any Section.*
(1)	(2)	(3)	(4)
m^3/sec.	mm	mm	mm
(i) 0 to less than 50 ..	150	150	75
(ii) 50 to less than 100 ..	225	225	110
(iii) 100 and above ..	300	300	150

NOTE.—A maximum tolerance of 10 per cent is permissible in the thickness of lining and the dimensions of stones.

5. *Preparation of sub-grade.*

5·1. The sub-grade shall be prepared and dressed true to level and grade according to the required cross-section of the canal to form a firm compacted bed for the lining.

5·1·1. In other than predominantly sandy reaches where the dry bulk density of the natural soil is not less than 1·8 g/cm³ and where the lining is not done immediately after excavation, the initial excavation shall be done upto about 30 cm. above final section and cutting to final shape shall be done immediately before laying the lining.

5·1·2. Sample profiles true to the cross-secion of the canal shall made at suitable intervals to ensure correct formation of sub-grades. To ensure uniformity of side slopes a chord shall be stretched across two profiles over a spacer of uniform thickness of 12 mm. at each profile. A third spacer shall be run under the chord to check the evenness of the surface. This process shall be repeated at short intervals along the slopes till the surface between two profiles is properly levelled and dressed from top to bottom.

5·1·3. If at any point, material of prepared sub-grade has been excavated beyond the neat lines required to receive lining, the excess excavation shall be filled with material compatible with sub-grade material and throughly compacted.

5·1·3.1. When partial filling of an existing canal is necessary to reduce the cross-sectional area to that required for lined canal the fill shall be placed and suitably compacted to avoid its settlement and rupturing of the lining.

5·1·4. To cover up lapses in the compaction of the inner edges of the banks, a lip cutting width of not less that 50 Cm horizontally shall be provided. Depending upon the nature of soil and the side slopes of the canal, the lip-cutting width may be in the range of 50 to 100 cm.

6·0. *Laying.*

6·1. Sub-grade (both bed and slope) of the canal shall be divided into compartments by stone masonry or concrete ribs. The compartment shall have dimensions of not mor than 15 m along and across the centre line of the canal. The spacing of ribs across the centre line shall be so chosen as to divide the canal bed and slope symmetrical about the centre line and in such a manner that ribs are provided at the junction of the slope and bed and at the upper extremity of the slope.

6·1·1. If stone masonry ribs are used the stone shall meet the requirements specified in 4·3.

6·1·2. If concrete ribs are used they shall be made of Grade M 100 concrete in accordance with I.S. 456—1964.

6·1·3. Ribs shall be rectangular in cross-section with width equal to the dimension of stone along its longer axis, as specified in 4·2 and depth equal to the depth of lining.

6·2. A 15 cm. thick layer of filter material, where required, shall be laid in compartments formed by ribs. Filter material shall be in accordance with the requirements specified in 7.

6·3 Stones shall be carefully hand packed in the compartments. The placing method shall be such as to ensure a reasonably smooth surface and uniform thickness.

6·3.1. Spaces betwen the stones shall be minimised. Such spaces shall be wedged with spalls of suitable size to avoid filter material being washed out. Such filling shall immediately follow the placing of stones.

7. *Filter.*

7·1. Filter material where required shall be free from flakes, soft particles, shale, organic matter or other deleterious substance.

7·2. Filter material shall be such that 15 per cent size of the filter material shall not be greater than 4 times the 85 per cent size of the finest layer of soil in contact with it. In order to ensure that the filter material/has the maximum permeability and is not itself washed into the boulder layer above it,its grain size sould be as large as is permissible and its 15 per cent size should be at least four times of that of the coarsest adjacent layer of soil it is retaining.

7·2·1. Where a large difference exists between the grading of the free draining material and of the soil to be retained, it may be necessary to use more than on layers of filter material, each progressively larger in grain size but satisfying the filter criteria given in 7·2 with respect to adjacent lower layer.

7·3 *Construction of filter.*

7·3·1 The sub-grade, before placing the filter, should be firm and if necessary be lightly tamped.

7·3·2 Clean filter material should have sufficient water content (3 to 10 per cent) during placement and placement should be such that segregation is prevented.

EXTRACT FROM I.S. 1200 (PART IV)—1970.

Method of measurement of building and civil engineering works—Stone masonry.

3. *Walling.*

3·1 The type of stone, nature of walling and mix of mortar shall be desrcribed. If beds are to be horizontal or joints dressed, it shall be so stated. The item of general walling shall be deemed to include the following:—

(*a*) Bond stones;

(*b*) Raking out joints for plastering or for pointing done as a separate process or finishing joints flush as the work proceeds;

(*c*) Preparing tops of existing wall and the like for raising;

(*d*) Rough cutting and waste for forming gables, cores of arches, splays at eaves and like and all rough cutting in the body of the walling unless otherwise stated;

(*e*) Leaving or making holes for pipes, etc;

(*f*) Building in holdfasts, air bricks, fixing bricks; etc. ;

(*g*) Bedding and pointing wall plates, lintels, sills, etc in or on walls, bedding roof tiles and corrugated sheets in or on walls;

(*h*) Building in ends of joists, beams, lintels, etc., and making good; and

(*j*) Openings and flues for which no deduction is made (see 4·3.)

3·1.1 Random or uncoursed rubble walling brought upto course shall be measured separately stating the minimum and maximum heights of courses.

3·1·2 In case of coursed work, the heights of course shall be stated, if regularly diminished, it shall be so described stating the maximum and minimum heights of courses.

3·1·3 Stone walling circular on plan to a mean radius not exceeding 6 m. shall be measured separately and shall include all cutting and waste and templates.

3·1·4 Stone walling circular on plan to a mean radius exceeding 6 m. shall be measured net and included with the general walling.

3·1·5 The following class of work shall also be included with the general walling:—

(*a*) Footings;

(*b*) Battered stone masonry (measured net). The battered surfaces shall, however, be measured separately in square metres as an extra-over; and

(*c*) Stone walling in chimney breasts, chimney stacks; smoke or air flues.

4. *Measurements.*

4·1 Except where otherwise stated, stone masonry generally shall be measured in cubic metres and face work in square metres.

4·2. No deduction or addition shall be made on any account of the following;—

(*a*) Ends of dissimilar materials (that is, joists, beams, lintels posts, girders, rafters, purlines, trusses, corbels steps etc.) upto 0·1ms in section;

(*b*) Openings upto 0·1 m^2 in area (see note); and

(*c*) Wall plates and bed plates, and bearing of slabs, *CHAJJAS* and the like, where the thickness does not exceed 10 cm and the bearing does not extend over the full thickness of the wall.

NOTE.—In calculating, the area of opening, separate lintels or sills shall be included along with the size of the openings but the end portions of the lintels shall be excluded [see 4·2 (*a*)] and the extra width of rebated reveals, if any, shall also be excluded.

16. *Dressed stone work*:

16·1 Dressed stone work as in sills, steps, string courses, cornices columns, caps, copings, lintels, etc, shall be measured in cubic metres and the type of dressing shall be fully described.

16·2 Dressed stone work as in *CHAJJAS, JALLIES* shelves shal be measured in square metres (inclusive of bearing).

16·3 String courses and cornices shall be fully described and measured as "extra over" dressed stone work in running metres.

EXTRACT FROM I.S. 1123—1957.

Method for petrographical examination of natural building stones.

1. *Scope.*

1·1 This standard lays down the procedure for petrographical examination of natural building stones.

2. *Sampling.*

2·1 The sample shall be selected to represent a true average of the type or grade stone under consideration.

2·2 The sample shall be selected by the purchaser or his authorized representative from the quarried stone or taken from the natural rock as described in 2·2·1 and 2·2·2 and shall be of adequate size to permit the preparation of the requisite number of test pieces.

2·2·1 *Stone from ledges or quarries.*—The ledge or quarry face of the stone shall be inspected to determine any variation in different starta Differences in colour and strucutre shall be observed. Separate samples of stone weighing at least 25 kilograme each of unweathered specimens shall be obtained from all strata that appear to vary in colour and strucure'. Pieces that have been damaged by blasting shall not be included in the sample.

2·2·2 *Field stone and boulders.*-A detailed inspection of the deposits of field stone and boulder over the area where the supply is to be obtained, shall be made. The different kinds of stones and their condition in the various deposits shall be recorded. Separate samples shall be selected of all classes of stones that would be considered for use in construction as indicated by visual inspection.

2·3. When perceptible variations occur in the quality of rock, the purchaser shall select as many samples as are necessary for determining the range in porperties.

3. *Test procedure.*

3·1 The sample shall be examined macroscopically and microscopically for its colour, structure, dexture, and mineral constituents.

4. *Report of test results.*

4·1. From the results of the examination, the classification of rock shall be determined.

4·2. The broad classification of the common types of natural building stones is given in Table 1.

TABLE 1—PETROGRAPHICAL CLASSIFICATION OF THE COMMON TYPES OF NATURAL BUILDING STONES.

(*Clause* 4·2.)

Class. (1)	*Type.* (2)	*Colour.* (3)	*Structure.* (4)	*Texture.* (5)	*Constituents.* (6)	*Remarks.* (7)
				1. IGNEOUS ROCKS.		
Igneous Rocks.	Granite ..	White to light grey and pink.	Rift and grain structure which are directions of comparatively easy splitting at right angles to one another. Also jointing, sheet and banded structure.	Holocrystaline, hypidiomorphic and phanenocry-stalline. Also porphyritic and graphic.	It consists essentially of quartz and felspars with any of the following :— Biotite, muscovite, amphiboles and pyroxenes.	Felspar is often kaolinized and scricitized and the amphiboles andÆ pyroxene chloritized.
Do.	Phyolite ..	White to light grey, pink and greyish black. Black when extreme glassy (obsidian and pitchstone).	Fluidal structure. Also spherulitic, nodular and lithophysal structures.	Merocrystalline. porphyritic, fluidal, spherulitic and perlitic. Rarely holohyaline.	A volcanic rock corresponding in chemical composition to granite and generally having small phenocrysts of quartz and orthoclase (or other alkali-felspar) in a glassy or crystocrystalline ground-mass.	Do.
Do.	Syenite ..	Dark green, grey and bluish grey.	Jointing, sheet and platy structures	Holocrystalline, hypidiomorphic and phanerocry stalline, Also trachytoid.	It consists essentially of alkali-felspars and one or more of mafic minerals, especially hornblende. When quartz is present, the term quartz syenite is used.	Do.
Do.	Diorite ..	Dark colour ..	Jointing, sheet and platy structures.	Holocrystalline, hypidiomorphic and phanerocrystalline.	It is composed of plagioclase felspar and mafic minerals, such as hornblende, biotite and augite. If quartz be present, the term quartz-dorite is used.	Felspar is often kolinized and sericitized and the amphiboles and pyroxenes chloritized.
Do.	Trachyte ..	Greyish white ..	Flow structure ..	Microcrystalline, aphanitic. Trachytic, hyalopilitic, porphyritic.	A volcanic rock containing alkali-felspars and one or more mafic minerals of which biotite and augite are the most common.	Do.
Do.	Andesite ..	Dark colour ..	Do.	Microcrystalline, aphanitic, porphyritic.	A volcanic rock composed essentially of palgioclase felspar together with one or more of the minerals, biotite, hornblende and pyroxenes.	Do.
Do.	Gabbro ..	Dark colour ..	Jointing and banded structures.	Holocrystalline, panidiomorphic and phanerocrystalline. Sometimes also allotriomorphic.	It consists of labradorite or bytwonite (lime felspars) and augite. With the incoming of olivine, the rock becomes olivine gabbro.	Flespars are often kaolinized and augite uralitized and Chloritized Olivine alter to serpentine..
Do.	Dolerite ..	Dark colour ..	Ophimottling ..	Holocrystalline, panidiomorphic and ophitic.	It consists of plagioclase (not less calcic than labradorite) and pyroxene. Olivine bearing types are dis-tinguished as olivine-dolerite.	Do.

Class. (1)	Type. (2)	Colour. (3)	Structure. (4)	Texture. (5)	Constituents. (6)	Remarks. (7)
Igous Rocks.	Basalt ..	Dark colour ...	Block and ropy surface of lavas, pillowy structures, flow banding vesicular and amygdaloidal. Also columnar and prismatic structures.	Microlithic, porphyritic Aphanitic as a whole or in the groundmass ALSO intergranular.	It is composed essentially of plagloclase (at least as labradorite) and pyroxene with or without interstitial glass, when olivine is present, the rock is termed as olivine basalt.	Felspars are often kaolinized and augite uralitized and chlortiized. olivine alters to serpentine.
Do.	Trap ..	(It is an old name originally applied to igneous rocks which were neither coarsely crystalline like granite nor cellular, but obviously volcanic, like pumice and scoria. The rocks so designated include basalts, dolerites, andesites and porphyrites (types often grouped as whinstones) ; altered varieties of some of these, such as epediorites and diabase (types grouped as greenstones) and finally the mica traps or lamprophyres.)				
			2. SEDIMENTARY ROCKS.			
Sedimentary Rocks.	Sandstone .	Depending on cementing material, red to brown, earthy to buff, white and sometimes yellow or greenish. Greywacke is dark in colour.	Stratified (often false bedded).	Fine to coarse grained.	Mainly quartz grains compacted and cemented together by silceous, calcareous, argillaceous and ferruginous cements. When interspaces are completely filled by silica, a very solid, compact, hard rock is then formed, which is termed quartzite.	Do.
Do.	Laterite ..	Brownish red ..	Bedded, often colitic and pisolitic.	Cellular	A mixture of hydrated ferric oxide with hydroxide of aluminium in various proportions ; frequently also with manganese dioxide, titanium dioxide and free silica.	Hardness on exposure.
Do.	Shale ..	Grey, greyish, white, reddish. pink, blue, brown and black.	Stratified with shaly cleavage.	Plastic ; grain size less than 0·01 mm.	A mixture of clay minerals with clalcraous, ferruginous or carbonaceous matter. Often micaceous and chloritic.	...
Do.	Limestone and dolomite.	White, grey, pink, blue, brown and black.	Stratified ..	Amorphous, granular.	Essentially calcium carbonate (Calcite) with varying impurities or magnesium carbonate, and of siliceous, argillaceous, glauconitic, ferruginuous, phosphatic and bituminous varieties.	Hardens on exposure.
			3. METAMORPHIC ROCKS.			
Metamorphic Rocks.	Gneiss ..	White to light grey, pink and greenish black.	Gneissose (alternation of schistose and granulose bands which are dissimilar both in mineral composition and texture).	Crystalloblastic. palimpset and xenoblastic. Also porphyroblastic.	Generally (but not necesarily) of granitic or dioritic composition.	....

Class. (1)	*Type.* (2)	*Colour.* (3)	*Structure.* (4)	*Texture.* (5)	*Constituents.* (6)	*Remarks.* (7)
Metamorphic Rocks.	Schist ..	Variable from purple to greenish black and dark grey. Also light grey or greenish pink and green soapstones.	Schistose (foliated).	Crystalloblastic	Generally consiss of lamellar minerals, such as mica, chlorite, talc and hornblende or of stressed minerals like quartz and calcite.	....
Do.	Slate ..	Highly variable from purple to greenish black, dark grey, greenish grey and purplish grey.	Slaty. (Having the property of easy fissibility along planes independent of the original bedding).	Aphanitic ..	Formed from fine grained deposits, such as shales, mudstones and volcanic ashes.	....
Do.	Granulite ..	Greenish-blue and bluishrey.	Massive rocks ; bedding is rare.	Even-grained ; foliation rare.	Quartz-felspathic granulites are characterized by distinctive high temperature assemblages quartz-orthoclase-plagioclase-Kyanite-sillimanite-garnet. The pyroxene granulites are composed of plagioclase, hypersthene and diopside.	They can be used as road-metal because the best stones for road making purposes are equigranular medium to fine-graine rocks.
Do.	Amphibolites	Dark green or dark blusihgreen.	Generally occur in the form of dykes (metamorphosed dykes) or as small irregular patches.	Foliated metamorphic rocks Schistesity is not necessarily conspicuous in types containing no mica.	Composed essentially of hornblende and plagioclase Garnet, epidote, biotite and quartz may be present sphene, apatite and opaque ores are almost always present.	Felspar is often kaolinized and sericitized.
Do.	Lamprophyres	Dark coloured rocks.	Occur as dykes ..	They have a pronounced porPhyrite texture	All of them carry well-crystalline ultra mafic minerals like pyroxenes amphiboles, olivine, etc., They also contain abundant carbonates, sulphides, apatite and hydrous minerals, such as serpentine, chlorite and zeolites.	They are susceptible to weathering because of the presence of carbonate and sulphur minerals.
Do.	Quartzites.	White, milky or grey.	Stratified ; compact beds.	Granulose metamorphic rock.	Quartz is the important and most predominant mineral. Felspar may or may not be present. Contain various accessory minerals like zircon, garnet, apatite, iron ore, etc.	Quartzites make good paving. and curb stones Judged from the attrition tests quartzite and vein quartz stand high in the list of building stones
Do.	Phyllites ..	A grey, pink, greenish and lustrous rock.	Joints and cracks are frequent. Bedding is frequently disturbed by joints.	It is a foliated rock with its minerals not so well defined as a schist.	The foliation in phyllite is mainly due to sericte (a flaky mineral). The iron oxide is present in the form of haematite which appears as minute scales. Quartza, few micaceous minerals, garnets and andalusite are the other mineral association.	These rocks are very friable.

Class.	Type.	Colour.	Structure.	Textures.	Constituents.	Remarks.
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Do.	Hornfels ..	Greenish-grey ..	Bedded. Joints are common.	A dense, compact rock. It has got a typical criss-cross structure (a different arrangement, in which corresponding areas of contiguous crystals lie in diverse directions).	Chlorite, biotite andalusite, graphite, etc. It is formed due to metamorphism of argilaceous (clay) rocks.	The criss-cross structure imparts to the hornfels a remarkable toughness and is, therefore good for a building stone.
Do.	Acid porphyry.	Light coloured, white to grey, leucocratic.	Porphyritic, intrusive, such as dykes and sills.	Porphyritic, inequigranular, poikilitic, medium to fine grained.	It consists essentially of quartz, alkali-felspar and biotite, amphibole and rarely pyroxene, The rock is formed in two generations and consists of phenocrysts and fine grained groundmass. Porphyrics are the equivalent of granites in the plutonic and ryolites in volcanic rocks.	The quartz phenocrysts have the form of more or less corroded bipyrandds as in rhyolites Orthoclase (Potash felspar) forms well shaped crystals to some degree sericitized or kaolinized.
Do.	Sub-acid porphyry.	Light coloured, white to grey leucocratic.	The mode of occurrence of these is intrusive, such as dykes and sills.	Medium to fine grained, porphyritic, inequigranular.	Potash felspar (orthoclase) is the dominant mineral often occurring in two generations, accompanied by hornblende, biotite and in more acid by a little interstitial quartz. It is the equivalent of syenites in the plutonic and trachytes in the volcanic rocks.	The quartz phenocrysts have the form of more or less corroded bipyranods as in rhyolites. Orthoclase (potash felspar) forms well shaped crystals to some degree serioitized or kaolinized.
Do.	Porphyrites or porphyritic Micro-diorites.	Light grey to dark grey, meso-type.	Mode of occurrence as minor intrusions.	Medium grained, Inequigranular, graphic and porphyritic.	Graphic intergrowth of quartz and alkali-felspar forms the groundmass in which numerous phenocrysts of plagioclase, hornblende are closely, packed. The felspar is much stained, and the general aspect of the rock is syenitic. The prominent and noteworthy phenocrysts are hornblende, plaglocase and less commonly augite. Many contain a little quartz and probably micro tonalite is the commonest type. Porphyrites are the equivalent of diorites in the plutonic and andesites in the volcanic rocks.	The quarty phenocrysts have the from of more or less corroded bipy ranods as in rhyolites. Orthoclase (potesh felspar forms well shaped crystal) to some degree serioitized or kaolinized.

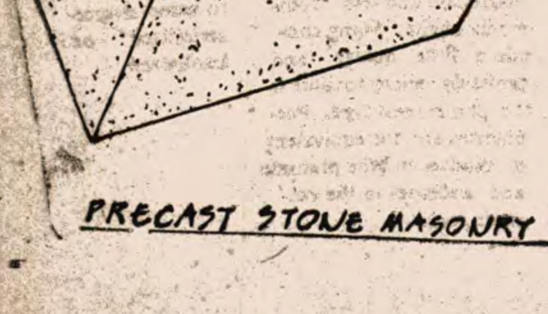
Class.	Type.	Clour.	Structure.	Texture.	Constituents.	Remarks.
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Metamorphic Rocks.	Marble (crystalline lime stone).	Varieties of colour—white opalescent, grey, black, pink, red, brown, yellow, green, blue and combination of these.	Jointed ..	Crystalline ..	The term when used without a mineralogical prefix implies a variety, such as statuary marble composed almost entirely of calcite. In commercial sense all calcareous rocks capable of taking polish and crystalline dolomites are classed as marbles, as also serpentine rocks.	....

EXTRACT FROM C.B.R.I.
Data Sheet No. 8.
Precast stone masonry block walling.

Introduction:

In some parts of the country, stone forms the chief walling material It is being used mostly in the form of random rubble masonry for constructing walls of thicknesses generally 38 and 45 cm. Of late, 30 cm. thick walls are also being used. The thicknesses adopted have been mainly dictated from practical considerations. They require excessive materials and are undesirably massive. Besides, the construction is time consuming and calls for more skilled labour. In stone masonry walls, the external face is generally pointed maintaining the stone texture, while the internal surface is plastered. The average thickness of plaster required is more due to the unevenness of stones.

A study was undertaken with a view to reduce the thickness of wall as well as level of skills normally required in the traditional method of construction. Application of precasting technique was thought of and a scheme of producing masonry units in the form of precast stone masonry blocks (Fig.) was developed such that stone texture is maintained on the external face and the internal face even to have minimum thickness of plaster. These can be easily produced at factory or site with semiskilled worker without any special equipment. This Data Sheet describes method of production of stone masonry blocks, construction of wall and also gives basic data for cost computation.



PRECAST STONE MASONRY BLOCK.

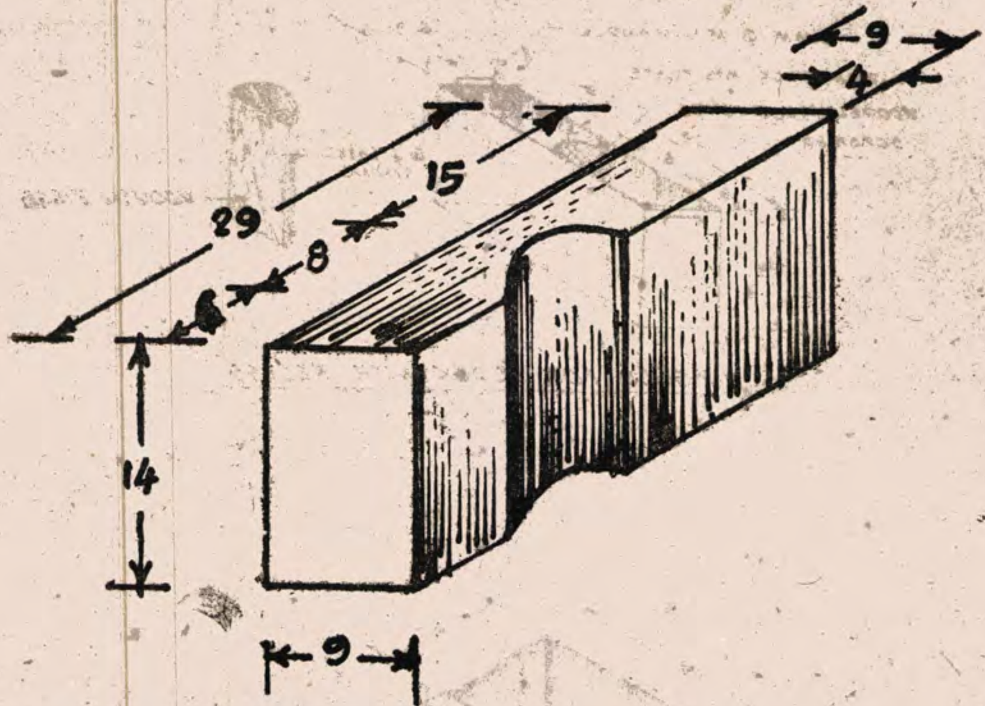
Method of production :

Considering ease in handling and other requirements, the nominal length and height of the block is kept 30 cm. and 15 cm. respectively with three widths as 20cm, 15cm and 10cm. The actual block dimensions are short by 1 cm. to accommodate mortar joint thickness. These blocks weigh from 9 to 18 kg. To get stone texture on the outer face of wall, the blocks are cast such that the bottom face during casting forms the exposed face when laid in wall. The block sizes and mould dimensions are given in Table 1.

TABLE 1.— DIMENSIONS OF BLOCK AND MOULDS.

Serial number.	Block size (cm). Nominal.			Mould dimensions (cm). Actual.			Internal.		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	L	B	H	L	B	H	L	B	H
1	30	20	15	29	19	14	29	19	14
2	30	15	15	29	14	14	29	14	14
3	30	10	15	29	9	14	29	9	14

In addition to the above sizes, 1/4, 1/3, 1/2, 2/3 and 3/4 length blocks are also required or breaking the joints in alternate courses Special blocks of $29 \times 9 \times 14$ cm. and $19 \times 19 \times 14$ cm. with a semi-circular recess on one face (Fig.) are required to accommodate vertical reinforcement at corners and openings for seismic considerations. The various steps for casting blocks are given below:—

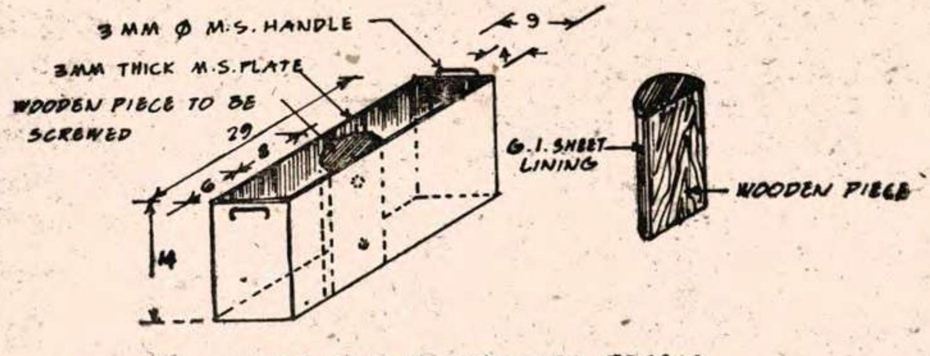


BLOCK WITH RECESS FOR VERTICAL REINFORCEMENT

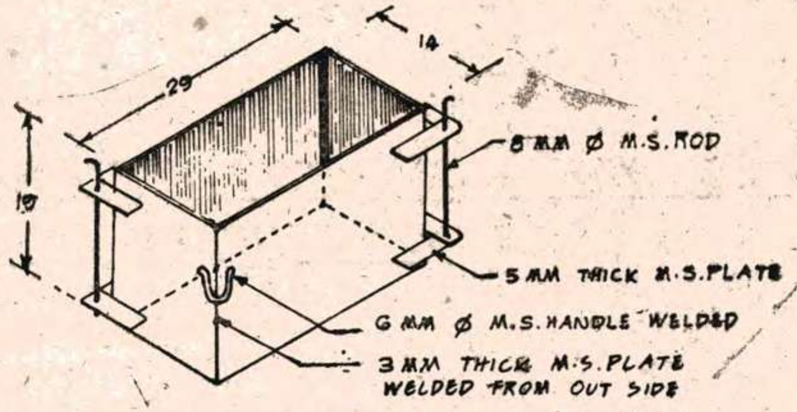
Mould :

The blocks are cast in isolated steel moulds of dimensions as given in Table 1. These consist of rectangular boxes made from 3 mm. thick M.S. sheet open from top and bottom and having 2 handles of 6 mm. diameter bars welded on both sides across the widths (Fig.). For fabrication of the mould, all welding is done from outside so that the internal edges are sharp and free from welding flux. For a production of 500 blocks per day about 8 to 10 moulds are sufficient. Smaller size blocks required for breaking bond can be cast by partitioning these moulds with G.I. sheet or alternatively separate moulds, one for each type may be made. A separate steel mould of 29×9×14 cm. with a semicircular timber piece of 8 cm. dia.×14 cm. height is used for casting blocks with recess to provide vertical reinforcement from seismic considerations (Fig.). The same mould is also used for casting 2/3 size long special block by plugging the end 10cm portion. A 10 to 12 mm. thick timber or plywood piece of 28 cm.×13 cm. is used for keeping the cast block pressed during demoulding. Alternative to fixed open box type moulds, split type steel mould (Fig.) can also be used. In this case, the area of casting platform needed will be more but demoulding will be easy and the cast blocks will be less disturbed in green stage.

STEEL MOULD (BOX TYPE)



MOULD FOR BLOCK WITH RECESS



STEEL MOULD (SPLIT TYPE)

Casting plotform :

A smooth level and hard surface is required for casting the blocks. The casting platform may consist of 30 mm. thick 1 : 3 : 6 cement concrete finished smooth with neat cement on a base of either brick soling or lean concrete. For a production rate of 500 blocks/day, a casting area of 80 sq.m. is required.

Materials :

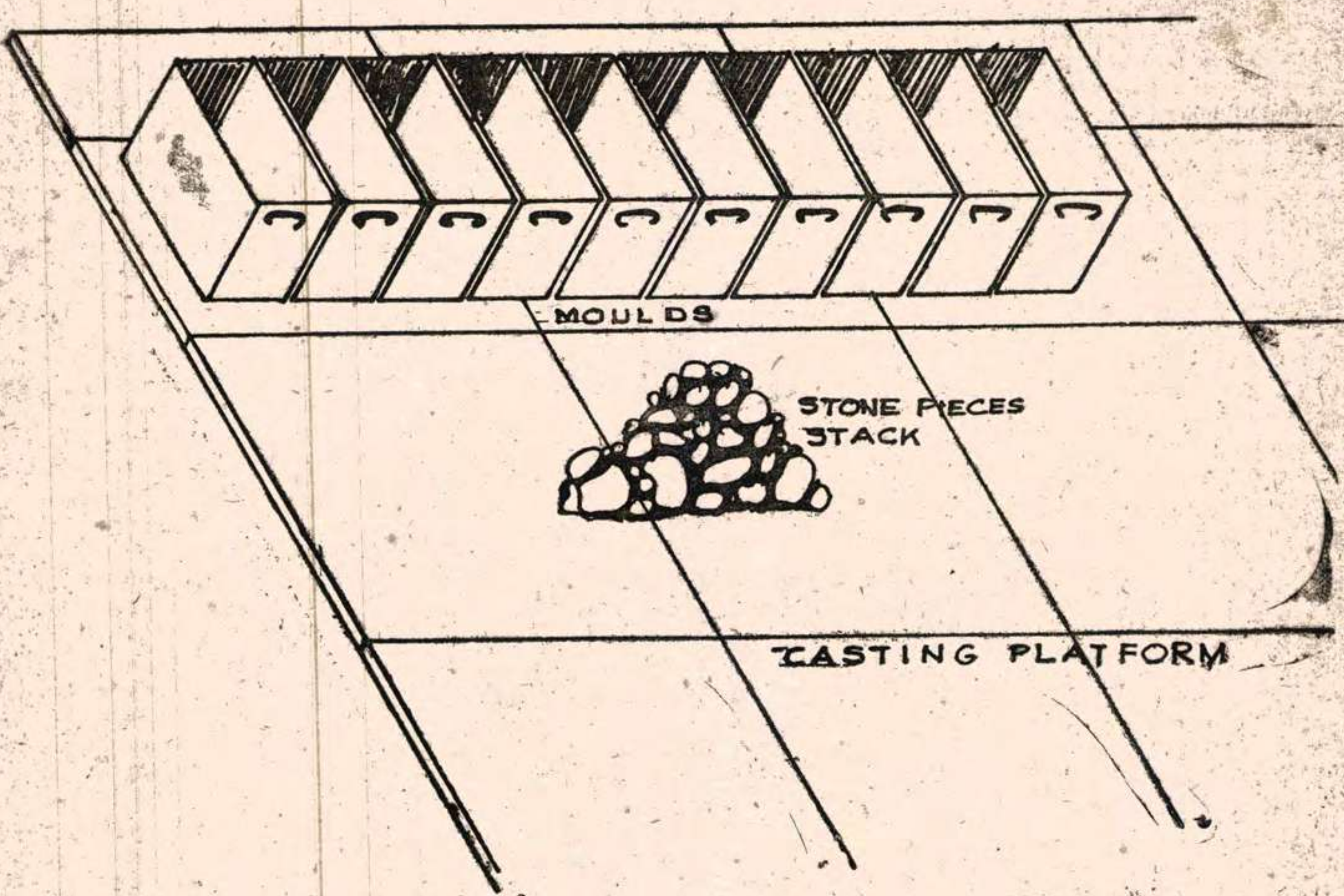
The stone masonry blocks are made of large size stone pieces binded together with lean cement concrete mix. of 1 : 5 : 8 (cement : sand : stone aggregate 10 mm. and down). The stone pieces used are as large size as can be accommodated in the mould. These can be from 5 to 26 cm. size, and obtained either from quarry or breaking the river boulders to provide rough surface for better and also a flat surface stone texture.

To save on the cement consumption, cement concrete is used as binding material instead of cement mortar. The concrete should, therefore, possess good workability and cohessiveness at the green stage. Since the proposed concrete mix is very lean, it lacks in fine particles to impart it plasticity and workability. Therefore, the role of sand in the concrete is very significant and the size, shape, texture and its grading to be carefully choosen. To impart good workability and bond, the sand should be well graded and should have fine particles (15—20 per cent) passing I.S. sieve No. 300 micron and (5—15 per cent) passing IS sieve No. 150 micron.

Where such sand is not available, the proportioning of sand to aggregate should be suitably adjusted by a few trials to have good workability and plasticity at green stage. In areas where fly ash is available, this may be used as substitue for the fine particles of sand.

Casting of blocks :

(i) Clean the platform and moulds properly. Apply any lubricating oil inside the moulds once a day. Place moulds side by side in a row after oiling the platform or placing waste paper at their bottom (Fig.).



MOULDS ARRANGED IN ROW.

(ii) Arrange as large size stones as possible in the mould. The number of stone pieces may be one or two depending upon their size which may be in length from 10—26 cms., in width up to 12 cms. and in heigh t from 7 to 16 cms. Care is to be taken that there is a minimum gap of 1·5 cm. between any two stone pieces and between stones and the mould to provide proper cover of the binding material all around (Fig.)

(iii) Fill up th e gaps between the stone pieces and mould in its lower portion with lean cement concrete by trowelling to cover the stones already placed. The slump of the concrete is to be kept 3 to 4 cms. Fill the remaining portion of the moulds with stone pieces of 5 to 7 cm. size. Maximum quantity of the stone pieces is to be used taking care that adequate concrete cover is available around every stone piece. Fill concrete and compact by mason's trowel and also by tamping the mould and finish the top level and smooth (Fig.).

(iv) When 6 to 8 blocks have been filled up, the demoulding started from the block cast first by placing timber piece on top and keeping it pressed by thumb while pulling the mould up in case of box type mould or by removing the pins and separating the sides in case of split type of mould. The demoulding is to be done soon after the casting (3 to 7 min. depending upon the weather) to avoid setting of concrete and its adhesion with mould.

(v) The moulds are rearranged in a row and subsequent casting continued in the same way as described above. The casting of special blocks are also done in the same way by using special moulds or tin sheet partition and timber block for making recess or cut out.

STONE PIECES ARRANGED IN MOULD

CONCRETE FILLED UP TO TOP

(vi) The next day of casting or after 48 hours depending upon weather, the cast blocks are slightly pushed to break bond and lifted. These are placed on level ground having layer of sand and cured by frequent sprinkling of water over the stacks for 2 weeks and air cured for another 2 weeks before laying them in wall.

(vii) For quality control, two blocks out of every 500 blocks, be tested for its compressive strength after providing proper capping as per test procedure laid down in I.S. 2185—1967.

Compressive strength :

Stone masonry block is hetrogenious consisting of stone pieces of different sizes and shapes and lean cement concrete. Further, the bond of the lean concrete with the stone pieces is very much influenced by the grading and type of the sand. Added to this the size, shape, quality and position of placement of the stone pieces has great influence to the performance of the stone masonry blocks under load. Therefore depending upon the materials namely cement, the type and grading of sand and the quality and quantity of the stones used, large variation in the strength of the blocks can be expected. To know the actual strength of the blocks, it is necessary that blocks be made by using the local materials and tested. For guidance, the crushing strength of the blocks cast and tested at C.B.R.I. with different con rete proportions using local materials is given in Table 2.

TABLE 2—COMPRESSIVE STRENGTH OF PRECAST STONE MASONRY BLOCKS WITH DIFFERENT CONCRETE MIX PROPORTIONS AND LARGE SIZE STONE PIECES.

Serial number.	*Concrete mix proportion by volume Cement : Sand : C. aggregate.*	*Block base dimensions L. × B.*	*Block height H.*	*H/B.*	*Average ultimate crushing load.*	*Average compressive strength.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
		(CM.)	(CM.)		(TONS.)	(KG/CM2.)
1	1 : 2 : 4	29 × 19	14	0·74	100	182
2	1 : 3 : 6	29 × 19	14	0·74	63	114
3	1 : 4 : 8	29 × 19	14	0·74	43	78
4	1 : 5 : 8	29 × 19	14	0·74	38	69
5	1 : 5 : 10	29 × 19	14	0·74	35·6	65
6	1 : 6 : 12	29 × 19	14	0·74	27·2	50

Masonry construction :

The blocks are used both for load bearing and non-load bearing walls. Depending upon the strength of the blocks and the mortar to be used for laying, the permissible stresses in the masonry is taken from the I.S. Code 1905—69 "Structural Safety of Buildings—Masonry Walls". The thickness of the walls is decided depending upon the load coming over it. While many of the construction features for building with these blocks are similar to these traditionally used in brick laying, there are certain important differences which must be recognised in order to obtain the best results. These are discussed below :—

(i) As cutting of these blocks is not recommended, the building should be planned to suit the block dimension, i.e. all lengths of walls openings, spaces between the openings, etc. shall be multiple of 10 cms, and all heights shall be multiple of course height, i.e. 15 cms.

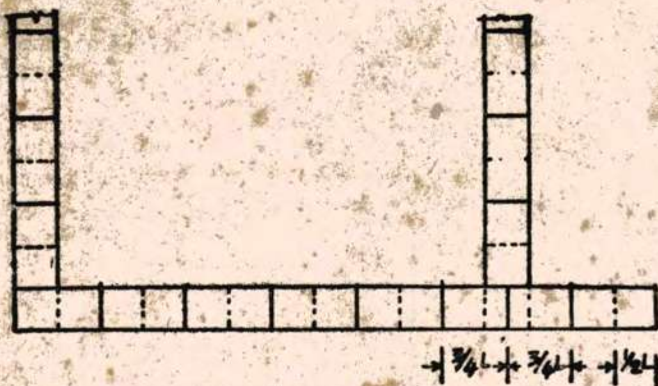
(ii) As a load bearing wall construction, these blocks can be used up to 3 to 4 storeyed construction. The wall thickness is decided based on the strength of the blocks and the load coming over it.

(iii) The mortar for laying the blocks is not to be learner than 1 :6 (cement : sand) and where good quality lime is available, pozzolanic mortar and composite mortar may be used.

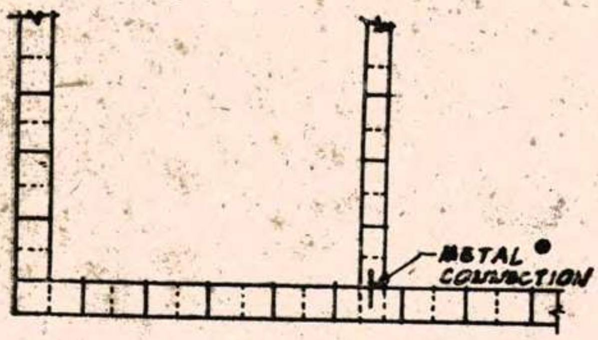
(iv) The blocks should be dry at the time of laying in the masonry. If the climate is hot and dry, the blocks may be wetted on the surface only in order to reduce their suction from mortar. However, wetting is generally neither necessary nor desirable. The consistency of the mortar should be adjusted to suit the suction of the blocks, rather than the blocks be wetted to suit the mortar.

(v) For breaking of vertical joints in alternate courses, smaller length blocks (depending upon the wall length) are used. The masonry bonds for various wall thicknesses, at corners and junctions are shown in (Fig.). The salient features to be adopted are given below:—

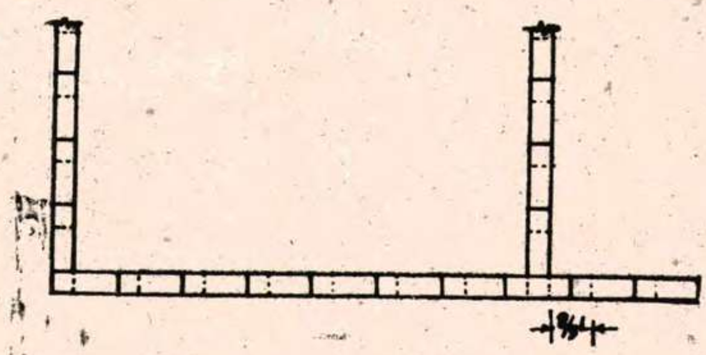
(a) CORNER & T-JUNCTION OF 20 X 20 CM WALL



(b) CORNER & T-JUNCTION OF 15 x 15 CM WALL

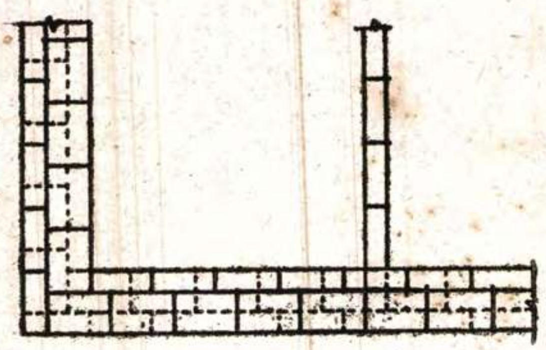


(c) CORNER & T-JUNCTION OF 20 X 20 CM WALL

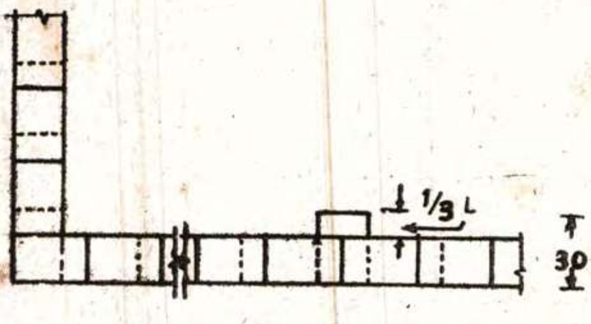


(d) CORNER & T-JUNCTION OF 10 X 10 CM WALL

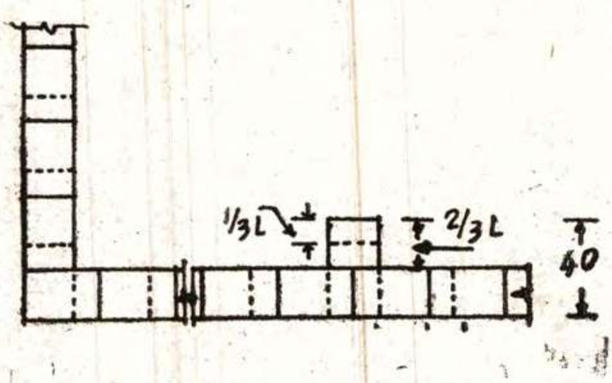
(e) CORNER & T-JUNCTION OF 20 X 10 CM WALL.



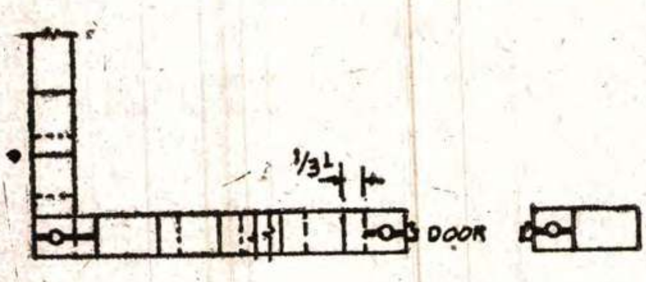
(f) CORNER OF 30 x 30 CM WALL & JUNCTION OF 30x10 CM WALL



30 CM PILASTER WITH 20 CM WALL



40 CM PILASTER WITH 20 CM WALL



BONDING AT CORNER & DOOR OPENING FOR VERTICAL REINFORCEMENT

(*a*) At T junction of 20 cm. with 20 cm and 15 cm with 15 cm thick walls, a vertical joint at the centre line of cross wall is provided in alternate courses by providing 1/3 and or 2/3 size blocks in case of 20cm. thick wall and 1/4 and or 3/4 size blocks in case of 15cm thick walls as shown in Figs.

(*b*) In case of T junction of 20 cm × 10 cm and 10 cm × 10 cm thick walls, the joints are staggered by using 1/3rd and 2/3rd length blocks in alternate courses as shwon in Figs.

(*c*) For 20 cm to 15 cm and 15 cm to 10 cm wall junctions the bonding is achieved by providing 20 cm. long 6 mm dia. bar in alternate courses. The arrangement for 15 to 10 cm wall junction is shwon in Fig. For embedding the metallic ties, only cement, mortar is used.

(*d*) The bonding for 30 cm with 30 cm and 30 cm with 10 cm walls is shown in Fig. The bonding for 30 cm and 40 cm thick pilasters with 20 cm thick walls are shown in Figs.

(*e*) The bonding at corners and door/window openings with special blocks for providing vertical reinforcement from seismic considerations are shown in Fig.

(vi) The hold fasts of doors, windows and ventilators are fixed by embedding in M-100 cement concrete.

(vii) The bearing of lintel is kept 10 cm. on either side. To match the top level of lintel with the course height, insitu concrete of required thickness is provided at the bearing.

(viii) Only double scaffolding is to be used. No holes in the masonry for supporting scaffolding are to be allowed.

(ix) The external face be finished with any desirable pointing the internal face may or may not be plastered.

(x) The plugs for fixing service pipes and electrical fittings etc. be preferably inserted at the joints of the masonry. Where large openings are required to be for sanitary fittings, full blocks be taken out, and the gaps filled with lean concrete after taking the fitting through the walls. Space for nitches or for fixing electric switch boards, etc. is created, by using thin blocks it is preferable to preplan the services and make provision during the construction of walls.

TABLE 3—BASIC DATA FOR MATERIAL AND LABOUR REQUIREMENTS.

Item.	*Nominal thickness of block.*		
	20 *cm.*	15 *cm.*	10 *cm.*
(1)	(2)	(3)	(4)
Nominal size block (cm.) ..	30×20×15	30×15×15	30×10×15
Actual size of block cm. ..	29×19×14	29×14×14	29×9×14
Concrete mix proportion by volume (Cement : sand : 10mm. and down, coarse aggregate.)	1:5:8	1:5:8	1:5:8

TABLE 3 —BASIC DATA PER MATERIAL AND LABOUR REQUIREMENTS—*cont.*

Item.	*Nominal thickness of block.* 20 *cm.*	15 *cm.*	10 *cm.*
(1)	(2)	(3)	(4)
Labour *.			
Production.			
MOULD Fixed Open box type (No.)	1	1	1
M.S. Plate 3 mm. thick (m^2).	0·16	0·12	0·08
Fabrication and welding char (L.S.) Rs.	12·00	10·00	8·00
CASTING OF BLOCKS (No.)	100	100	100
Materials.			
Cement (Bags)	1·54	1·14	0·77
Sand (m^3)	0·27	0·20	0·14
Coarse aggregate (m^3) ..	0·43	0·32	0·22
Stone pieces (m^3) (stack volume.)	0·37	0·27	0·15
Mason (M. days)	0·30	0·25	0·20
Unskilled worker (M. days).	2·12	1·75	1·40
Production per day by gang of one mason and seven unskilled workers (Nos.)	330	400	500
Sundries.			
Cost of casting platform and mould oil, etc. L.S.—Rs. (for 100 blocks).)	1·00	0·80	0·60
Masonry Work (10 m^2).			
Materials.			
Precast stone masonry blocks (Nos.)	222	222	222
Mortar (m^3)	0·19	0·14	0·09
Labour for foundation and plinth.			
Mason (M. days)	1·30	1·1	0·90
Unskilled worker (M. days).	2·60	2·2	1·80
Extra for super structure upto floor two level.			
Mason (M. days)	0·20	0·18	0·10
Unskilled worker (M. days).	0·50	0·40	0·20

* The above labour includes casting, lifting, curing and tackings the blocks within a lead of M.

NOTE.—(1) The cost of scaffolding, T & P, water and contractor's profit and overheads are to be added extra.

(2) The labour for transportation of blocks from stack to construction site has been included for a lead of 50M only. For every additional 50 M lead 0·40, 0·30, 0·20m days of unskilled worker may be added for 100 Nos. of 20 cm., 15 cm. and 10 cm. thick blocks respectively.

Comparison of cement consumption.

Since for the production of precast stone masonry blocks cement is used, it is often considered that this technique would consume excessive cement as compared to brick masonry walling or random rubble stone walling. To clarify the position, the consumption of cement for different types of walling is given in Table 4. It may be seen that the 20 cm. thick precast stone masonry block walling plastered on one side and pointed on external face consume only 13 per cent more cement as compared to 23 cm. brick wall plastered on both faces. In case the internal plastering on precast stone masonry block walling is not done because there being less of unevenness, the cement consumption will be at par with brick masonry. But as compared to random rubble this technique saves 26 per cent in cement consumption.

TABLE 4—CEMENT CONSUMPTION POR ALTERNATIVE WALLING—10M^2.

Item.	*Cement Consumption (bags).* 23 *cm. thick brick wall.*	20 *cm. thick precast stone masonry block wall.*	30 *cm. R.R. stone wall.*
(1)	(2)	(3)	(4)
1 Blocks	..	3·42	..
2 Mortar (CM 1 : 6) ..	2·85	0·95	4·95
3 Plaster (12 mm. in CM 1:6)	0·72	0·72	..
4 Plaster (20 mm. in CM 1:6)	1·12	..	2·24
5 Pointing (in CM 1 : 3) ..	..	0·20	..
Total ..	4·69	5·29	7·19

Advantages.

The precast stone masonry block walling has the following advantages :—

(i) It is a labour intensive technique of prefabrication. It does not call for heavy capital investment and power consumption.

(ii) The use of stone spalls saves cement consumption and provide strength even with lean concrete mix which works as a binder only. It also reduces the cost of block.

(iii) The stone masonry blocks can be produced at site or factory by semiskilled workers on a mass scale.

(iv) Because of prefabrication of masonry units, consistent and better equality is achieved.

(v) The precast stone masonry block walling give better form of construction. Productivity in laying is increased and wall can be built by ordinary masons.

(vi) The wall provides a more uniform strength and as such the thickness is reduced to 20 cm. and 15 cm. thereby saving cubical content of materials both in foundation and superstructure masonry and also gives larger floor area for the same plinth area. It is amenable to quality control.

(vii) One face of the block being in stone texture, the external wall face is flush pointed which apart from saving in cement also gives the natural stone appearance of a coursed rubble masonry at lesser cost and various architectural patterns can be obtained.

(viii) The internal plaster finishing can be eliminated with care during production and laying. Even if plastering is done, the thickness required is only 12mm. against the 20 to 25 mm. in brick and random rulble masonry respectively.

(ix) This provides improved performance to rain water penetration/seepage which is not attainable in random rubble masonry.

EXTRACT FROM I.S. 6042—1969.

CODE OF PRACTIC FOR CONSTRUCTION OF LIGHT WEIGHT CONCRETE BLOCK MASORY.

10 : *Laying concrete block masonry in superstructure.—*

10.1. *Use of mortar in masonry—*

10.1.1. Lightwieght concrete block masonry in superstructure shall be laid either in 1 : 2 : 9 or 1 : 1 : 6 cement/lime, sand mortar as explained in 6.1. If good quality lime is not available, 1 : 6 cement sand mortar may be used.

10.1.2. Mortar shall not be spread so much ahead of the actual laying of the units that it tends to stiffen and lose its plasticity, thereby resulting in poor bond. For most of the work, the joints, both horizontal and vertical, shall be 10 mm. thick. Except in the case of extruded joint con truction described in 10.2.3., the mortar joint shall be struck off flush with wall surface and when the mortar has started stiffening, it shall be compressed with a rounded or U-shaped tool. This compaction is important, since mortar, while hardening has a tendency to shrink slightly and thus pull away from the edges of the block. The mortar shall be pressed against the units with a jointing tool after the mortar has stiffened to effect intimate contact between the mortar and the masonry unit and obtain a weather-tight joint.

10.2. *Operations for laying block masonry.*

10.2.1. *First Course.*—The first course of concrete block masonry shall be laid with great care, making sure that it is properly aligned levelled and plumbed. as this may assist the mason in laying succedin. courses to botain a straight and truly vertical wall.

10.2.1.1. Before laying the first course, the alignment of the wall shall be marked on the damp proof course. The blocks for this course shall first be laid dry, that is without mortar along a string stretched between properly located corners of the wall in order to determine the correct position of the blocks including those of the cross walls jointing it and also adjust their spacing. When the blocks are set in proper position. the two corner blocks shall be removed, a mortar bed spread and these blocks laid back in place truly level and plumb. The string shall then be stretched tightly along the faces of the two corner blocks and the faces of the intermediate ones ajdusted to coincide with the line. Thereafter, each block shall be removed and relaid over a bed of mortar. After every three or four blocks have been laid, their correct alignment level and verticality shall be carefully checked.

10.2.2. The construction of walls may be started either at the corners first or started from one end proceeding in the other direction. If the corners of the wall are builtfirst, they shall be built four or five courses higher than the centre of the wall. As each course is laid at the corner, it hall be checked for alignment and level and for being plumb. Each block shall be carefully checked witha level or straight edge to make certain that the face of the block are all in the same plane. This precaution is necessary to ensure truly straight and vertical walls.

10.2.2.1. The use of a storey-rod or course pole which is simply a board with markings 200 mm. apart, provides an accurate method of finding the top of the masonry for each course. Each course in building the corners, shall be stepped back by a half-block and the horizontal spacing of the block shall be checked by placing a mason's level diagonally across the corners of the block.

10.2.3. When filling in the wall between the corners, a mason's line shall be stretched from corner to corner for each course and the top outside edge of each block shall be laid to this line. The manner of handling or gripping the block shall be such as to position the block properly with minimum adjustment.

10.2.3.1. To assure satisfactory bond, mortar shall not be spread too far ahead of actual laying of the block as it will stiffen and lose its plasticity. As each block is laid, excess mortar extruding from the joints shall be cut off with the trowel and thrown back on the mortar board to be reworked into the fresh mortar. If the work is progressing rapidly, the extruded mortar cut from the joints may be applied to the vertical face shells of the block just laid. If there be any delay long enough for the mortar to stiffen on the block. the mortar shall be removed to the mortar board and reworked. Dead mortar that has been picked up from the scaffold or from the floor shall not be used.

10.2.4. *Closure bolck.*—When installing the closure block, all edges of the opeining and all four edges of the clousre block shall be buttered with mortar. The closure block shall be carefully lowered into place. If any mortar falls leaving an open joint, the closure block shall be removed, fresh mortar applied and the operation repeated.

10.3. *Provisions for door and windows frames.*

Mild steel bar holdfasts should be so fastened to the door or window frames that these occur at block course level.

10.4. *Provisions for lintels.*—Lintels may be either precast or cast in situ with appropirate reinforcement. Where openings occur close to one another, a continuous lintel shall be provided.

10.5. *Provision for roof.*

10.5.1. The top of the roof course shall be finished smooth with a thin layer of 1 : 3 cement mortar and covered with a coat of crude oil or craft or oil paper to ensure free movement of the roof.

10.5.2. Where the roof slab projects beyond the external wall face, it shall be provided with a drip.

10.6. *Intersecting walls.*—All walls wherever they meet or intersect shall be bonded or tied securely in accordance with 10.6.1. and 10.6.2.

10.6.1. *Bearing walls.*—When two bearing walls meet or intersect and the courses are to be laid up at the same time, a true masonry bond between at least 50 per cent of the units at the intersection s necessary. When such intersecting bearing walls are laid up separately, pockets with 200 mm. maximum vertical spacings shall be left in the first wall laid. The corresponding course of the second wall shall be built into these pockets.

10.6·2. *Non-load bearing walls.*—Meeting or intersecting non load bearing walls shall be bonded by either of the two methods recommended for bearing walls or provided with adequate lateral supports.

10.6.3. The side walls of long buildings shall be stiffened at regular intervals with pilasters or by sealed bonds which are about twiee the thickness of the wall.

SECTION VII

FLOORING

SECTION VII

FLOORING

CONTENTS

SECTION VII

FLOORING

INDIAN STANDARDS—EXTRACTS.

SECTION VII

FLOORING

SPECIFICATION No. 39.

GROUNDOR BASEMENT FLOORS WITH AND WITHOUT 100 MM. THICK CONCRETE BASE WITH AND WITHOUT SAND FILLING.

1. *General.*—

1.1. If a bed of sand filling is to the given under the concrete base then the depth of sand will be noted in the relevant schedule item working. This sand filling will not be included in the contract rate per 10 sq. metres for the flooring but will be paid for separately as another scheduled item for sand filling, When sand filling is to be done it shall comply with the Standard specifications for sand and for filling in basement.

2. The bed for the concrete whether sand or earth bed is specified shall be prepared to the standard specification for filling in basement level or sloped as specified or instructed.

3. On the bed thus prepared standard specification concrete broken brick or stone in lime or surki mortar as specified in the relevant schedule item shall be laid in one thickness and beaten with wooden rammers until the concrete shall have become throughly consolidated.

For I. S. Specifications I. S. 2571:1970 and N. B Code part VI and VII of specification shall apply.

4. A sample of the tiles, bricks, paving stones or slabs which are specified in the relevant schedule item for surfacing shall in all cases be submitted to the Executive Engineer and must receive his approval before they are laid in place.

5. Surfacing cost shall be laid as per I.S. 2571:1970 and I.S. 5766: 1970 and N. B. C. part V, VI and VII of appendices Bricks shall be so laid that all joints are full of mortar. The thickness of the joints shall be between 8 and 10 mm. The joints shall be flush pointed after being raked out 10 mm deep while the mortar is still green. The raked joints shall be well brushed to remove dust and loose particles and well wetted and shall be refilled with cement mortar 1 : 3 (1 cement : 3 sand) mixed with an approved colouring ngredient of the same colour as the floor.

5.1. In the case of the use of Cuddapah slabs the joint shall be grouted to the full depth of the slab with standard specification cement mortar 1 cement and 3 sand and well rubbed with a small clean trovel to form a smooth surface.

6. The above clauses apply to all the following flooring sub-specifications. The rates in all cases per 10 sq. metres of flooring shall be inclusive of pointing and finishing complete in accordance with this specification and the relevant sub-specification.

SPECIFICATION No. 39-A.

FLOORING WITH (*a*) IMPORTED MARBLE SLABS (*b*) DRESSED OR ORNAMENTAL TILES, OR (*c*) SQUARE MISSION TILES—OVER A BED OF CONCRETE 100 mm THICK AND POINTED WITH CEMENT.

Additional clauses to 'General' preceding.

1. The slabs or tiles shall be of a make which will be specified in the relevant schedule item.

1.1. The joints between the rows of slabs or tiles shall not exceed 3mm in width—unless otherwise specified.

SPECIFICATION No. 39-B.

FLOORING WITH SQUARE PAVING BRICKS OVER A BED OF CONCRETE 100 mm THICK AND POINTED WITH CEMENT MORTAR 1 : 3.

1. The work shall be executed as I.S. 5766 : 1970 and I.S. 3583 : 66.

SPECIFICATION No. 39-C.

BRICK ON EDGE FLOORING OVER A BED OF CONCRETE 100 MM THICK AND POINTED WITH CEMENT.

1.1. To be executed as per I.S. 5766:1970.

SPECIFICATION No. 39-D.

FLOORING WITH PAVING STONE IN LIME OR CEMENT MORTAR LAID ON 100 MM BROKEN STONE LIME OR CEMENT MORTAR CONCRETE POINTED WITH CEMENT MORTAR 1 : 3

Additional clauses to 'General' preceding.

1.1. The paving stone shall comply with standard specification for 'Flooring stone 75 mm to 100 mm thick' which specification also defines the thickness of joints in flooring.

2. The paving stone shall be laid in standard specification lime or cement mortar over the concrete is bed before the latter finally set with all joints and beds fully set in mortar. The beds of mortar for levelling up should be guarded against by careful selection of stone of uniform thickness.

3. Pointing flush shall be done as instructed under 'General preceding.

SPECIFICATION No. 39-E.

FLOORING WITH PAVING STONE IN LIME OR CEMENT MORTAR LAID ON SAND BASE AND POINTED WITH CEMENT MORTAR 1 : 3 (SAND BASE TO BE PAID FOR UNDER A SEPARATE ITEM OF WORK.)

1.1. *Additional clauses to 'General' Preceding.*

1.2. The thickness of bed of sand shall be as defined in the relevant schedule item. It will be paid for separately under a schedule item for sand filling,

1.3. The work shall be done in accordance with the preceding specification except that the concrete base is omitted and a sand base provided—the levelling bed course of lime or cement mortar being also not required.

466-3—44

SPECIFICATION No. 39-F.

LAYING IN SITU CEMENT CONCRETE FLOORING WITH FLOOR TOPPING.

1. I.S. 2571-1970 and 5491 ; 69 shall apply.

For granolithic concrete floor topping the mix proportion given in I.S. 5491-1969 shall be adopted and as regards specifications on size of panel laying floor topping, etc., the same specification as given in I.S. 2571-1970 for cement concrete flooring shall be followed.

NOTES : To make a coloured floor the following materials should be mixed in the quantities stated, with every cut metre of top layer cement concrete.

Red : One-twelfth cubic metre red-oxide iron powder.

Black : One-sixth cubic metre manganese dioxide.

Buff : One-sixth cubic metre of yellow ochre or 'Gopi'.

SPECIFICATION No. 39-G.

FLOORING WITH 100 MM. CONCRETE AND 20 MM. CEMENT CONCRETE SURFACE ELLIS PATTERN.

(*First sort.*)

(1) The 100 mm. concrete base shall be prepared as detailed before under "General" For preparing the base I.S.: 2571-1970 also shall apply.

(2) On the clean wet surface of the concrete base, before it has set, will be laid a layer of cement concrete to give a finished depth of 20 mm. over the lime concrete.

The cement concrete will consist of standard specification hard broken stone chippings, graded from gauges 3 mm. to 10 mm. and well mixed with standard specification. Cement neat, in the proportion of 3 broken stone to 1 cement, or as otherwise specified or instructed by the Executive Engineer.

The Cement concrete shall be spread immediately it has been mixed, using a straight edge. The concrete must be well beaten with 2.5 kg. wooden "thapies" until cement slurry comes to the surface—say for not less than 15 minutes—and it is very important that the consolidation should be carried out quickly, as otherwise the initial set of the cement is likely to spoil the work, if the beating is continued too long or is not sufficiently thorough. When the mortar has come to the surface, the floor shall be polished with trowels.

(3) To prevent large areas of cement concrete from cracking due to construction during setting, the floor shall be divided into strips extending across the width of the room, or into squares or rectangles 1.2 m. to 2.5 m. in width. The edge of each section into which the floor is divided should be defined by flat bars of steel or wood, their depth being the same as that proposed for the finished floor. They should be white washed in order to prevent them from adhering to the concrete.

When the slabs have set, the bars should be removed and the joints filled in, with standard specification cement mortar 1 : 2.

(4) If it is desired to have a fine finish cement may be sprinkled over the surface of the concrete which has set, and rubbed over with polishing stones.

(5) After the floor has been completed, it should be covered with two inches of grass, sand or saw dust and kept wet for three weeks. It is better not to be brought into use for a month after laying.

Notes.—(*a*) The notes given under 39-F shall apply.

(*b*) Special care is necessary that the filling under the lime concrete is wetted and thoroughly consolidated in accordance with the standard specification for "filling" in basement—as otherwise the whole floor is liable to crack.

SPECIFICATION No. 39-H.

FLOORING WITH CONCRETE 100 MM. THICK AND PLASTERED OVER WITH CEMENT MORTAR 1 : 3-12 mm. THICK.

1. For flooring with cement concrete I.S. 2571—1970 shall apply.

1.1. Standard specification cement plastering 1 : 3 12 mm. thick is to be applied to the floor before the concrete has set in order to obtain a good bond with the base.

2. Cement plaster gauges or other gauges should be put on the concrete floor about 3 metres apart to ensure even thickness.

3. Cement plastering must be done in squares or strips or else cracks will appear, if a large surface is done.

SPECIFICATION No. 39-I.

FLOORING WITH RED CEMENT PLASTER, POLISHED SURFACE AND THREAD LINED.

1.1. The concrete base shall be well cleaned bruhsed free from any dust or loose concrete materials and then wetted. 1 kg. of red-oxide of iron per square metre of flooring shall be added to the cement mortar 1 : 3 and well incorporated during mixing and one coat of the mixture applied to the floor, otherwise conforming to the—standard specification "Plastering with cement mortar". The plaster flooring shall be threadlined in squares diagonal to the sides of the room and size as instructed by the departmental officer-in-charge of the work. The squares should be of equal size and finished off regularly at the edge or border around the room either at a cornor or midline of the square. The surface shall be brought to a fine polished finish by the use of polishing stones.

2. The precautions against cracking and instructions for watering given in the standard specification for "Plastering with cement mortar" shall be followed.

SPECIFICATION No. 39-J.

TERRAZO (MARBLE CHIPS) FLOORING-LAID IN SITU.

The thickness of the under layer shall be measured correct to a mm. The thickness of the top layer shall not be less than that specified.

1.1. *under Layers.* Cement concrete of specified mix shall be used and the specifications given below shall apply.

This shall be prepared by mixing graded stone or brick-aggregate of nominal size as specified with fine aggregate and cement in specified proportions with required quantity of water.

The grading and quality of aggregates shall be such as to give minimum compressive strength of 140 kg. cm² and 210 kg./cm² at 7 days and 28 days respectively in case of mix. 1 : 2 : 4.

One sample consisting of 6 cubes 15×15×15 cm., shall be taken for every 10 cubic metres or part thereof of cement concrete 1 : 2 : 4. The cube tests shall not be carried out in case the quantity of cement concrete 1 : 2 : 4 placed on any day is less than 10 cu. m. unless otherwise specified. For other details refer "R.C.C. work".

The panels shall be of uniform size, not exceeding 2 sq. m. in area and 2 m. in length for inside situations. In exposed situations the length of any side of the panel shall not be more than 1·25 metres. Cement slurry at 2·00 kg. per sq. m. shall be applied before laying of under layer over the cement concrete/R.C.C. surface.

Strip fixing.—4 mm. to 6 mm. glass strips or 2 mm. aluminium strips shall be fixed with their top at proper level, giving slopes.

3. *Top layer.*

3.1. *Mortar.*—The mix for terrazo topping shall consist cement with or without pigment, marble powder, marble aggregate (Marble chips) and water. The cement and marble powder shall be mixed in the proportion of 3 parts of cement to one part marble powder by weight. For every part of cement marble powder mix, the proportion of aggregate by volume shall be as follows :—

TABLE 1.

Size of aggregates.	*Proportion of aggregates to binder mix.*
(1)	(2)
For grades 00,0 and 1	1·75 parts.
For grades 2 and 3	1·50 parts.
For grades 4 and 5	1·25 parts.
Mixed size aggregate	1·50 parts.

The marble chips shall be white or pink Makrana, black Bhainslana Chittor black, Jaisalmer yellow, Baroda green, Dehradun white, Chittor pink, yellow Patam Cherala (Madras), grey Gadu (Surat) Chittor green and yellow and Alwar black or as specified. It shall be hard, sound, dense and homogeneous in texture, with crystaline and corase grains. It shall be uniform in colour and free from strains, cracks, decay and weathering. The maximum thickness of the top layer for various sizes of marble aggregates (marble chips) shall be as under :—

TABLE 2.

Grade number.	*Size of aggregate in mm.*	*Minimum thickness of top layer (mm).*
00	1—2	6
0	2—4	9
1	4—7	9
2	7—10	12

Where aggregate of size larger than 10 mm. are used the minimum thickness of topping shall not be less than $1\frac{1}{2}$ times the maximum size of the chips. Where large size chips such as 20mm. or 25mm.are used they shall be used only with a flat shape and bedded on the flat face so as to keep the minimum thickness of wearing layer.

Before starting the work, the contractor shall get the sample of marble chips approved by the Executive Engineer. The cement to be used shall be ordinary grey cement, white cement, coloured cement or cement with admixture of colouring matter of approved quality in the ratio specified in the description of the item or in the ratio to get the required shade as ordered by the Executive Engineer. Colouring matter where specified, shall be mixed dry thoroughly with the cement and marble powder and then marble chips added and mixed as specified above. The full quantity of dry mixture of mortar required for a room shall be prepared in a lot in order to ensure a uniform colour. This mixture shall be stored in a dry place and will be covered and protected from moisture. The dry mortar shall be mixed with water in the usual way as and when required. The mixed mortar shall be homogeneous and stiff and contain just sufficient water to make it workable.

The terrazo topping shall be laid while the under layer is still plastic, but has hardened sufficiently to prevent cement from rising to the surface, this is normally, achieved between 18 to 24 hours after the under layer has been laid. A cement slurry preferably of the same colour as the topping shall be brushed on the surface immediately before laying is commenced. It shall be laid to a uniform thickness slightly more than that specified in order to get the specified finished thickness after rubbing. The surface of the top layer shall be trowelled over, pressed and brought true to required level by a straight edge and steel floats in such a manner that the maximum amount of marble chips come up and are spread uniformly over the surface.

3.2. *Polishing, curing and finishing.*—Polishing shall be done by machine. About 36 hours after laying the top layer, the surface shall be watered and ground evenly with machine fitted with special rapid cutting grit blocks (carborundum stone) of coarse grade (No. 60) till the marble chips are evenly exposed and the floor is smooth. After the first grinding, the surface shall be thoroughly washed to remove all grinding mud and covered with a ground of cement or/and colouring matter in same mix and proportion as the topping in order to fill any pin holes that appear. The surface shall be allowed to cure for 5 to 7 days and then ground with machine fitted with fine grit blocks (No. 120). The surface is cleaned and repaired as before and allowed to cure again for 3 to 5 days. Finally the third grinding shall be done with machine fitted with fine grade grit blocks (No. 320), to get even and smooth surface without pin holes. The finished surface should show the marble chips evenly exposed.

Where use of machine for polishing is not feasible or possible, rubbing and polishing shall be done by land, in the same manner as specified for machine polishing except that carborundum stone of coarse grade (No. 60) shall be used for the first rubbing, stone of medium grade (No. 80) for second rubbing and stone of fine grade (No. 120) for final rubbing and polishing.

After the final polish either by machine or by hand, exolic acid shall be dusted over the surface at 33 gm. per square metre sprinkled with water and rubbed hard with a namdah block (Pad of woollen rags). The following day, the floor shall be wiped with a moist rag and dried with a soft cloth and finished clean.

Curing shall be done by suitable means, such as laying moist saw dust or ponding water.

4. *Precautions.*—Flooring in lavatories and bathrooms shall be laid after fixing of water closet and squatting pans and floor traps. Traps shall be plugged, while laying the floors and opened after the floors are cured and cleaned. Any damages done to W.Cs. squatting pans and floor traps during the execution of work shall be made good by the Contractor.

During cold weather, concreting shall not be done when the temperature falls below 4° C. The concrete placed shall be protected against frost by suitable coverings. Concrete damaged by frost shall be removed and work redone. During hot weather, precautions shall be taken to see that the temperature of wet concrete does not exceed 38° C. No concreting shall be laid within half an hour of the closing time of the day, unless permitted by the Executive Engineer.

The floor shall be protected from any damage during the execution of work.

5. *Measurements.*

5.1. Length and breadth shall be measured correct to a c.m. before laying skirting, dado or wall plaster. The area as laid shall be calculated in square metre correct to two places of decimal. No deduction shall be made nor extra paid for any opening in floor of area upto 0.1 square (10 dm²). Nothing extra shall be paid for laying the floor at different levels in the same room or courtyard.

5.2. Terrazo (marble) chips flooring laid as floor borders, margins and similar bands upto 30 c.m. width and / or staircase treads, shall be measured under the item of terrazo flooring but extra shall be paid for such work. This extra in the case of staircase treads shall include the cost of forming the Nosing also. However, moulded nosing shall be paid in running metres except where otherwise stated, returned moulded ends and angles to mouldings shall be included in the description.

5.3. Dividing strips of metals inserted in terrazo to form bays, patterns, shall be described stating the materials, its width and thickness and measured in running metres.

5.4. Special surface finishes to treads, risers and the ends of concrete steps and the like shall be measured separately and given in square metres and shall include form work, if required.

Rate.—The rate shall include the cost of all materials and labour nvolved in all the operations described above including cleaning of surface of R.C.C. slab or sub-grade and application of cement slurry but shall not include the cost of sub-grade concrete and strips of glass or aluminium used for making panels.

7. *Terrazo (Marble Chips) Skirting—In Sittu —*

7.1. *Under coat.*—The under coat of skirting shall be of cement plaster of the thickness and mix described in the item. Specifications given under shall apply.

A band of plaster at the bottom of wall not exceeding 30 c.m. in height above the floor shall be classified as skirting. It shall be flush with wall plaster or projecting out uniformly by 6 m.m. from the wall plaster, as specified. The work shall be preferably carried out simultaneously with the laying of floor. It's corners and juctions with floor shall be finished neatly as specified.

Thickness.—The thickness of the plaster specified shall be measured exclusive of the thickness of key, i.e., grooves or open joints in brick work. The average thickness shall not be less than the specified thickness, bore 6 m.m. The average thickness should be regulated at the time of plastering by keeping suitable thickness of the gauges. Even thickness required in daubing behind rounding of corners at juctions of wall shall be ignored.

Preparation of wall surface.—The joints shall be raked out to a depth of at least 15 .m.m. in masonry walls, while the masonry is being laid. In case of concrete walls, the surface shall be roughened by backing. The surface shall be cleaned thoroughly, washed with water and kept wet before skirting is commenced.

As regards application, the work shall be carried out in the manner described in paragraph below except that the under coat shall be finished rough with a scratching tool to form a key for the top coat.

Application.—Skirting with specified mortar and to specify thickness shall be laid immediately after the surface is prepared. It shall be laid along with the border or adjacent panels of floor. The joints in skirting shall be kept true and straight in continuation of the line of joints in borders or adjacent panels. The skirting shall be finished smooth and true, with top truly horizontal and joints truly vertical except where otherwise indicated.

7.2. *Top Coat.*—The specifications as in paragraph shall hold good as far as applicable and shall include cutting to line and fair finish to top edges of terrazo and polishing.

7.3. *Thickness.*—The thickness of the bottom and top coats shall be as specified. The total thickness of skirting specified is of the total thickness of plaster as measured from the unplastered face of the masonry. Average thickness of the under coat shall not be less than m.m. and minimum thickness over any portion of the surface shall not be less than 4 m.m. The thickness of top coat shall not be less than the thickness specified.

7.4. *Measurement.*—Length and height shall be measured correct to a cm and its area shall be calculated in sq. m. correct to two places of decimal stating the thickness. Length shall be measured as finished length of skirting. Height shall be measured from the finished level of floor correct to 5 mm. where the height of skirting does not exceed 30 cm. and where the height exceeds 30 cm. it shall be measured correct to a cm.

7.5. *Rates.*—The rate shall include the cost of all the operation described above.

8.0 *Crazy Marble Flooring.*

8.1. *Sub-Grade.*—Crazy marble stone flooring shall be laid on cement or lime concrete sub-grade. The sub-grade shall be provided with slope required for the flooring in verandah and court yards to drain off working and rain water. The surface of sub-grade shall be roughened with steel wire brushes, without disturbing the concrete, wetted and smeared with a floating coat of cement slurry at 2 kg. of cement spread, over an area of one square metre so as to get a bond between sub-grade and flooring. Before laying the flooring on R.C.C. slab the laitance shall be removed, the surface of slab hacked and a coat of cement slurry at 2k. g. of cement spread over an area of one sq. m. shall be applied so as to get a good bond between R.C.C. slab and floors.

8.2. *Under Layers.*—The under layer of crazy marble flooring shall be of cement concrete of thickness as specified. The mix shall be 1:2:4 (1 cement : 2 coarse sand : 4 graded stone aggregate 12·5 m.m. nominal size) by volume unless otherwise specified. It shall conform to the specification given in paragraph 1 above.

8.3. *Top Layers.*—The mix of crazy marble stone flooring shall consist of cement with or without pigment, marble powder, are chips of 00 Nos. and marble stone pieces and water. The marble stone pieces shall be hard, sound, clause and homogeneous in tenture with crystaline and course grains. It shall be uniform colour and free from strains, cracks, decay and weathering. Before starting the work the contractor shall get the sample of marble stone appoved by the Executive Engineer. The marble stone pieces shall be of sizes as approved by the Executive Engineer but the thickness shall be as specified.

The cement and marble powder shall be mixed in proportion of 3 parts of cement and one part of marble powder by weight. And the portion of marble chips to binder mix by volume shall be 7 parts of marble chips to 4 parts of binder mix. The marble chips shall be white or black or as specified. It shall be hard, sound, dense and homogeneous in texture. It shall be uniform in colour and free from stains, cracks, decay and weathering.

8.4. *Laying.*—A coat of cement slurry at the rate of 2 kg. of cement per square metre of area shall be spread and then the marble stone pieces shall be laid by hand in such a manner that the top surface of all the laid marble stone shall be true to the required level and slopes. After fixing, the cement marble chips mixtures shall be filled in between the gaps of laid marble stones pieces. The filled surface then shall be trowelled over, pressed and brought to the level of the laid marble stone pieces.

8.5. *Polishing, curing and Finishing.*—Shall be as described in 3.2

8.6. *Precautions.*

Flooring in lavatories and bathrooms shall be laid after fixing of ater closet and squatting pans and floor traps. Traps shall be plugged, while laying the floors and opened after the floors are cured and cleaned. Any damage done to W.Cs. squatting pans and floor traps during the execution of work shall be made good by the contractor.

8.7. *Measurements.*—Length and breadth shall be measured correct to a c.m. before laying skirting, dado, or wall plaster and its area as laid shall be calculated in square metres correct to two places of decimal. No deduction shall be made nor extra paid for opening in floor or area upto 0.1. square metre (10 dm.). Nothing extra shall paid for laying the floor at different levels in the same room or in courtyards.

8.8. *Rate.*—The rates shall include the cost of all materials and labour involved in all the operations described above including the cost of cleaning of R.C.C. slab surface and applying the cement slurry but it shall not include the cost of sub-grade.

9. *Terrazo Tile Flooring.*

9.1. *Terrazo Tiles—*

9.1.1. Terrazo tiles shall generally conform to IS : 1237-1959. The sizes of tiles shall be as given in Table 3.

The specific sizes of tiles to be used shall be as shown in the drawings or as required by the Executive Engineer.

TABLE 3.

Length.		*Breadth.*		*Thickness.*
Nominal.	*Actual.*	*Nominal.*	*Actual.*	*not less than.*
(1)	(2)	(3)	(4)	(5)
20 cm	19·85 cm	20 cm	19·85 cm.	20 mm.
30 cm.	29·85 cm.	30 cm.	29·85 cm.	25 mm.
25 cm.	24·85 cm.	25 cm.	24·85 cm.	22 mm

9·1·2. *Tolerance.* Tolerances on length and breadth shall be plus or minus one millimetre, tolerance on thickness shall be plus 5 mm. The range of dimensions in any one delivery of tiles shall not exceeds 1 mm. on length and breadth and 3 mm. on thickness.

9·1·3. The tiles shall be manufactured under hydraulic pressure of not less than 140 kg. per square centimetre and shall be given the first grinding with machine before delivery to site.

9·1·4. The proportion of cement to aggregate in the backing of the tiles shall not be leaner that 1·3 by weight. Similarly the proportion of cement to marble chips aggregate in the wearing layer of the tiles and the proportion of pigment to be used therein shall not exceed 10 per cent of weight of cement used in mix.

9·1·5. The finished thickness of the upper layers shall not be less than 5 mm. for size of marble chips from the smallest upto 6 mm. and also, not less than 5 mm. for size of marble chips ranging from the smallest upto 12 mm. and not less than 6 mm. for sizes of marble chips varying from the smallest upto 20 mm.

9.2. *Laying —*

9·2·1. Sub-grade concrete or the R.C.C. slab on which the tiles are to be laid shall be cleaned, wetted and mopped. The bedding for the tiles shall be with cement mortar 1 : 3.

The average thickness of the bedding mortar shall be 20 mm. and the thickness at any place shall not be less than 10 mm.

9·2·2. Cement mortar bedding shall be spread, tamped and corrected to proper levels and allowed to harden for a day before the tiles are set. Over this bedding, neat grey cement slurry of honey like consistency shall be spread at the rate of 4·4 kg. of cement per square metre over such an area as would accommodate about twenty tiles. Tiles shall be washed clean and shall be fixed in this grout one after another, each tile being gently tapped with a wooden mallet till is properly bedded, and in level with the adjoining tiles. The joints shall be kept as thin as possible not exceeding 1·5 mm. and in straight lines or to suit the required pattern.

9·2·3. The surface of the flooring during laying shall be frequently checked with a straight edge atleast 2 metre long, so as to obtain a true surface with the required slope.

9·2·4. Where full size tiles cannot be fixed, these shall be cut (sawn) to ther equired size and their edges rubbed smooth to ensure a straight and true joint.

9·2·5. Tiles which are fixed in the floor adjoining the wall shall enter not less than 12 mm. under the plaster, skirting or dado. The junction between wall plaster and tile work shall be finished neatly and without waviness.

9·2·6. After the tiles have been laid, surplus cement grout that may have come out of the joint shall be cleaned off.

9·3. *Curing, Polishing and Finishing.*

9·3·1. The day after the tiles are laid all joints shall be cleaned of the grey cement grout with a wire brush or trowel to a depth of 5 mm. and all dust and loose mortar removed and cleaned. Joints shall then be grouted with grey or white cement mixed with or without pigment to match the shade of the topping of the wearing layer the tiles. The same cement slurry shall be applied to the entire surface of the tiles in a thin coat with a view to protect the surface from abrasive damage and fill the pin holes that may exist on the surface.

9·3·2. The floor shall then be kept wet for a minimum period of 7 days. The surface shall there after be grounded evenly with machine fitted with coarse aggregate grade grit blocks (No. 60). Water shall be used profusely during grinding. After grinding, the surface shall be thoroughly washed to remove all grinding mud, cleaned and mopped. It shall then be covered with a thin coat of grey or white cement mixed with or without pigment to match the colour of the topping of the wearing surface in order to fill any pin hole that appear. The surface shall be again cured. The second grinding shall then be carried out with machine fitted with fine grade grit blocks (No. 120)

9·3·3. The final grinding with machine fitted with the finest grade grit blocks (No. 320) shall be carried out the day after the second grinding described in the preceding para or before handing over the floor, as ordered by the Executive Engineer.

9·3·4. For small areas or where circumstances so required, hand polishing may be permitted in lieu of machine polishing after laying Forhand polishing the following carborundum stones, shall be used.

1st grinding coarse grade stone (No. 60).

Second grinding medium grade (No. 80).

Final grinding fine grade (No. 120).

In all other respects, the process shall be similar as for machine polishing.

9·3·5. After the final polish, oxalic acid shall be dusted over the surface at the rate of 33 gm. per square metre sprinkled with water and rubbed hard with a ' namdah ' block (pad of woolen rags.) the following day the floor shall be wipped with a moist rag and dried with a soft cloth and finished clean.

9.3.6. If any tile is disturbed or damaged, it shall be refitted or replaced, properly jointed and polished.

The finished floor shall not hollow when tapped with a wooden mallet.

9.4. *Measurements*:

9.4.1. Coloured terrazo tile flooring shall be measured separately and classified as in paragraph 5. Terrazo tile flooring shall be measured as laid in square metre correct to two places of decimal. For length and breadth dimensions correct to a cm. before laying skirting dado or wall plaster shall be taken. No deduction shall be made nor extra paid for any opening in the floor of area upto 0·1 square metre (10 dm). Nothing extra shall be paid for use of cut tiles nor for laying the at floor different levels in the same room or courtyard.

9.4.2. Terrazo tile flooring laid in floor borders and similar band shall be measured under the item of terrazo tile flooring. No extract shall be paid in respect of these and similar bands formed of half size or multiples of half size standard tiles or other uncut tiles.

9.4.3. Treads of stairs and stops paved with tiles without nosing shall also be measured under flooring. Moulded nosing shall be paid in running metre except where otherwise stated, returned moulded ends and angles to mouldings shall be included in the description Extra shall, however, be paid for such area where the width of tread does not exceed 30 cm.

9.5. *Rate*.—The rate shall include the cost of all materials and labour involved in all the operations described above.

10. *Terrazo Tiles in Risers of steps, skirting and dado*:

10.1. The terrazo tile shall be as specified in 9-1. as for as applicable. The minimum finished thickness of tiles shall however be 12 mm. The finished thickness of the upper layer shall be not less than 5 mm. for size of marble chips from the smallest upto 12 mm. and not less than 6 mm. for size of chips varying from the smallest upto 20 mm. where the bigger sized chips are used the tiles shall not be less than 20 mm. thick.

10.2. *Preparation of surface*.—The specifications for this shall be the same as 7.1.

10.3. *Laying*.— 12 mm. thick plaster of cement mortar 1 : 3.—(1 cement : 3 coarse and) or mix as specified, shall then be applied and allowed to harden. The plaster shall be roughened be with wire brushes, or by scratching diagonal lines 2 mm. deep at approximately 7·5 cm. centre both ways.The back of tiles shall buttered with a cost of grey cement slurry and edge with grey or white cement slurry with or without pigment to match the shade of tiles and set-in the bedding mortar. These shall be temped and corrected proper planes and lines. The tiles shall be set in the required pattern and butt joined. The joints shall be as fine as possible. Top of skirting or dado shall be truly horizontal and joints truly vertical except where otherwise indicated.

The risers of steps, skirting or dado shall rest on the top of the tread or flooring. Where full size tiles cannot be fixed, the tiles shall be cut (sawn) to the required size and their edges rubbed smooth.

10.4. *Curing, Polishing and Finishing*.—The specifications as in 9.3 shall hold good as far as applicable. Polishing shall be done with hand.

10.5. *Measurements*.—The thickness of the skirting shall be tested. Length shall be measured along the finished face of riser, skirting or dado correct to a cm. Height shall be measured from the finished level of tread or floor to the top (the underside of tread in the case of steps). This shall be measured correct to 3 mm in case of risers skirting (not exceeding 30 cm. in height) and dado. The area shall be calculated in square metre, correct to two places of decimal.

Where the height of risers, skirting or dado does not admit of full size or other standard size tiles and the tiles are to be cut (sawn), extra shall be paid for the same. In the case of dados, this extra shall be confined to the area of the portion of cut tiles used.

10·6. *Rate*.—The rate shall include the cost of all materials and labour involved in all the operations described above.

Extra rates shall be paid for risers, skirting and portions of dado where cut (sawn) tiles are used.

11. *Chequered Tile Flooring*:

11.1. *Chequered Tiles* :—The tiles shall be of nominal sizes such as 20 × 20 cm. 25 ×25 cm and 30 × 30 cm. or of standard sizes with equal sides. The size of tiles to be used shall be as shown in drawings or as required by the Executive Engineer. The centre to centre distance of chequers shall not be less than 2·5 cm. and not more than 5 cm.

The overall thickness of the tiles shall not be less than 22 mm. The grooves in the chequers shall be uniform and straight. The depth of the grooves shall not be less than 3 mm. The chequered tiles shall be cement tiles, or terrazo tiles as specified in the description of item. The thickness of the appear layer, measured from the top of the chequres shall not be less than 6 mm.

The tiles shall be given the first grinding with machine before delivery to site.

The tile shall conform to the specifications for plain concrete or terrazo tiles in respect of method of manufacture and the mix of backing and wearing layers.

11·2. *Laying, Curing, Polishing and Finishing* :—Shall be as specified in 9.2 and 9·3 except that the polishing of the tiles and the chequer grooves, after laying, may be done by hand. Special care shall be taken to polish the grooves in such a manner as get a uniform section and that their finish shall match with the finish of the flat portion of the tiles.

11·3. *Measurement and rate*.—Shall be specified in 10·4 and 10·5.

12. *Chequered Tiles in Stair Treads.*

12·1. *Chequered Tiles*.—The specifications for tiles shall be as specified in 30-J-11-1 except in the following respects :—

(1) The length of the tiles including nosing shall be as specified.

(2) The nosing edge of the tile shall be rounded.

(3) The minimum thickness of the tile shall be 30 mm.

(4) The front portion of the tile for a minimum length of 75 mm. from and including the nosing shall have grooves running parallel to the nosing and at centres not exceeding 25 mm. Beyond that the tiles shall have the normal chequer pattern.

(5) The nosing shall also have the same wearing layers as the top.

12.2. *Preparation of Surface and Laying* :

12-2-1. R.C.C. or brick, work treads on which the tiles are to be laid shall be cleaned, wetted and mopped. The bedding for the tiles shall be with lime mortar of either 1 : 1 : 1 (1 lime putty: 1 surkhi : 1 coarse sand) or 1 : 4 (1 cement : 4 coarse sand) or as specified mix. The minimum thickness of bedding mortar at any place shall be 10 mm. Bedding mortar shall be spread tamped and corrected to proper levels. After laying bedding mortar, neat grey cement slurry of honey like consistency shall be spread over the mortar at the rate of 4·4 kg. of cement per square metre over each thread. Tiles shall be washed clean and shall be fixed in this grout one after another, each tile being gently tapped with a wooden mallet till it is properly bedded, and in level and line with the adjoining tiles. The joints shall be kept as thin as possible and in straight lines. The surface shall be checked with a straight edge during laying to obtain a true surface.

12-2-2. The square end of the tile shall, as far as possible but against the riser face of the concrete or brick tread and in any cases shall be embedded under the side wall plaster skirting or dado and under the riser tile or other finish to a depth of not less than 10 mm.

12.2.3. Where full size tiles cannot be fixed, these shall be cut (swan) to the required size (along the groove of the chequers where the cut edge is exposed) and used. The cut in the case of embedded edges will be neat and true while the cut in the case of exposed edges shall in addition be rubbed smooth to ensure a straight and ture joints.

12.2.4. After the tiles have been laid surplus cement grout shall be cleaned off.

12.3. *Curing, polishing and finishing.*—The specifications shall be as described in 39-J-73 except that polishing of the treads nosing and chequered grooves, after laying, may be done by hand in the same manner specified under terrazo tile flooring. Special care shall be taken polish the nosing and the grooves insuch a manner as to get a uniform section for the grooves and the nosing and their finish shall match with the finish of the flat portion of the tiles.

12.4. *Measurements.*—Chequered tiles on stair treads shall be insured in square metre correct to two places of decimal. Length shall be measured from the finished face of skirting, dado or all palster as the case may be, correct to a cm. Width shall be measured from the outer edge of the tread to the finished face of riser or in the case of the edge tiles of the landing and wide steps, to the near edge of the chequered stair tread tile.

12.5. *Rates.*—The rate shall include the cost of all material sand labour involved in all operations described above.

No extra shall be payable for cutting the tiles tothe size of trends and also for nosing.

SPECIFICATION No. 40.

BEST TERRACED FLOORING WITH BRICK ON EDGE 75 *mm.* CONCRETE AND 12 *mm.* CEMENT PLASTERING 1:3 TO TOP AND BOOTTOM.

1.1. I.S.: 2119/1962 shall apply.

2. The flooring will be carried into the walls for 15 cm. excep for interior cross walls where the flooring will be carried through the width of the wall and continued in the adjoining room in cases where such rooms are terrace floored.

2.1. The finished surface of the flooring must be perfectly level unless a slope for drainage is specified or instructed to be given by the Executive Engineer. The portion of flooring in set into walls will be paid for as walling and not as flooring.

SPECIFICATION No. 41.

BEST TERRACED FLOORING WITH BRICK ON EDGE, 75 *mm.* CONCRETE 12 *mm.* CEMENT PLASTERING 1 : 3 TO BOTTOM AND ON TOP PRESSED TILES SET IN LIME MORTAR AND POINTED WITH CEMENT MORTAR 1:3.

1.1. I.S. : 2119/62 and I.S. : 1237/1959 and I.S. : 1443/1959 shall apply.

SPECIFICATION No. 42.

FLOORING WITH GRAVEL 15 *cm.* THICK.

1.1. After completion of the bed in accordance with the standard specification for "Filling in basement" level or sloped as shown in the sanctioned plans or ordered by the Executive Engineer, standard Specification gravel shall be mixed with sand in the proportion of 9 : 5 (nine gravel and five sand) and with water and worked with mamoties till it can be formed into stiff plastic balls. It shall then b laid in one thickness and well rammed with flat iron or woodene rammers the finished depth of the gravel shall be 15 cm.

SPECIFICATION No. 43.

TEAKWOOD FLOORING 40 *mm.* THICK.

1.1. I.S.: 3670/1966 and N.B. Code Parts V, VI and VII. of appendix shall apply.

EXTRACT FROM I.S. 5766/1970.

Code of practice for laying burnt clay brick flooring.

6.3. *Laying the bricks.*

6.3.1. *Soaking of Bricks.*—To reduce excessive section, the bricks before being laid shall be soaked in clean water and then allowed to drain until they are surface dry.

6.3.2. The bricks shall be laid in plain, diagonal, herringbone or other suitable patterns. The bricks shall either be laid flat or on edge. Damaged bricks shall not be used. Broken bricks shall not be used in flooring except for closing a line.

6.3.3. Bricks shall be laid on lime mortar or cement mortar bed and each brick shall be properly bedded flat or on edge and set by gentle tapping with handle of trowel or wooden mallet. The inside faces of the bricks shall be smeared with mortar, beforethe nextbrick is laid and pressed against it. On completion of a portion of flooring the vertical joints shall be fully filled with mortar from the top. The surface of the flooring during laying, shalle befrequently chceked with a straight edge at least 2 metres long, so as to obtain a true surface with the required slope. In case of flat brick flooring, bricks shall be laid with frog down. When laid flat in plain courses, the units shall be bonded to break joints at half the length of the bricks.

6.4. *Joints.*—Bricks shall be so laid that all joints are full of mortar. The thickness of the joints shall be between 8 to 10 mm. the joints shall be flush pointed after being raked out 10 mm. deep while the mortar is still green. The raked joints shall be well brushed to remove dust and loose particles and well wetted ; and shall be refilled with cement mortar (1 cement : 3 sand).

6.5. *Curing.*—The flooring shall be kept wet for at least 7 days after completion. In case of cement lime mortar, curing shall commence two days after the laying and shall continue for seven days.

EXTRACT FROM I.S. 5491—1969.

Code of practice for laying in situ granolithic concrete floor topping.

0. *Forward.*

0.2. Granolithic concrete floor topping is adopted for floors of heavy engineering factories, workshops, garrages, warehouses, etc., where the floor is subjected to heavy loads and severe abrasion combined with impact. The granolithic concrete essentially consists of a rich concrete made with specially selected aggregate of high hardness, surface texture and particle shape suitable for use as a wearing finish to floors. Although plain concrete as laid conforming to I.S. 2571-1963 would be satisfactory for many purposes, granolithic concrete is chosen because of its high abrasion resistance and used for floor toppings wherever abraison combined with impact is likely to be severe.

4.4. *Mix proportions.*—Mix proportion for the granolithic concrete floor topping for different types of floor finish shall be 1 :1 :2 (Cement : fine aggregate : coarse aggregate, by volume).

7.1. Floor Topping laid Monolithically with the suspended slab.

Note (1).—In the monolithic method of construction the granolithic concrete floor topping may be regarded as contirbuting to the struutural strength of the suspended floor.

Note (2).—The monolithic construction of granolithic concrete floor topping presents certain difficulties in construction due to other activities, such as plastering of walls and ceilings, fixing of joinery, movement of scaffoldings, ladders, etc., which are likely to damage the floor finish.

7.3. Floor Topping laid over cushioning layer (*See* Table 3) :

Note.—Where lime and good quality of bricks are not avilable 1 : 4 : 8 cement concrete may be used.

TABLE 3—DIFFERENT TYPES OF GRANOLITHIC CONCRETE FLOOR TOPPING.

(*Clauses* 6.1., 6.2 *and* 7.1 *to* 7.3).

Serial Number and Type floor topping.	*Thickness of granolithic concrete floor topping in mm, Min.*	*Remarks.*
(1)	(2)	(3)
A. Floor topping laid over base concrete on ground.		
1 Floor topping laid monolithically with the base concrete.	20	Granolithic concretefloor topping shall be laid monolithic with the base concrete.
2 Floor topping laid separately on hardened base concrete.	40	Granolithic concrete floor topping shall be laid separately over specially prepared surface of set and hardened base concrete.
B. Floor topping laid over suspended slabs.		
Floor topping laid monolithically with the suspended slab.	20	The granolithic concrete topping shall be laid and finished monolithic with the suspended slab. For this purpose the topping shall be laid immediately after the structural concrete of the suspended slab has stiffened enough (but is still green) to allow the workmen to tread over it by placing pianks.
4 Floor topping laid over the hardned suspended slab.	40	The topping shall be laid separately over the specially prepared surface of set and hardened suspended slab.
5 Floor topping laid over cushioning layer	40	Cushioning layer of lime concrete of 40 to 50 mm thickness shall be laid over the prepared surface of suspended slab. Granolithic cencrete topping shall be laid as in 4.

8. *Curing* :

8.1. Immediately after the flooring surface is finished it shall be protected from rapid drying, by erecting barriers against wind or draught and strong sunlight. As soon as the surface had hardened sufficiantly to prevent damage to it, shall be kept continuouly moist for at least ten days by means of wet gunny bags, 50 mm thick layer of damp sand spread over the surface or pooling water on the surface: During this period the flooring shall not be exposed to any traffic premature exposure to traffic will lead to damage to the surface which cannot be satisfactorily repaired.

EXTRACT FROM I.S. 2571—1970.

Code of practice for laying in situ cement concrete flooring.

(First Revision.)

0. *Forward.*

0.2. In-situ cement concrete flooring consists essentially of rich cement concrete, and possesses good wearing properties and facility of easy cleaning and maintenance which make it suitable for use in houses, offices, schools, hospitals and light industrial buildings Depending upon the amount of loading and the degree of wear resintance needed, the floor finish has to be laid in various thickness and a careful selection has to be made regarding mix proportions panel sizes and number of layers. Also the laying operations have to ensure the proper bonding of the finish to the base or sub-floor This code provides necessary guidance in the selection of matrials and laying and finishing of cement concrete flooring for obtaining satisfactory performance.

4.2.1.1. *Coarse aggregate* :— The grading of graded coarse aggregate for cement concrete flooring mix shall be within the limits given in Table 1. The coarse aggregate shall generally be of the following sizes :—

(a) Base concrete (lean cement concrete or lime concrete).	Graded from 40 mm. and below.
(b) Cement concrete topping of thickness 40 mm and above.	Graded from 16 mm and below.
(c) Cement concrete topping of thickness 25 mm.	Graded from 12.5 mm and below.
(d) Under-layer of cement concrete topping two layers.	Graded from 12.5 mm and below,

TABLE 1—COARSE AGGREGATE.

(*Clause* 4.2.1.1.)

I.S. sieve designation. in mm.	*Percentage passing for graded aggregate of nominal size.*			
	40 mm.	20 mm.	16 mm.	12.5 mm.
(1)	(2)	(3)	(4)	(5)
40	95 to 100	100	..	..
20	30 to 70	95 to 100	100	100
16	..	..	90 to 100	..
12.5	..	..	..	90 to 100
10	10 to 35	25 to 55	30 to 70	40 to 85
4.75	0 to 5	0 to 10	0 to 10	0 to 10
2.36	..	..	..	..

4.2.1.2. *Fine aggregate*:—The grading of fine aggregate for cement flooring mix shall be within the limits of one of the two zones given in Table 2. The fine aggregate shall be described as fine aggregate of the grading zone into which it falls.

TABLE 2—FINE AGGREGATE.

I.S. sieve designation.	*Percentage by weight passing I.S. sieve.*	
	Grading zone 1.	*Grading zone* 2.
(1)	(2)	(3)
10.00	100	100
4.75	90—100	90—100
2.36	60—95	75—100
1.18	30—70	55—90
600 micron	15—34	35—59
300 micron	5—20	8—30
150 micron	0—10	0—10

5.2. *Mix proportions.*—Mix proportions for the base concrete and the topping for different types of floor finish shall be as specified in Table 3.

NOTE :—So far the practice had been to use 1:2:4 cement concrte for topping for bonded finish, but this mix is being increasingly replaced these days by 1:2½:3½ mix. because it gives much better workability and finish.

TABLE 3—RECOMMENDED SPECIFICATIONS FOR DIFFERENT TYPES OF CEMENT CONCRETE FLOOR FINISHES.

Type.	*Sub-base.*	*Base concrete.*		*Topping.*		*Remarks.*
		Minimum thickness. in mm.	*Mix.proportion.*	*Minimum thickmess in mm.*	*Mix. proportion.*	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
		A. CONCRETE FLOORING LAID OVER GROUND.				
I	Thoroughly consolidated ground covered with 100 to 150 mm. well rammed (preferably course) sand.	100 ..	Cement concrte 1:4:8 (cement: fine aggregate: course stone aggregate of 40 mm and below by volume).	20 ..	Cement concrete 1:2 to 3 (cement; stone aggregate of size 4.75 mm and below by volume).	Cement concrete topping shall be laid monolithic with the base concrete.
1-A	100 mm thick hard core of well consolidated dry brick or stone aggregate blinded with MOORUM (disintegrated rock) or coarse sand laid over well rammed sand filling of 100 mm. thick.	100 ..	Cement concrete 1:4:8 (cement: fine aggregate: coarse stone) aggregate of 40 mm. and below by volume.	25 ..	Cement concrete 1:2:4 (cement: fine aggregate: coarse stone aggregate of size 12.5 mm and below by volume).	In places such as garrages where wheeled traffic comes into contact with the flooring the sub-base shall have a hard core over the well ramned sand filling. The Cement concrette topping shall be laid monolithic with the base concrete.

TABLE 3—RECOMMENDED SPECIFICATION FOR DIFFERENT TYPES OF CEMENT CONCRETE FLOOR FINISHES.

Type	*Sub-base.*	*Base concrete*		*Topping.*		*Remarks.*
		Minimum thickness in mm.	*Mix-proportion.*	*Minimum thickness in mm.*	*Mix-proportion*	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
I-B	Stone ballast (40 mm. graded aggregates) mixed with locally available yellow or redsoil or soft Moorum in 1:1 proportion shall be compacted to about 300 mm. thickness and thoroughly saturated with water. This surface should be further covered with another 200 mm thick layer of soft MOORUM or cinder or sand and compacted properly before laying the base concrete.	100	Cement concrete 1.4.8. (Cement: fine aggrigate: coursc stone aggregate of 40 mm. and below by volume.)	20	Cement concrete 1:2 to 3 (cement stone aggregate of size 4.75 mm and below by volume).	In the regions having expansive soils like the black cotton soil the sub-base shall be laid as described. The topping shall be laid monolithic with the base concrete.
II.	Thoroughly consolidated ground covered with 100 to 150 mm well rammed (preferably coarse sand.)	100	Cement concrete 1:5:10 (Cenent; fine aggregate: coarse stone aggregate of size 40 mm and below by volume) (or lime concrete).	25	Cement concrete 1:2½: 3½ (Cement; fine aggregate: coarse aggregate of size 12.5 mm. and below by volume)	Topping shall be laid separately over specially prepared surface of set and hardened base concrete.
III.	Thoroughly consolidated ground covered with 100 to 150 mm. well rammed (preferably coarse sand).	100	Cement concrete 1:5:10 (Cement: fine aggregate: coarse stone aggregrate of size 40mm. and below by volume or lime concrete.	Under layer 25.	Under-layer cement concrete, 1:3:6. (cement: fine) aggregate coarse stone aggregate of size 12.5 mm. and below by volume.	Under-layer shall be laid separately over specially prepared surface of set and hardened base concrete. Wearing layers shall then be laid over the green surface of under layer and finished monolithick with it.
				Wearing layer 15.	Wearing layer cement concrete 1:2 to 3 (cement : stone aggregate of size 4.75 mm and below by volume).	

NOTE.—In regions having expansive soils, the sub-base shall be laid as given in type I-B for both Type II and Type III flooring.

B. FLOOR TOPPING LAID OVER STRUCTURAL / SUSPENDED SLABS.

IV.	..	..	—	15	Cement concrete 1:2 to 3 (Cement: stone aggregate of size 4.75 mm. and below by vloume).	Cement concrete topping shall be laid and finished monolithic with the structural slab. For this purpose the topping shall be laid immediately after the structural concrete has stiffened enough (but is still green) to allow for the workemen to tread over it by placing planks.

TABLE 3—RECOMMENDED SPECIFICATIONS FOR DIFFERENT TYPES OF CEMENT CONCRETE FLOOR FINISHES—*ont.*

Type.	*Sub-base.*	*Base concrete.*		*Topping.*		*Remarks.*
		Minimum thickness in mm.	*Mix-proportion.*	*Minimum thickness in mm.*	*Mix-proportion.*	
(1)		(3)	(4)	(5)	(6)	(7)
V.			..	25 ..	Cement concrete 1:2½:3½(Cement: fine aggregate: coarse stone aggregate of size 12.5 mm. and below by volume).	Topping shall be laid directly over the specially prepared surface of set and hardened structural slab.
VI	..	..	..	Under layer 25. ..	Under layer cement concrete 1:3:6 (cement: fine aggregate: coarse stone aggregate of size 12.5mm and below by volume.)	Under layer shall be laid directly over the specially prepared surface of set and hardened structural slab. Wearing layers shall then be laid over the green surface of under layer and finished monolithic with it.
	..	..	..	Wearing layer 15 ..	Wearing layer cement concrete 1:2 to 3 (Cement: stone aggregate of size 4.75 mm and below by volume.)	
VII	..	50 to 75	.. Lime concrete.	Same as for V or VI		Cushioning layer of lime concrete shall be laid over the prepared surface of structural/suspended slab. Cement concrete topping shall be laid as for V or VI. Lime concrete shall be prepared and laid as per relevant requirements of I.S.2541-1965" Code of Practice for use of lime concrete in buildings."

5·7. *Size of panels.*—Floor finish shall be divided into suitable panels so as to reduce the risk of cracking. Size of the panel is governed by the thickness of floor finish, the type of construction (monolithic or bonded construction) local conditions of temperature, humidity and the season in which flooring is laid. For floor finish laid in exposed situations or in hot and dry climates, the size of the panels shall be smaller as compared to the floor finish laid in less exposed situations or in cold and humid climates; the size of panels for integral floor finish can be larger than that of floor finish laid separately on the hardened base. Generally, no dimension of a panel shall exceed 4 m in case of floor finish laid monolithically with the base concrete and 2 m in case of floor finish laid separately on a hardened base; length of a panel shall not exceed 1 1/2 times its breadth.

5·7·1 The joints in the floor finish shall extend through the borders and skirtings. If the skirting is laid monolithic with the flooring a border of about 300 mm width must be provided a round the floor. The width of border provided around the floor when the skirting is not monolithic with floor finish shall not exceed 450 mm.

5·7·2. Construction joints between bays of the floor finish should placed over any joints in the base concrete.

8. *Laying concrete flooring on ground.*

8·1. *Floor finish laid monolithically with the base concrete* (finish types, I and I-A and I-B).

8·1·1 *Preparation of sub-base.*

8.1.1.1. The ground or earth filling shall be thoroughly compacted so that there are no loose pockets left any where in the whole area This shall then be covered with clean sand well consolidated to a thickness of not less than 100 mm. Great care is necessary in the preparation of the sub-base, as a settlement in the sub-base may cause the failure of the whole floor.

8·1·1·2· In situations, such as garages where wheeled traffic comes into contact with the flooring sub-base shall consist of well compacted sand layer of 100 mm thick and an additional 100 mm thick well compacted hard core of dry brick or stone ballast (40 mm size) blinded with *Moorum* disintegrated rock or coarse sand.

8·1·1·3· In the case of expansive soils, like black cotton soil, stone ballast (40 mm graded aggregates) mixed with locally available yellow or red soil or soft *Moorum* in 1:1 proportion shall be compacted to about 300 mm thickness and thoroughly saturated with water. This surface should be further covered with another 200 mm. thick layer of soft *Moorum* or cinder or sand and compacted properly before laying the base concrete. Special care is necessary in consolidation of the ground as otherwise the settlement of sub-base may cause cracking of the whole floor.

8·1·2 *Laying the base.*—The area to be paved shall be divided into suitable panels keeping in view the limits specified in 5·7. This shall be done by fixing screed strips, the depth of which shall be equal to the combined thickness of the base concrete and the topping Before being laid in position the screed strip shall preferably be coated with a thick coat of lime wash so as to prevent them from sticking to the concrete deposited in the panels.

8.1·2,1. Before placing the base concrete, the sub-base shall be properly wetted. The concrete shall then be deposited between the screed strips thoroughly tamped and the surface screeded unifomly below the desired finished grade of flooring to acommodate the required thickness of topping. Any slope desired in the floor finish shall be given in the base concrte. The surfaces shall not be finished smooth but kept rough to provide adequate bond for the topping.

8·1·3· *Laying the topping.*—On the clean, green surface of the base concrete, the topping shall be placed in position as soon as possible but generally not later than two or three hours of laying the base concrete depending upon the temperature and the atmospheric conditions. The base concrete at the time of laying the topping shall be still green but sufficiently firm to enable the workman to work over it by placing planks on its surface.

8·1·3·1. The concrete mix for the topping shall be deposited on the base concrete in the screed strips already laid and thoroughly compacted to the finished thickness. Glass or aluminium strips may be provided for effective separation of panels and to provide straight edges and corners for the panels where good workmanship is required. The mix for the topping shall be stiff enough to prevent accumulation of any excess water or laitance on the suface. If water or laitance rises to the surface when consolidating (which indicates that too, much of water has been used in the preparation of concrete) the concrete should preferably be scraped and replaced by a fresh mix. If it is desired to absorb surplus water for any reason, it should be mopped up; it should on no account be absorbed by spreading dry cement. The topping shall then be floated with a wooded float to render the surface even and after the surface is slightly hardened it shall be finished smooth as described in 8·1·3·2.

8·1·3·2. *Finishing the surface.*—After the concrete has been fully compacted it shall be finished by trowelling or floating, finishing operations shall start shortly after the compaction of concrete and shall be spread over the period of one to six hours depending upon the temperature and atmospheric conditions. The surface shall be trowelled three times at intervals so as to produce a uniform and hard surface. The satisfactory resistance of floor to wear depends largely upon the care with which trowelling is carried out. The object of trowelling is to produce as hard and close knit a surface as possible The time interval allowed between successive trowellings is very important. Immediately after laying only just sufficient trowelling shall be done to give a level surface. Excessive trowelling in the earlier stages shall be avoided as this tends, to work a layer rich in cement to the surface. Sometime, after the first trowelling, the duration depending upon the temperature, atmospheric conditions and the rate of set of cement used, the surface shall be retrowelled to close any pores in the surface, and to bring to surface and scrap off any excess water in concrete or laitance (it shall not be trowelled back into the topping). The final trowelling shall be done well before the concrete has become too hard but at such a time that considerable pressure is required to make any impression on the surface. Trowelling of a rich mix of dry cement and fine aggregate on to the surface shall not be permitted.

8·1·4. The base concrete and the topping shall be laid in alternate panels the intermediate panels being filled in after one to two days depending upon the temperature and atmospheric conditions. The screed strips should be removed the next day after the concrete has been deposited in the panels and the edges of panels shall be examined for any honey combing or undulation which, if found shall be repaired straight and smooth by cement mortar. If the intermediate panels are not to be filled the next day the screed strips shall then be cleaned and put back against the edges of panels till the concrete in the alternate panel is to be deposited. When the concrete is being deposited in the alternate panels the screed strips shall be removed. When the concrete is being compacted in new panels, care shall be taken to avoid damage to the panels already laid. If glass or aluminium strips are provided for effective separation of panels the base concrete and the topping may be laid in all the panels simultaneously.

8·2. *Floor finish laid separately or hardened concrete base:*
(Finish type II).

8·2·1. *Preparation of sub-base*—The sub-base shall be prepared as described in 8·1·1·1, 8·1·1·2 and 8·1·1·3.

8·2·2. *Laying the base concrete*—The base concrete may be deposited in the whole area at a stretch. Before placing the concrete the sub-base shall be properly wetted and rammed. The concrete shall then be deposited between the forms, where necessary, throughly tamped and the surface finished level with the top edges of the forms. The surface of base concrete shall be left rough to provide adequate bond for the topping. Two or three hours after the concrete has been laid in position, the surface shall be brushed with a hard brush to remove any scum or laitance and swept clean so that the coarse aggregate is exposed.

8·2·3· *Laying the topping.*—Before the operation for laying the topping is started the surface of base concrete shall be throughly cleaned of all dirt, loose, particles, caked mortar droppings, and laitance if any, by scrubbing with coir or steel wire brush. Where the concrete has hardened so much that roughening of surface by wire brush is not possible, the entire surface shall be roughened by chipping or hacking. Before laying the topping, the surface shall be soaked with water, at least for twelve hours and surplus water shall be removed by mopping immediately before the topping is laid in position.

8·2·3·1. The screed strips shall be fixed over the base concrete dividing it into suitable panels as recommended in 5·6. The screed strips shall be so arranged that the joints, if any, in the base concrete shall coincide with the joints in the topping. Before placing the concrete mix for topping, neat cement slurry shall be throughly brushed into the prepared surface of the base concrete just ahead of the finish. The topping shall then be laid very throughly tamped, struck off level and the surface floated with a wooden float. The surface shall be tested with the straight edge and mason's spirit level to detect any inequalities in the surface which, if any shall be made good immediately. The finish shall be laid in alternate panels as described in 8·1·4. for topping laid monolithic with the base concrete.

8·2·3·2. *Finishing the surface.*—The surface shall be finished as given in 8·1·3·2.

8·2·4. *Laying the topping in two layers.*—Where the topping is to be laid in two layers to obtain very smooth and dense finish (see finish type III, Table 3), the sub-base, base concrete and under layer of topping shall be laid as described in 8·2·1 to 8·2·3 with the exception that the surface of the concrete in the under layer of topping shall not be finished smooth with a trowel but left rough after tamping it with screed board.

8·2·4·1 The top 15 mm. thick wearing layer of mix 1:2 to 3 cement concrete (depending upon the quality of finish and abrasive resistance desired) of consistency stiffer than that of under-layer concrete shall then be immediately laid over the rough but green surface of under-layer, and throughly tamped struck off level, and the surface floated with wooden float. The surface shall then be tested with a straight-edge and mason's spirit-level to detect any undulation in the surface which, if any, shall be made good immediately. The surface shall then be finished smooth in accordance with 8·1·3·2.

9· *Laying floor topping on suspended slabs.*

9·1. Floor topping laid monolithically with the structural/suspended slab (Finish type IV).

9·1·1. The form work for structural slab shall be erected to the finished thickness of floor finish. Structural concrete shall be deposited in the forms, throughly consolidated and surface finished below the top edge of the form to accommodate the required thickness of the topping. Any slope required in the floor finish shall be given in the structural concrete itself, and any laitance or scum shall be brushed away from the surface of concrete when it is still green. The surface shall not be finished smooth but kept rough to provide an adequate bond for the topping.

9·1·2. On the green surface of the structural concrete, topping, shall be placed in position immediately after the structural concrete has stiffened enough (but is still plastic) to allow for the workmen to tread over it by placing planks. Laitance and foreign matter, if any, shall be removed before the topping is placed in position. The topping shall be throughly campacted and screeded to the finished grade. The mix for the structural concrete as well as the topping shall be as stiff as possible cansistent with workability so as to prevent accumodation of excess of water or laitances on the surface. The topping shall then be floated with a wooden float to render the surface even. After the surface is lightly hardened, it shall be finished in accordance with 8·1·3·2.

9·2· Floor topping laid directly over the hardened, structural/ suspended slab (Finish types V and VI).

9.2.1. Preparation of surface of structural suspended slab.—When the topping is to be laid separately but directly over the structural slab without any cushioning layer, the structural concrete, 3 to 4 hours after its laying in the forms, shall throughly brushed with a coir or steel wire brush to remove any scum or laitance and swept clean to expose the coarse aggregates and leave the surface rough.

9.2.2. *Laying topping.*— Before the operation of laying the topping is started the surface of structural slab shall be throughly cleaned of the dirt, loose particles, cake mortar droppings and laitance, if any, by scrubbing with coir or steel wire brush. Where the concrete has hardened so much that roughening of surface by wire brush is not possible, the entire surface shall be roughened by chipping or hacking.

9.2.3. The screed strips shall then be fixed over the structural slab dividing it into suitable panels as recommended in 5·7. Immediately before depositing the concrete for the topping, neat cement slurry shall be throughly brushed into the prepared surface of the structural slab, just ahead of the finish. The topping shall then be laid thoroughly tamped, struck off level and surface floated with a wooden float. The surface shall then be tested with a straight-edge and mason's spirit level to detect any inequalities and undulations in surface which, if any, shall be made good immediately. The finish shall be laid in alternate panels as described in 8·1·4 and other laying and finishing operations shall be done as in 8.2.3 and 8.2.41 depending upon whether the topping is to be laid in single or two layers.

9.3. *Floor topping laid over cushioning layer of lime concrete* :

9.3.1. *Preparing the sub-floor.*— Before laying the lime concrete, the surface of sub-floor shall be thoroughly cleaned of dirt, loose particles and laitance (in case of RCC slabs) by scrubbing with steel wire brushes. The surface shall then be thoroughly cleaned and soaked with water overhight and surplus water removed by mopping immediately before lime concrete is laid in position On the clean damp surface of sub-floor, lime concrete shall then be evenly spread between forms, if necessary, thoroughly tamped and levelled. In the preparation and laying of lime concrete the relevant provisions of I.S. 2541—1965 shall as far as possible, be followed.

9.3.2. *Laying the topping.*— Before laying the topping, surface of lime concrete shall be thoroughly cleaned and prepared as recommended for base concrete in 8.2.2. and 8.2.3. immediately before spreading the concrete for topping, the surface shall be brushed with a thin layer of neat cement slurry. The topping whether in single or two layers shall then be laid as given in 8.2.3 and 8.2.4.

11. *Curing* :

11.1. Immediately after the flooring surface is finished, it shall be protected from rapid drying by erecting barriers against wind or drought and strong sunlight. As soon as the surface has hardened sufficiently to prevent damage to it shall be kept continuously moist for at leasts Fifteen days by means of wet gunny bags, 50 mm thick layers of damp sand spread over the surface or pooling water on the surface. During this period the flooring shall not be exposed to any traffic. Regular traffic on the floor should be allowed only after 28 days.

EXTRACT FROM I.S. 1443—1959.

Code of practice for laying and finishing of cement concrete flooring tiles.

7.2. *Completion of preceding work.*

7.2.1. All the inside walls, ceiling and outside walls shall be plastered and door frames and windows fixed in place. All heavy work in the room shall be completed.

7.2.2. The sub-floor shall be finished to a reasonably true plane surface about 35 mm to 45 mm below the level of the finished floor properly graded and free from loose earth, dirt or dust and lumps.

7.3. Before the tiling work is started, all points of level for the finished tile surface shall be marued out. This is particularly necessary in the case of finished staircase buildings.—Wherever slopes in finished floors are desired, points of level and outlets shall be correctly marked and outlet openings made beforehand.

7.4. *Protection against dampness.*—Wherever it is feared or suspected that dampness may percolate on the top of the sub-floor or base during any time of the year, the same shall be treated or covered with any of the recognized damp-proofing methods to prevent dampness or water occurring on the top of the sub-floor or bast. Where it is suspected that water may percolate from the side wall the same shall also be properly water proofed up to at least 15 cm, (or 6 in) above the level of the sub-floor.

9. *Bedding* :

9.1. *Preparation of mortar*.—Lime mortar is definitely preferable to cement mortar for preparing the bed of the tiles.

9.1.1. Care shall be taken in the preparation of the mortar to ensure that there are no hard lumps that would interfere with the even bedding of the tiles.

9.2. *Spreading*.—Before spreading the lime or cement mortar, the sub-floor or base shall be cleaned of all dirt, scum or laitance, and of loose material and then well wetted down without forming any water pools, on the surface. In the case of reinforced concrete floors, the top shall be left rough and the surface shall be scoured with brush or broomstick while the base concrete is green. The mortar shall then be evenly and smoothly spread over the base by the use of screed battens. The thickness of this bedding shall normally be not less than 10 mm (or 3/8 inch) and not more than 20 mm (or 3/4 in.) in any place.

Screeds properly levelled, shall be fixed at the correct height to out the thickness of the screed bed. The lime mortar shall be spread on the sub-floor or base and levelled with a screeding Board. The slightly rough surface left by the screeding board forms a satisfactory key for the tiles.

Wherever big areas of floor are to be tiled, the level of the central portion of the floor shall be kept 10 to 20 mm higher than the level marked at the walls (depending on the size of the hall), unless specified otherwise. This is normally done to aviod the optical illusion of a depression in the central portion of the tiled hall.

The actual fixing of the tiles may being after the bedding mortar has become sufficiently hard to offer a fairly rigid cushion for the tiles and to enable the mason to place a wooden plank across and squat on it. The fixing may be done on the same or the next day.

10. *Fixing*.

10.1. Neat cement grout of the honey like consistency shall be spread over the mortar bed, over such an area at a time as would accommodate about 20 tiles. The tiles shall be fixed in this grout one after the other, each tile being gently tapped with a wooden mallet till it is properly bedded and in level with the adjoining tiles. The mason shall keep the joints as close as possible and in straight lines. The joints between the tiles shall normally be 1·5 mm (or 1/10 in.) wide.

10.2. After the tiles have been laid in a room or the day's fixing work is completed, the surplus cement, grout that may have come out of the joints, shall be cleaned off, generally, with saw dust.

10.3. The day after the tiles have been fixed, the joints shall be re-filled with cement paste or grout of the same or approximate shade as the colour of the matrix of the tile. Before the joints are filled, they shall be cleaned with a wire brush or with the point of a trowel and any loose cement, dirt or dust in the joints shall be removed. The freshly laid portion of mortar bedding shall be prevented from damage by providing suitable barricading.

10.4. Tiles which are fixed in the floor adjoining the wall shall go about 10 mm. (or 1/2 in.) under the plaster, skirting or dado as may be required by the designor. For this purpose, by mutual agreement between the tile layer and the wall plastering contractor the wall plaster may be left unfinished by about 50 mm. (or 2 in.) above the level of the proposed finished floor level, and the unfinished strip may be plastered later or after the tiles are fixed and polished

10.5. Generally, where tile flooring is intended to be used, the dimensions of room each way may be designed to be multiples of tile dimension centre to centre of joints. In cases where the dimensions of the room may not possibly be adjusted to be a multiple of the tile dimensions, a fractional tile may be used to fill the space. When the extra space is less than 25 mm. (or 1 in.) it may be filled with a mortar of equal parts of sand, marble chips and cement, coloured to match with the tiles.

10.6. After fixing, the flooring shall be allowed to mature undisturbed for seven days so that the bedding acts properly. After this, it may be used for light traffic. Heavy traffic shall not be allowed on the floor for at least 14 days after fixing the tiles.

11. *Polishing*.

11.1. Polishing of the tiles shall be commenced only after the floor as well as the joints have dried up.

11.2. Polishing may be done either by hand or by machine.

11.2.1. If polished by hand, the tiles shall first be thoroughly wetted with clean water and rubbed down with a suitable polishing stone evenly and without scratching the surface. Therefore, the floor shall be washed clean and again rubbed hard with felt and slightly moistened oxalic acid powder.

11.2.2. When polishing with machine, carborundum stones of the following grit shall be used :—

(*a*) For levelling (usually done in the factory. Also *see* 12.)	24 to 60
(*b*) For second grinding (for removal of filling of plaster on the surface of the tile).	120 to 150
(*c*) For final grinding	220 to 350

Sufficient quantity of water shall always be used when polishing with machine to prevent scratching.

11.3. After polishing the floor shall be very carefully washed clean and dried. When dry, the floor shall be covered with oil-free, dry saw dust which shall be removed only after all the construction work, such as painting, distempering, etc., in the area is finished, and just before it is occupied, while removing the saw dust, finer polish may be obtained by running the floor machines fitted with bessian bobs or felts until the floor shines.

11.4. Terrazo tiles shall ordinarily be polished by machine as in 11.2.2. but for small areas or if circumstances so require, as in the case of wall-tiling they may be polished by hand as in 11.2.1. Plain cement tiles may be polished by hand or by machine.

11.5. *Chequered or grooved tiles*.—These tiles, whether plain or terrazo, shall always be polished by hand as in 11.2.1. Machine polishing shall not be used as it may damage the embosed or chequered portions of the tiles.

12. *Laying of rough tiles*.

12.1. Where tiles have been supplied and fixed in rough condition (not ground and filled by the manufacturer), the first grinding shall be done at about seven days after fixing the tiles. A floor surfacing machine with carborundum stones of 24 to 60 girt shall be used and the tiles ground till the cross section of the marble chips or grains are sufficiently exposed. Thereafter, the floor shall be throughly washed and brushed so as to remove any loose particles or dust from the pores and joints of the tiles.

12.2. The pores and joints shall then be filled with coloured cement paste or grout, as the case may be, the colour being as far as possible of the same shade as of the matrix of the tiles. The filling shall be firmly rubbed into the surface of the tiles so that all the pores are well and properly filled.

12·3. The filling shall be kept moist for two days and then allowed to dry for eight days. Thereafter the tiles shall be polished as in 11.

13. *Skirting, dado work, staircase tread work, etc.*

13·1. The skirting, where required, shall be fixed only after laying the tiles on the floor. If tiles are to be fixed on walls (dado work) the protion of the wall to be so tiled shall be left unplastered. Also, dado work shall be done only after fixing tiles on the floor.

13.2. Before fixing tiles on brick or concrete wall the wall surface shall first be wetted with clean water. There after, it shall be evenly and uniformly covered with a coating of lime or cement mortar about 20 mm. (or 3/4 in.) thick. Before the cushioning mortar has hardened, the back of each tile to be fixed shall be covered with a thin layer of neat cement paste and the tile shall then be gently tapped against the wall with a wooden mallet. The fixing shall be done from the bottom of the wall upwards. Each tile shall be fixed as close as possible to the one adjoining and any difference in the thickness of the tiles shall be evened out in the cushioning mortar or cement paste so that all the tile faces are set in conformity with one aaother.

13·3. Wherever possilbe skirtings and dado shall be ground and polished just as for floor work with machine suitable for the purpose. Skirtings and dado may also be polished by hand.

13.4. Precast treads and risers for staircases shall be bedded and polished as for flooring.

13.5. The laying and polishing of tiles for external paving shall be done similar to that of ordinary flooring.

14. *Cleaning.*

14·1. Upon completion of tiling work in each portion of floor or wall, as the case may be, all unused surplus materials, rubbish, debris, etc., of the tiling work shall be removed away from the finished surface. The finsihed work shall be thoroughly cleaned with water using a scrubbing brush, coarse cloth or broom. Acids, harsh abrasive cleaning powers or steel wire shall not be used under normal circumstances :

15. *Appearance.*

15.1. The finished floor shall have an even, smooth surface. It shall not be waxed with a view to increasing its gloss. Joints shall be filled and set in correct alignment.

NOTE (1).—Normally all freshly laid tile floors and dado work may show efforescence even after the tiles are polished. This may be particularly noticeable in plain tile floors. This may not affect the quality of the tiles or of the finished floor; the same may acquire a beautiful, natural sheen after two to three months of daily cleaning. When all the salts from the concrete have come to the surface and are washed off, there will be no more trouble from this cause and the floor will require less work for its upkeep. If quality tiles have been used, their natural gloss will improve with age and wear.

NOTE 2.—Pin holes may also appear in the finished floor. Tiny air cells, which may be too small to be filled, may be sometimes opened up in terrazo tiles on account of the polishing process.

NOTE 3.—Variations may occur in the shades of cement used in the matrix, in the colour and shade of the marble chips and in the distribution of the chips over the tiles. Within limits, such variations may add to the character and attractiveness of the overall colour and design.

16. *Maintenance.*

16·1. *Care immediately after the work* :

16.1.1. After laying, the floor shall be allowed to remain clean and free from cement, oil, paint, distemper, plaster droppings and all materials likely to stain or spoil the tiles. If appliances, such as trestles, ladders, stops, etc., have to be used for electricians, plumber's and other light work it shall be arraged that parts in contact withd. the flooring are badded by the contractor doing such work and no sliding of the appliances on the fiinished flooring is permitted. The owner shall also take care, when the floor is used for subsequent operations, that staining, damaging or pitting of the tile work is entirely prevented.

16.2. *Subsequent maintenance* :

16·2·1. Cement tile floors shall be daily swabbed with clean water for atleast three months after they have been fixed and polished. If they are very dirty, water and soap may be used. Care shall be taken to remove any soap film deposited in washing, as failure to do so will result in the floor becoming slippery and dull-looking. Use of soda, acid etc., shall be avoided.

EXTRACT FROM I. S. 3670—1966.

Code of practice for construction of timber floors.

4. *Materials* :

4·1. *Species of timber* :

4·1·.1 Species of timber recommended for use of floor boards shall be those specified in Appendix A. Species of timber selected for girders, binders and projecting joists shall be those specified in Appendix B.

4·1·2· Timber selected for construction of the fioor, namely, boards and the supporting members shall conform to the requirements specified in Appendix C.

7. *Construction* :

7.1. *Single joisted floors* :

7·1·1· Bridging joists shall be laid to support the floors. The maximum span of the joist shall not exceed 3·5 m.

The minmum width of bridging joists shall not be less than 5 cm and shall have the ratio of depth to breadth between 3 and 4· These shall be designed strong enough and shall not deflect more than 1/360 of the span.

7·1·2. *Single joisted floors at ground level.*—While laying such floors the steps as given in 7-1-2-1 to 7-1-2-7 shall be adopted.

7.1.2.1. The area below the floors shall be cleaned of vegetation.

7.1.2.2. The cleared area shall be evenly spread and spade-finished 15 cm. with a layer of cement concrete 1:3:6· (1 Cement; 3 sand; 6 coarse aggregate of 19 mm gauge).

7.1.2.3. Honey combed sleeper walls or dwarf walls shall be of half brick (12 cm) thickness minimum built at a maximum distance apart of 2 to 2·5 m.

7·1·2·4. Air space shall be provided in the intermediate walls to give maximum cross ventilation to avoid dead spots by providing honeycomb constructions.

7·1·2·5· The ventilated space per linear metre of outer foundation walls shall be provided as given below:

Climate.	*Space required.*	*Climate.*	*Space required.*
(1)	(2)	(1)	(2)
	cm^2		cm^2
Very humid ..	85	Mild ..	45
Humid ..	65	Dry climate ..	22

7.1.2.6. Proper cross ventilation shall be provided under the floor by means of air-bricks or honey combed ventilators in order to avoid condensation of moisture contetnts on the underneath of timber floor thus minimising the possiblities of attack by fungus, rot, etc., which decay the timber. These outer ventilators shall be covered with wire guaze or other such effectual methods to avoid entry of reptiles, rats, etc.

7·1·2·7. A mimum of 30 cm. floor space shall be provided between the underside of every joist or girder of the ground floor and the top surface of the concrete or the level of floor below.

7·1·3. *Single joisted upper floors.*—While laying such floors steps as given in 7·1·3·1 to 7·1·3·5 shall be followed.

7·1·3·1· Bridging Joists shall be placed across the shortest span.

7·1·3·2. The joists shall rest on wall plates. No wall plate shall be built into solid walls as it causes decay. When joists are built into walls without wall plates, the ends of joists bedding into the wall shall be treated with suitable preservative.

7·1·3·3. Where the space between the bridging joists is greater than 2·5 m. strutting shall be provided between the joists in continuous rows at intervals of not more than 2 m. apart.

7·1·3·4. Strutting shall normally be of herring bond type, the minimum size of members being 5×3 mm. Solid strutting, usually provided for heavy floors, may also be provided. The depth of strutting member in the latter case, shall be three-fourths of the depth of joist and breadth shall have a ratio of one-thrid to one-fourth to the depth.

7·1·3·5. Trimming or framing of timbers, around the openings in floors shall consist of trimming joists, trimmer joists and trimmed joists fitted by means of tusk tenon joints.

7·2. ***Double joisted floors*** **:**

7·2·1. This type of floor shall be adopted where span of bridging joints is more than 3·5 m but less than or equal to 5 m.

7·2·2. *Laying of floor.*—The floor shall be supported on bridging joists which, in turn, shall be supported on binders. The binders shall have a maximum span of 5m. These shall not be placed over door, window openings unless supported by lintels or beams designed to support the incumbent load.

7·3. ***Triple joisted floors or framed floors*** **:**

7·3·1. This type of floor shall be adopted where span of binders exceeds 5m but not exceeding 10 m.

7·3·2. *Laying of floors.*—Bridging joists shall be supported on binders which in turn shall rest on timber girders.

7·3·2.1. *Timber girders*.—The girders shall be laid along the short span, and shall be placed at a maximum spacing of 5 m.

7.3.2.2. *Binders.*—These shall be supported on timber girders and shall be jointed to those by tenon joints. The line of binders in each section shall be broken to avoid tenons coming directly opposite to each other and thus weakening the section.

7.4. *Solid timber floors.*

7.4.1. This type of floor consists mainly of a sub-floor of cement concrete and main floor of timber planks.

7.4.2. *Laying of floors.*—The laying of floor shall be carried out as follows :—

(*a*) *Sub-floor.*—It usually consists of cement concrete floor and shall have a thickness of 5 to 7·5 cm.

(*b*) *Wooden fillets.*—When the cement concrete sub-floor is still wet and has not set, timber fillets treated with presevatives made from heart wood of hardwood species of section 12.5×4 cm. shall be laid flush with the top of sub-floor. For floors where springing effect is desired, for example, in dance floors, the timber-fillets shall be raised by about 8 mm. above the level of sub-floor.

The fillets shall be laid along the short span, spaced 60 cm. apart centre, to centre, and shall be embedded minimum upto one-third of the depth of sub-floor to protect the timber planks from the dampness.

(*c*) *Main floor.*—It shall be of timber planks not less thn 2·5 cm. in thickness and shall be supported on timber fillets.

7.5. *Purpose made floor.*

7.5.1. These floors are primarily hollow floors with bridging joists and binders, etc., and are construeted for specific purposes. These are generally constructed for following purposes :—

(*a*) Skating rink floor ;

(*b*) Badminton floor ; and

(*c*) Squash floor.

7.5.2. *Laying of floors.*—Steps mentioned below shall be followed while laying such floors :—

(*a*) Timber fillets or plugs about 10 cm. deep shall be embedded in the cement concrete floor when it is still wet ;

(*b*) The timber fillets or plugs shall be at a maximum distance of one metre centre to centre along the longer length of the walls of the room ;

(*c*) On two opposite fillets or plugs in the opposite walls, the two ends of a timber floor joist shall be laid on the concrete floor ;

(*d*) An iron screw shall pass through the joist and the wooden fillets ;

(*e*) On one deeper side of the floor joist a groove 2 cm. high × 2 cm. deep shall be made before the erection of the joist ;

(*f*) Timber runners of type as shown in Figs. 10-A and 10-B shall then be inserted in the groove and adjacent to the floor joists ;

(*g*) Timber flooring boards shall then be placed at right angles to the length of the floor joists below ; and

(*h*) Screws shall pass through the wooden runners and the flooring boards starting from the bottom end of the wooden runners and going into the flooring boards upto three-fourth depth such that the screws are invisible from above (*See* Figure 10).

Figure.—10-A Section through the floor ; 10-B Enlarged detail of timber runner.

8. *Timber floor boards.*

8.1. Unless otherwise specified, the flooring boards, namely planks shall be 40 mm. thick and shall not be greater than 15 cm. *wide* and 3 m. long.

9. *Jointiug details for floor boards* (see *figure* 11).

9.1. The following types of ioints (listed in order of their efficiency) shall generally be used for joining of the floor boards:—

(*a*) Square of butt ;

(*b*) Splayed (Figure 11-B) ;

(*c*) Rebated and filleted (Figure 11-C) ;

(*d*) Rebated (Figure 11-D) ;

(*e*) Tongued and grooved (Figure 11-E) ;

(*f*) Rebated, tongued and grooved (Figure 11-F) ;

(*g*) Splayed, rebated , tongued and grooved (Figure 11-G) ; and

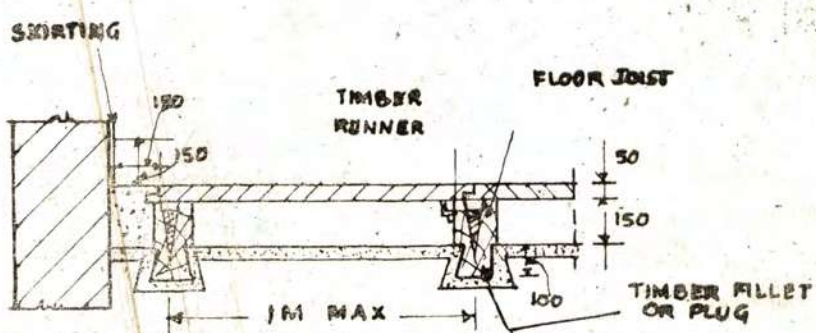
(*h*) Ploughed and tongued (Figure 11-H).

9.2. For all the joints detailed above, the screw shall be driven from the top of, the floor boards down to the timber floor joist below and shall be screwed from the top.

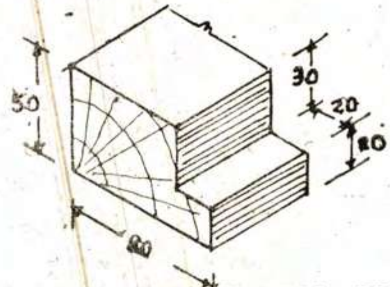
9.2.1. If it is intended that the screw may not be visible from the top, another type of tongued and grooved joint shall be provided with screws driven at the beam angles from the bottom tip of the tongue of the plank going to the joints below (*See* Figure 11-E).

10. *Floor Seals.*

10.1. The porous of timber floor shall be sealed with an efficient type of floor seal. The type of floor seal shall depend upon the purpose of the floor.



10 A. SECTION THROUGH THE FLOOR



10 B ENLARGED DETAIL OF TIMBER RUNNER

ALL DIMENSIONS IN MILLIMETRES

FIG 10. PURPOSE, MADE FLOORS

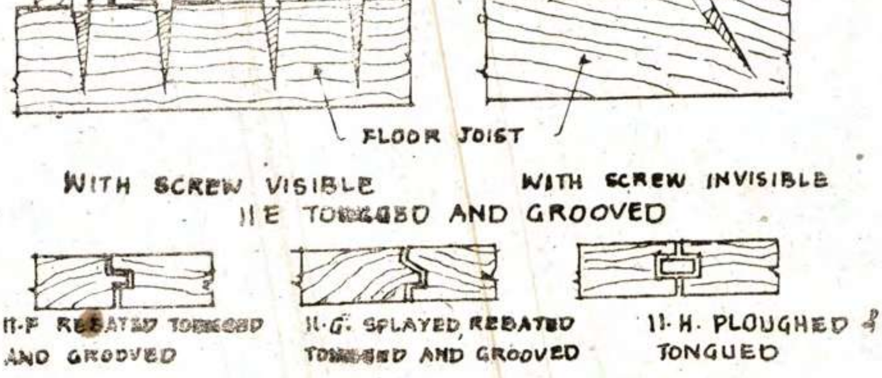


FIG 11. DIFFERENT TYPES OF JOINTS IN TIMBER FLOORING BOARDS

APPENDIX A.

(*Clause* 4.1.1.)

Species of timber recommended for timber floors.

A-1. The following species listed according to the percentage of identation for hardness, taking teak (tectona grandis) as 100 may be used for floor boards :—

GURJAN (Dipterocarpus tuberculatus)	135
ROHINI (Soymida febrifuga)	130
SATINWOOD (Chloroxylon swictenia)	130
MANIAWGA (Carallia lucida)	125
AXLEWOOD (Anogeissus latifolia)	120
KALASIRIS (Albizzia odoratissima)	120
BIJASAL (Pterocarpus Marsupium)	100
LAUREL (Terminalia tomentosa)	100
WHITE CHUGLAM (Terminalia bialata) ..	100
TEAK (Tectona grandis)	100
LONDI (Lagerstroemia Parviflora)..	95
WHITE CEDAR (Dysoxylum malabaricum) ..	95
KINDAL (Terminalia Paniculata)	95
PALI (Dichepsis eliptica)	90
KOKKO (Albizzia lebbeck)	90
ROSEWOOD (Dalbergia latifolia)	90
KASI (Bridelia retusa)	85
SISSCO (Dalbergia Sissoo)	85
PINEY (Hardwickia Pinnata)	85
JARUL (Lagorstroemia hypoleuca)	80
ANJAN (Hardwickia binata)	70
FIR (Abies Pindrow)	65
CYPRESS (Cupresseus torulosa)	60
MACHILUS (Machilus Macrantha)	55

A-1.1. For detailing the species of timber suitable for floor board-(listed in order of strength in hardness) other important characs teristics, namely, shock resisting ability, strength as a beam and retention of shape have also been taken into account..

APPENDIX B.

(*Clause* 4.1.1.)

Species of timber recommended for girders and projecting poists.

B-1. For girders, binders and bridging joists, the following species may be used :—

(*a*) For spans of 12 m. and greater, all species of group "Super" specified in I.S. 3629—1966.

(*b*) For spans greater than 6 m. but less than 12 m. all species of group "Standard" specified in I.S. 3629–1966.

and

(*c*) For spans up to and including 6 m.—all the species of group "Ordinary" specified in I.S. 3629—1966 may be used.

APPENDIX C.

(*Clause* 4.1.2.

Specification of Timber for Wooden Floor Board.

C-1. Timber for floor board.

C-1.1. The appearance of timber shall be a matter for agreement between purchaser and vendor.

C-1.2. The abrasion (Hardness) resistance shall be sufficient to withstand constant wear and tear.

C-1.3. The species should preferably be of non-refractory nature such that it is easily seasoned in open air and sun with systematic stacking.

C-1.4. Thickness of floor boards should be from 2·5 to 4 cm.

C-1.5 Depending upon the availability and strength, any of the species given in A-1 may be used as floor boards.

C-2. *Timber Floor Joists Binders and Girders* :

C-2.1. The modulus of elasticity, E, of the species should not be less than 56 246 Kg./Cm^2.

C-2.2. The extreme fibre stress ft. of the species should not be less than 85 Kg./Cm^2.

C-2.3. The species shall be such as will rapidly be seasoned free from defects.

NOTE.—Depending upon the availability and strength desired, the species for floor joists, binders and girders shall be selected from I.S. 3629-1966 and as specified in Appendix B.

EXTRACT FROM I.S. 2119—1962.

Code of practice for brick-cum-concrete composite (Madras Terrace) floor or roof.

7.3. *Preparation of terrace bricks.*—The terrace bricks shall be kept immersed in water for at least 4 hours before use in the work. The skin shall then be allowed to dry. This treatment is necessary to develop adhesion with mortar in the terrace-brick-work.

9. *Laying of terrace bricks*—

9.1. After preparation as in 7.3, the terrace bricks shall be laid on edge in diagonal rows spanning over the joists. The laying shall start from one corner and proceed towards opposite corner. Each row shall be completed before the next one, adjacent to it, is started.

9.2. The bricks shall be laid in lime mortar of mix 1 : 12 (Lime putty : sand, by volume). The thickness of mortar joints shall not exceed 1 cm.

9.3. During laying, the bricks shall be pressed against the adjacent row already laid so that it bonds well with the mortar and also partially develops lateral adhesion preventing it form slipping. To enhance the self-supporting arch action of the brick work, the bricks may be so laid as to obtain for the brickwork a slight rise in between the joists, the rise being generally not exceeding 5 mm.

9.4. After laying, the brickwork shall be sured by keeping it moist for a period of not less than 10 days so as to set properly.

10. *Laying of lime brick-jelly concrete.*

10.1. After the terrace brick has set, a layer of lime-brick-jelly concrete of mix 1 : 2½ (slaked lime-brick-jelly, by volume) shall be laid and spread to an average thickness of 10 cm.

10.2. After the lime-brick-jelly concrete is laid initial ramming shall be done with a wooden rammer of weight not excceeding 2kg. so that the layer of lime concrete is consolidated to 7.5 cm thickness. After this the consolidation shall further be done with the hand beater (see 2.4) so that the concrete hardens and the beater makes no impression on the concrete and readily rebounds from the surface when struck on it.

10.3. After compaction the surface shall be wetted by sprinkling on a solution prepared by soaking in water the dry nuts of Terminalia Chobula (Kadukai).

Note.—The solution of Kadukai may be prepared as follows :— The dry nuts shall be broken to small pieces and allowed to soak in water. The resulting liquor is decanted and used for the work.

If the surface during the process of compaction becomes so uneven that water lodges in pools, the surface shall be pricked up and fresh concrete spread and consolidated as necessary to obtain an even surface.

10.4. The concrete shall then be cured by sprinkling water and allowed to harden for a period of not less than six days before laying the floor or roof finish.

11.2. The ceiling shall be finished with lime plaster of mix 1 : 2 or cement plaster of mix 1 : 3 as required. The plaster shall be in a single coat 12 mm thick.

11.3. The finished surface of the terrace and ceiling shall be cured with water for a period of not less than three weeks.

EXTRACT FROM I.S. 1196—1968.

Code of practice for laying bitumen mastic flooring.

(First Revision)

5. *Materials.*

5.1. Bitumen mastic shall conform to the requirements given in I.S. 1195—1968.

7. *Constuction.*

7.1. The base on which the bitumen mastic flooring is to be laid shall be adequately strong to receive the mastic and to carry the anticipated traffic over it.

7.2. *Preparation of the base* : The base shall have a true, even and dry surface which has been slightly coarsened by means of a stiff broom or wire brush and should be free from ridges and hollows. A steel trowelled finish is not desirable. The levels of the base should be such that the specified thickness of bitumen mastic may be applied uniformly. If the finished floor is likely to have water or industrial liquors upon it, a straight fall of not less than 1 in 75 should be provided Channels should be provided as necessary to ensure adequate drainage.

7.3. *Treatment of the base* : The treatment of the base shall be decided by the designer in consultation with those responsible for the flooring. One of the following may be used :

(*a*) A screeded bed of cement concrete not less than 25 mm thick.

or

A bitumen mastic undercoat to level up irregularities in the surface ;

(*b*) An isolating membrane or underlay ; or

(*c*) On metal floors, a thin priming coat of bitumen paint applied over a clean and dry surface. The paint should be dry before the mastic is laid.

7.4. *Underlay* : Where an underlay is to be used it shall be a layer of bitumen felt conforming to I.S. 1322—1965.

7.4.1. An underlay shall be essential to be used in the following cases :

(*a*) On a timber base ;

(*b*) On a base of porous or open texture, such as no-fines, clinker ;

(*c*) When concrete is cracked ;

(*d*) When concrete has been contaminated by foreign matter from Industrial processes, such as oils, greases, sugar solutions or chemicals ;

(*e*) When the concrete has been chemically treated, for example, with silicate of soda ; and

(*f*) When the mastic is to be laid over a thermal insulating medium, for example, in cold stores.

7.4.2. An underlay is not considered to be essential at the design stage, yet circumstances may arise immediately before or at the time of laying which render essential the use of an underlay as for example ;

(*a*) When the bitumen mastic is found to cool too rapidly to allow the material to be manipulated for a sufficient length of time to enable a proper finish to be imparted. Pre-mature cooling takes place by the dissipation of heat through the base or by reason of the weather conditions, or both. It may also occur where it is necessary to transport the bitumen mastic far from the mixture. Under these conditions a felt underlay acts as a thermal insulating medium to assist the retention of heat in the material for a longer time after laying than would otherwise be possible.

(*b*) When 'blowing' of the bitumen mastic is experienced and cannot be overcome by dusting the surface with limestone dust of rock asphalt powder.

NOTE.—The reasons for 'blowing' are at present obscure' but it may he caused by extreme dampness or dryness or by the nature of the surface texture of the concrete. It is important that, where it is known in advance that these conditions may arise, as for example, when the conarete has been newly laid these responsible for the laying of the mastic should he notified.

7.5. *Placing the underlay* : The underlay, when required should be laid loose with lapped joints.

7.6. *Setting out* : The setting out of the floor area into bays is normally decided according to workable requirements. The arrangement of the bays depends upon the design of the floor and the number of sprealiers engaged so that the laying and finishing processes may both be easily controlled by the operatives.

7.7. *Re-melting at site* :—Re melting is the tern applied to the melting at the site or in a moblie mixer of the pieces hroken bitumen mastic blocks. The blocks shall he hroken to convenient size and loaded into the mechanically agitated mixer or mastic cocker at the site of work. The materials shall then be carefully remelted. At this stage any coarse aggregate preferably procheated shall he fed in successive portions until the complete charge is thoroughly incorporated. After all the coarse aggregate has heen incorporated, the material shall be mixed centinuously for a period of not less than one hour before laying is begun, and mixing shall be continued until laying operation is completed so as to maintain the coarse aggregate in suspension. At no stage during the remelting and mixing process, shall the temperature exceed 205 degree C.

7.8. *Laying*.

7.8.1. *Transport of molten material* : When the material is sufficiently molten to be workable it should be carried in buckets to the point of laying. To prevent the molten material from sticking to the buckets, they may be sprinkled inside with a minimum quantity of inorganic dust, such as limestene dust. Cement, has or oil shall not be used.

7.8.2. *Spreading* : Bitumen mastic should generally be laid in bays in the coat. It should be spread to the specified thickness by means of suitable hand tools, gauges, straight edges and head levels heing used to ensure accuracy. Type bitumen mastic should then be ficated to a uniformly level surface and should be free from ughness and imperfections

7.8.2.1. If blowing occurs, the bubbles should be punctured and the area affected carefully made good while the mastic is still hot.

7.8.2.2. Two-coat should be treated in a manner similar to that for single coat work, but care should be taken to arrange that the joints in successive layers are staggered.

7.8.3. *Surface finish*:—The top of surface finish required should be specified by the designer. The following are the two types ;

(*a*) *Matt finish* : The surface should be rubbed in with sand during the final floating operation. The sand should be clean and free from foreign matter. All surplus material shculd be removed after rubbing is completed.

(*b*) *Polished finish* : The surface should he finished with a float in a manner similar to that used for a matt finish but without the use of an abrasive.

7.8.3.1. Immediately after completion of the laying, the bitumen mastic should be protected from damage till the material cools to the surrounding temperature.

7.9. *Junctions* : Special care should be taken in effecting proper junctions between new and previously laid sections of work. The contact edges of the previously laid mastic should be cleaned and warmed by temporary application of hot mastic. This procedure should also be adopted at junctions between the floor finish and skirtings, covers or fillets.

7.10. *Skirtings* : Skirtings should be executed in not less than two coats, particular care being taken to ensure proper adhesion of the first coat to the base. Special care should be taken at external angles to ensure the full thickness of the material.

7.11. *Protection of the surface* : The newly laid surface should be protected from damage due to careless handling of construction equipment, spillage of oils. paints, chemicals, plying of vehicles, etc. Concrete or mortar shall not be mixed directly on the bitumen mastic surface.

7.12. *Bringing into service* : The mastic flooring should not be subjected to traffic until the material has cooled throughout to the temperature of the surrounding atmosphere.

9.2. *Repairs*.

9.2.1. When a damaged section has to be removed, it should be done carefully. Considerable damage may result from an attempt to cut away an affected area with the hammer and chisel or to soften it with a blow lamp. The correct method is to place hot mastic around and over the area concerned and after this has had a sufficient softening effect, the area shall be carefully cut away and made good with fresh bitumen mastic.

9.2.2. When two-coat work is being restored or made good, the edge along the perimeter of the area shall be cut back not less than 75 mm to half the total thickness of the mastic, to form a lapped joint.

EXTRACT FROM I.S. 3583—1966.

Specification for paving bricks.

4. *Dimensions and tolerances.*

4·1. *Dimensions.*—The standard sizes for paving bricks shall be as given below. The dimension of the brick shall be construed as applying to the body of the brick only, exclusive of lugs.

Length.	*Width.*	*Depth.*
CM.	CM.	CM.
19·5	9·5	9
19·5	9·5	4

4·2. *Tolerances* : The permissible tolerance on the dimensions specified in 4·1 shall be as follows :

Dimension cm.	*Tolerance* mm.
19·5	± 6
4	± 1·5
9·5 and 9	± 3

5. *General quality.*

5·1. The bricks shall be thoroughly well-burnt and shall be free from cracks and other flaws and lime nodules. Uniform quality of the bricks is of vital importance to ensure that pavement wears evenly. The bricks shall have plane rectangular faces and sharp straight right angled edges.

6. *Loss in abrasion.*

6·1. The maximum percentage of loss in abrasion of the paving bricks determined in accordance with the procedure laid down in Appendix-A of I.S. 1237–1959 shall be agreed to between the purchaser and the supplier.

NOTE.—Suitable limits for loss in abrasion will be specified in due course.

7. *Compressive strength.*

7·1. The average compressive strength when tested according to the procedure laid down in I.S. 3495—1966 shall not be less than 440 Kg./cm ^{2}.

8·0. *Water absorption.*

8·1. The water absorption by weight after 24 hours immersion in cold water when determined according to the procedure laid down in I.S 3495–1966 shall be not more than 5 per cent.

EXTRACT FROM I.S. 1237—1959.

Specification for cement concrete flooring tiles.

3. *Classification.*

3·1. Cement concrete flooring tiles shall be of two classes as given ow depending on the duty they perform :

a) General purpose Tiles-used for flooring in such places where scy light loads are taken up by floors; such as office buildings colleges, hospitals, residential buildings, etc.

such vy duty Floor Tiles—used for heavy traffic conditions and inpath and passages in auditorium, in railway platform godowns.

6. *Shape and dimensions.*

6·1. Flooring tiles shall normally be square shaped. Half-tiles rectangular in shape shall also be available. The dimensions of the sides and the thicknesses of the tiles shall be as given in Table I.

TABLE 1—DIMENSIONS OF SIDES AND THICKNESSES OF TILES.

	Size cm	*Thickness* (t) mm
Modular sizes	19·85 × 19·85 29·85 × 29·85	20 25
Non-Modular size ..	24·85 × 24·85	22

*This size does not fit in with the modular dimensions, but as this size is in use at present, it has been included in the Standard. The Sectional Committee, however , hopes that, with the gradual adoption of modular dimensions the use of this size of tiles will be dropped in due course.

NOTE 1.—Thickness of joints is assumed as 1.5. mm.

NOTE 2.—As a large number of tiles exactly to size 20 × 20 cm., 25 × 25 cm and 30 × 30 cm is being manufactured in the country at present, these sizes shall if supplied, be accepted in place of 19·85 × 19·85 cm., 24·85 × 24·85 cm and 29·85 × 29·85 cm sizes respectively for the time being, till the cancellation of this provision is announced.

6·1.1. Half-tiles for use with the full tiles in the floor shall have dimensions which shall be such as to make two half-tiles, when joined together, match with the dimensions of one full-tile.

6·3. *Tolerance.*—Tolerances on length and breadth shall be plus or minus one millimetre. Tolerance on thickness shall be plus 5 mm, But, the range of dimension in any one delivery of tiles shall not exceed 1 mm on length and breadth, and 3 mm. on thickness.

7. *Wearing layer.*

7·1. The minimum thickness of wearing layer for the various classes of cement concrete flooring tiles shall be as specified in Table III.

TABLE III—THICKNESS OF WEARING LAYER.

Class of tile.	*Minimum thickness of wearing layer* mm.
Plain cement and plain coloured tiles for General purpose.	3
Plain cement and plain coloured tiles for heavy duty ..	6
Terrazo tiles with chips of size varying from the smallest upto 6 mm (or 1/4 in.)	5
Terrazo tiles with chips of size ranging from the smallest up to 12 mm (or 1/2 in).	5
Terrazo tiles with chips of size varying from the smallest upto 20 mm (or 3/4 in).	6

8. *General quality of tiles.*

8·1. Unless otherwise required, the wearing face of the terrazo tiles shall be mechanically ground and filled. The wearing face of the tiles shall be plane, free from projections, depressions and cracks (hair cracks not included), and shall be reasonably perallel to the back face of the tile. All angles shall be right angles and all arises shall be sharp and true.

EXTRACT FROM I.S. 3629—1966—

Specifications for structural timber in building.

TABLE I—GROUPING OF TIMBERS FOR STRUCTURAL USE (CLAUSES 4·1·1, 4·1·2 AND 4·2).

Species for permanent structures.						Species for temporary structures.	
First choice.				Second Choice.			
Botanical name.	*Trade name.*	*Botanical name.*	*Trade name.*	*Botanical name.*	*Trade name.*	*Botanical name.*	*Trade name.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
GROUP—SUPER.							
Acacia Catechu Willd	Khair	Cynometra Ployandra Roxb.	Ping	Grewia tilia efolia vahl.	Dha man	Sterospermum chelonodies DC	Padri.
Albizzia Odoratissima Benth	Kala Siris	Diplerocarpus marerc-carpus Vesque.	Hollong	Poecilonenron indicum Bedd.	Ba Ilagi	....	....
Balanocarpus utilis	Karungkonge	Schleichera trijuga	Kusum	....	....	....	....
Hopea glabra and Hopea parviflora Bedd.	Kopea.	....	....	....	....	....	....
Mesua ferra Linn	Mesua.	....	....	....	....	....	....
Mimusops elengi	Bullet-wood	....	....	....	....	....	....
Pterocarpus Santalinus Linn. f.	Red-sanders	....	....	....	....	....	....
Shorea robusta Gaertn. f.	Sal (UP)	....	....	....	....	....	....
Vitex altissina Linn. f.	Milla	....	....	....	....	....	.....
GROUP—STANDARD.							
Albizzia lebbeck Benth	Kokko	Acacia arabica willd.	Babul	Altingia excelsa Norocha.	Jutilli	Anogeissus latifolia wall.	Axlewood.
Bassia butyracea	Hill mahua	Acrocarpus fraxinifolus wight.	Mundani	A moora sp	Amari	Artocarpus hirsuta Lamk.	Aini.
Garapa moluccensis	Pussur	Casuarina equisetifolia Linn.	Casuarina	Ancgeissus acuminate wall	Yon	Canarium strictum,	Roxb White dhub.
Dysoxylum malabaricum Bedd.	White Cedar	Cullenia excesla	Karani	Carallia lucida	Maniagwa	Chlorcuylon swietenia	Satinwood.
Eucalyptus engenioides.	Eucalyptus	Dipterocarpus sp.	Gurjan	Dichosis elliptica and	Pali and tali	Cinnamomum sp.	Cinnamon
Gluta travancorica Bedd	Gluta	Terminalia belerica Roxb.	Bahera	dishopsis polvantha		Dioxpyros melanoxylon Roxb.	Ebony
Hardwickia pirnate Roxb.	Piney	Terminalia chebula	Myrabolan	Engenia sp.	Jaman	Heritera sp	Sundri
		Terminalia tementosa wignt et Arn	Laurel	Growia vestita vahl.	Dhaman, (UP. MP).	Kayea floribunda	Karal
Lager stroemia lanceolate wall	Beneteak	Terminalia nian King	Black chuglam	Mimusops elengi	Bulletwood	Lagerstroemia parviflora Roxb..	Lendi
Pterocarpus dalber giodies.	Padauk	Guercus sp.	Indian oak	Terminalia paniculate Roxb.	Kindal (Bombay)	Machilus macrantha Ness.	Machilus
Pterocarpus marsupium Roxb	Bijasal			Terminalia paniculate Roxb.	Kindal (Madras)	Planchonia Andamanica	Red bombwe
Sho.	Sal (M.P.)					Saccopetalum tomentosum Hook f. et. th	Hoom.
Soymida fe.	Rohini					Terminalia bialata Steudal.	White chuglam.
Tectona grandis L.	Teak						
Xylia dolabriformia.	Irul.						

GROUP—ORDINARY.

Artocarpus integrifolius Auct	**Kathal**	Adina cerdifolia Hook f.	Haldu	Artocarpus Chaplasha Roxb.	Chaplash	Abies pindow spach	Fir
Artocarpus lakoocha Roxb	**Lakooch**	Albizzia procera	Safed siris	Bridelia retusa spreng	Kasi	Aegle Marmelos	Bel
						Ailanthus grandis	Gokul
Azadirachta indica	Neem	Anthocephalus Cadamba Miq.	Kadam	Calophylum sp	Poon	Anisoptera glabra	Kaunghmu
Bassia latifolia Roxb	Mahua	Castanopsis hystrix	Chestnut	Dalbergia sissoo Roxb	Sissoo	Bischofia javanica Blume.	Uriam
Careya arborea Roxb	Kumbi	Cedrala sp.	Toon	Elasocarpus tuberculatus Roxb.	Rudrak	Boswellia serrata Roxb	Salai
Cedrus deodara Loudon	Deodar	Chukrasia tabularis Adv. Juss.	Chickrassay	Lagerstoremia flosreginae Retz. and Lagertsroemi. Hypolenea Kurz	Pyinma and Jarul	Disophyros melanoxylon Roxb.	Ebony
Cupressus torulosa Don	Cypress	Dillenia sp.	Dillenia			Duabonga sonneratioides Ha m.	Lampati
Dalbergia Latifolia Roxb	Rosewood (MP)	Holopteleaintegrifolia Planch.	Kanju	Podocarpas sp.	Thitmin	Garuga pinnata Roxb	Garuga
		Mangifera indica Linn	Mango			Heterophragma Roxburghii	Pa lang
Dalbergia latifolia Roxb	Rosewood (Malabar).	Mitragyna parvifolia Korth.	Kaim			Juglans sp.	Walnut
Dalbergia Sisoo Roxb	Sissco (UP)	Pinus excelsa wall	Kail			Lophopetalum weightianum A rn.	Banati
Gmelina arborea linn	Gamari	Pinus longifolia Roxb	Chir			Machilus macrantha Ness.	Machilus
Hardwickia binata Roxb	Anjan	Pheebe sp	Bonsum			Michelia sp	Cha mp
Qugeimia dalbergioides Benth	Sandan	Pterosperrum a cerifolium willd	Hathipaila			Michelia sp	Mulberry
Tetona grandix Lin f.	Teak (MP)	Stereospermum chelonodies DC	Padri			Myristica attenuata, wall.	Jathikai
		Swintonia floribunda	Civit.			Pieea morinda Link	Spruce
		Terminalia arjuna bedd.	Arjun			Polyalthia fragrans	Debdara
		Terminalia myric carpa Heurck et Muell Arg.	Hollock			Ponga mia glabra	Sakyararji
						Schima wallichii choisy	Chilauni
						Shorea assamica Dyer	Makai
						Senneratia apetala	Keora
						Terminalia procera Roxb.	White Bambwe
						Vateria indica Linn	Vellapine.

4·2. *Grouping*.—Various species of structural timber are classified in three groups on the basis of thier strength characteristics, namely, modulus of elasticity (E) and flexure stress in bending or tension along the grain (f) as follows (*See* also Table 1).

Group.	Modulus of elasticity (E) Kg/cm².	(†) limit Kg/cm²
Super	Above 126 000	180
Standard	Above 98 000 and up to 126 000	120
Ordinary	Above 56 000 and up to 98 000	85

SECTION VIII

ROOFING AND CEILING

466-3—47

SECTION VIII

ROOFING AND CEILING

CONTENTS.

466-3—47A

SECTION VIII

ROOFING AND CEILING

INDIAN STANDARDS EXTRACTS

SECTION VIII

ROOFING AND CEILING.

SPECIFICATION 44.

ROOFING, GENERAL AND MATERIALS.

1. Specification for terrace bricks is covered by Appendix A of IS 2119/62 N.B.C.—Appendix Part VII. Tiles are specified in IS. 2690/1964 N.B.C. Appendix Part V—Soaking of bricks in water is mentioned in IS 2119/62.

2. Mangalore tiles: Specification of tiles is covered by IS. 654/ 72.

NOTE.—As there are Mangalore tiles of different sizes in the market the contractor should obtain instructions from the Executive Engineer regarding the spacings of the lugs and catches on the tiles to suit the spacing of the reepers.

3. Lime, sand, brick jelly and mortars used in roofing items must all comply with the respective standard specifications.

4. The above specifications for materials are to be complied with, where such materials are used in all the following roofing sub specifications.

Notes on design of roofing.

Appendix X of T.N.B.P. gives the information. Live loads and wind loads are dealt with in detail in N.B. Code Part VI—Section I.

SPECIFICATION No. 44-A.

BEST TILED ROOFING WITH FLAT AND PAN TILES AND LIME MORTAR BORDERS INCLUDING TEAK REEPERS.

Clauses additional to " General " preceding.

1. The maximum distance between centres of the common rafters for the roof shall not be more than 60 cm. unless otherwise specified in the drawing. The size of the reepers shall be 50 mm. x 12 mm. upto a spacing of 60 cm. between centre to centre of rafters. Reepers as specified above shall be nailed with reeper nails 40 m. long, at central distance suited to the size of the flat tiles (*i.e.*), 15 cm. for the standard size flat tiles. The reepers shall be of well seasoned teakwood and shall be straight pieces, of uniform size and colour and not shorter than the length necessary to cover at least four rafters. The under faces and size of the reepers shall be planed before fitting up. Joints between reepers shall be butt joints. No joints shall come except over the rafters. The joints of no two adjacent row of reepers shall come over the same rafter. At the eaves, there shall be two reepers side by side and the flat tiles shall start from the Centre of the last but one reeper. The lower reeper shall be of such thickness and shape that the uniformity of the top, slope of roof may be preserved. The rate for the roofing includes the cost of reepers and fixing the same.

2. The flat tiles shall be immersed in water for two hours and dried. They shall have their underside dipped in whitewash of the consistency of cream and allowed to dry and shall be laid dry on the reepers, the top surface of the reepers having been painted with tar—two coats. On the flat tiles shall be laid a layer of lime mortar 20 mm. thick, to prevent them from slipping or being lifted by the wind. Over the flat tiles thus finished, pan tiles shall be arranged in parallel ways touching each other in the exact line of the roof from eave to ridge.

3. The first layer of pan tiles shall be laid over-lapping lengthwise for a little more than half their length, the concave side being upwards; the second layer shall then be laid with the convex side upwards and covering the joints between the rows of tiles of the previous layer, the lap being two-thirds of the length of the tile. The first layer shall have the narrow end of the tile towards the eaves, while the second layer is laid with the wide end towrads the eaves.

4. Ridges and hips will be finished with large semi-cylindrical tiles set in mortar and neatly plastered. The rate per 10 sq. metres of roofing includes the cost of ridges and hips.

5. Valleys shall be lined with standard specification galvanized iron 1·25 mm. thick sheeting 1·2 metre wide, carried 75 mm. into the wall at top unless flashing is specified. One foot overlap shall be given at joints, if any, down the slope. No nails or solder shall be used where the sheets lap, the depth of the trough made by the sheeting should not be less than 100 mm. The sheets shall be laid over the reepers and not under and nailed on. Two reepers 50 mm x 12. mm. shall be fixed over the galvanized iron sheet 15 cm. away from the centre line of the valley on either side, to keep the tiles and mortar from falling into the gutter of the valley. The roofing rate does not include the cost of galvanized iron sheets, but it shall include labour, etc., for fixing.

6. Strips of mortar, slightly troughed to carry away the rain water falling on them, 25 cm. in width and 5 cm. in thickness, shall be laid down the slopes at intervals of not more than 2 metres and white washed two coats.

7. At the junction of the roof with a wall, the tiles shall be let into the wall to adepth of about 5 cm. and a strip of mortar border shall be formed 10 cm. thick above the roof surface after grouting the joint between the roof and the wall.

8. The joints of the flat tiles on the under side shall be neatly pointed and the tiles white washed after the roof is completed and before the painting of the reepers and rafters is commenced.

9. The roof shall be kept damp for at least a week to enable the mortar over the flat tiles to set properly.

10. The rate per 10 sq. metres for the roofing completely finished inclusive of cost of special tiles for ridges and hips, reepers, tarring same and fixing, but excluding only cost of the galvanized sheeting.

N.B.—The rise of the roof for this type of roofing will ordinarily be one-third span.

NOTE.—Experiments were carried out in Chengalput Division to determine the maximum length of straight slope roof suitable for pan tile roofing without leakage. The first layer of tiles laid with the narrow end, which acts as a spout, towards the eaves conveys the whole of the run off of the rain water, as the upper layer is only to seal the joints between the successive lower layer rows of tiles. Within imits then, an excess of tiles reduced the slope of run off in each row and is objectionable. It was found that best results were obtained when the cover of the lower tiles was half the tile length and for the upper layer, two-thirds the tile length cases being taken for rise one-third and one-fourth span, in accordance with the slopes laid down for this type of roof by Chief Engineer's memorandum. The maximum length of water-tight pan tile roof for a concentration of rainfall of 38 cm. in ten minutes was found to be 5.5 metres when the rise was one-third span and 4.2 metres when the rise was one-fourth span.

2. The tiles used were 20 cm. 12.5. cm.+10 cm.×9mm.. — with
2
a curvature of 30 mm. measured at the centre of the tile. The number of these tiles required for one square metre of roofing on the above basis was counted and found to be 1,650 without allowauce for breakages.

3. For slopes of longer lengths than noted above, it will usually be advisable to adopt other type of roofing or break the slope, by a drop in the roof, carrying away the run-off from the upper part of the roof by guttering.

SPECIFICATION No. 44-B.

BEST TILED ROOFING WITH PAN TILES AND LIME MORTAR BORDERS INCLUDING TEAK REEPERS AT 10 CM. CENTRES.

1. The work shall be executed to the standard specification for the same class of work with flat tiles, except that the flat tiles and the layer of mortar over them are to be omitted and the spacing of reepers centre to centre will now be 10 cm.-

2. The lime mortar borders and mortar junctions at all walls are to be formed similar to the standard specification for the same class of roofing with flat tiles.

3. The rate shall be per 10 sq. metres inclusive of ridges, hips reepers, etc.—*vide* preceeding specification regarding rate.

SPECIFICATION No. 44-C.

BEST TILED ROOFING WITH PAN TILES LAID ON BAMBOO RAFTERS, BAMBOO REEPERS AND BAMBOO MATS INCLUDING LIME MORTAR BORDERS.

1. Rafter couples, spiked and lashed with coir rope at top, notched slightly and spiked to the wall plates shall be placed at 45 cm. intervals. The couple rafters shall be of strong closely knotted bamboos, 75mm. to 100 mm. diameter or such other larger size as the requirements may demand and shall project to a distance 45 cm. horizontally from the outside face of the wall. Split bamboo reepers 20 mm. to 25 mm. width shall be nailed to th erafters with reeper rails, at intervals of 40 mm. centre to centre of reepers. Over the reepers shall be laid the bamboo mats, which shall be fixed securely to the reepers, so that they do not become displaced during the process of tiling.

2. The tiles., lime mortar borders, ridges, hips and valleys shall hen be laid on, in the manner discribed in the Standard specification 4–Best tiled roofing with pan tiles and lime mortar borders, etc.

3. The rate shlal be for the complete roofing excluding the cost of ılvanized iron sheeting for valleys, if any.

SPECIFICATION No. 44-D.

BEST TILED ROOFING WITH MANGALORE TILES SET IN MORTAR OVER FLAT TILES AND INCLUDING TEAK OR COUNTRY WOOD REEPERS.

1. *Clase additional to " General " Preceding.*

IS. 2858/1964 and N.B.C. Appendix to Part VII shall apply.

2. The roofing rate does not include the cost of the galvanized iron sheets but it shall include labourer, etc., for fixing.

3. The roof shall be kept watered for a week. The rate for 10 s.q metres of roofing shpll include cost of special hip and ridge tiles.

4. The joints of the flat tiles on the underside shall be neatly pointed and white washed after the roof is completed and before the painting of the reepers and rafters is commenced.

SPECIFICATION No. 44-E.

BEST TILED ROOFING WITH MANGALORE TILES INCLUDING TEAK OR COUNTRY WOOD REEPERS.

1. Clauses additional to " General " Preceding I.S. 2858/1964 shall apply.

2. If it is specifically stated in the Schedule item description or in the specifications that ventilating tiles are to be probided, then two ventilating tiles to every 10 square metres of finished roof surface shall be provided at places pointed out by the Executive Engineer. The ventilating tiles shall be of Standard pattern and make approved by e Ecu tive Engineer and shall be of the same coulour as the other tiles and well burnt. They shall fit close and tight with the other tiles; the rate for the roofing shall include the cost of the ventililating tiles in such case as they are specified to be provided.

3. The roofing rate does not include the cost of gplvanized iron sheet but it shall include laboutr, etc. for fixing.

SPECIFICATION No. 44-F.

MADRAS TERRACED ROOFING WITH BRICK ON EDGE 75 MM. CONCRETE THREE COURSES OF FLAT TILES AND THREE COATS OF LIME PLASTER TO TOP AND ONE COAT OF CEMENT PLASTFR TO CEILING.

1. I.S. 2119/62 and 3036-65 shall apply.

2. After six days or after the concrete laid has hardened, three courses of flat tiles shall be laid in standard specification lime mortar 1 : 1½ diagonally and breaking joint. The side joint of tiles and the beds shall not be more than 6 mm. set full in mortar.

3. The flat tiles shall be immersed in water for two hours before being used. The joints of the top layer shall be left open to afford a key for the plaster. The top surface shall then be plaster three coats of lime mortar in accordance with standard specification for the same and rubbed to a polished surface. The ceiling also shall be plastered with cement mortar 1 : 3.12 mm. thick.

4. Should the mortar perish through neglet of watering the work shall be pulled down and rebuilt at the contractors expense or should the contractor fail to wpter the work to the satisfaction of the Officer-in-charge of the work the latter may supply the requisite men or water the work properly and charge the cost to the contractor.

5. Special attention is to be paid to drainage openings in parapet and binding walk to ensure that the rain runs off quickly.

SPECIFICATION No. 44-G.

TERRACED ROOFING WITH BRICK ON EDGE, 75 MM. CONCRETE, TWO COURSES OF FLAT TILES IN C.M. 1 : 3 TO TOP AND ONE COAT OF CEMENT PLASTER 1 : 3 TO BOTTOM.

1. Clauses additional to General Preceding. I.S. 2119/62, 3036/65 and N.B.C. Parts V, VII Appendices shall apply.

2. After six days or after the concrete laid has prdened two courses of flpt tiles shall be laid in cement mortar 1 : 3 mixed with crude oil. The mortar shall be prepared as instructed in S.S. 45 except that the crude oil is to be in the proportion of 10 per cent of the weight of the cement. The tiles shall be laid first course diagerally and the second course square to the parapet thus breaking joint. The side joint of tiles shall not be more than 6 mm thick set full mortar The mortar layer bed over the roof slab shall not be less than 9 mm finished thickness after receiving the first layer of tiles and 9 mm. thick mortar bed between the two layers of tiles The tflat tiles shal be immersed in wpter for two hours before being used The tiles shal. be laid and finished off as instructed in S S 44-H

3. Before the work dries up completely, the tile joints shall be raked out and pointed over with cement mortar 1 : 3 mixed with crude oil prepared as instructed in clause 2 Supra. The joints shall be well rubbed over with thin bar trowels and the excess of mortar scrapped off until the surface of the pointing attains a black polish and becomes hard. The ceiling shall be plastered with one coat of Standard specification ·· Plastering with cement mortar 1 : 3, 12 mm. thick—S.S. No. 56. Clauses relating to the perishing of mortar and providing proper openings of drains in S.S. 44-G shall apply to this S.S. also.

SPECIFICATION No. 44-H.

Reinforced Concrete Roofing and Two Courses of Flat Tiles to Top.

1. *Clauses additional to "General preceding."*

The reinforced concrete roofing shall be laid as per I.S. 456/64 and N.B. Code Part VI Section 5. For extracts of I.S. See Section 4.

2. The reinforced concrete roof slab will itself be laid wherever possible at the required slope to secure proper drainage of the roof. This slope will be defined in the relevant plans or specified by the Executive Engineer. When the required slope has to be given by means of camber concrete over girders, this concrete—of the same mix as the floor slab—will be formed on the R.S. beams or on the Tee beams, as the case may be, along with the roof slab. The forms of the roof slab and the girders shall be so adhjusted as to enable the moulding of the camber concrete en-mass with the roof slab. This camber concrete shall be considered as included in the square metre rate for the roofing unless other method of payment is in the Schedule.

3. As soon as the setting period for the roof slab is over the top of the slab shall be thoroughly cleaned and wetted. Two courses of 20 mm. thick flat tiles shall be laid in cement mortar 1:3 mixed with crude oil and pointed in the same manner as instructed in clauses 2 and 3 of S.S. No. 44-G.

4. As the work proceeds it shall be kept thoroughly wetted until the mortar has set firm and hard. Watering shall be continued for three weeks after construction.

5. Clauses relating to the perishing of mortar and leaving proper opening for drains in S.S. 44-F shall apply to this specification also.

6. Payment shall be per 10 sq. metres superficial area on the completed roofing and the rate shall be either inclusive or exclusive of R.C. slab concrete as the case may be according to conditions in the tender schedule—*vide* also remarks in clause 2 supra regarding camber concrete, The bearing of the slab shall be not less than 15 cm. or the depth of the slab without the surfacing, whichever is greater. This area of bearing only shall be paid for at the roof slab rate irrespective of the actual bearing when this is greater, unless otherwise specifically defined in writing before a contract is entered into. Corresponding deduction for wall masonry work will be made If the roof slab is carried continuous over the wall to form a cornice or chajja, then the roof slab shall be measured as instructed and payment for the cornice or chajja portion will be defined in Schedule A of the contract on a lineal metre basis, or as may be otherwise specified, and shall include the portion bearing on the wall apart from that specified above for payment as roof slab.

7. If the parapet wall is of 20 cm. thick and more than two courses of flat tiles shall be laid continuous upto 50 mm. through the parapet wall. In addition to this, along the junction of the parapet and roof, tiles shall be laid inclined at 45° to the face of the parapet after laying necessary brick jelly concrete (*vide* Fig. 8-1). The inclined tiles also should be taken inside the wall for a depth of 50 mm.

8. If the parapet wall is of 10 cm. thick then 20 cm. thick parapet wall shall be built initially for a height of 30 cm. and over this 10 cm. thick parapet wall shall be built. Laying of tiles shall be similar to the specification described above for 20 cm. wall. (Fig. 8·3)

9. Where facia work in concrete is adopted instead of parapet wall, then a 20 cm. thick brick work shall be built behind the facia work for a height of 30 cm. Laying of tiles shall be similar to the pecification described above for 20 cm. wall. (Fig. 8·4).

10. Plastering of the parapet shall be done only after the tiles are laid.

11. The area of the tiles for which payment is to be made shall be the exposed area of the tiles at top. The contractor shall therefore quote his unit rate accordingly.

12. The additional brick jelly concrete and tiles at the junction of the parapet with roof shall be measured and paid for separately.

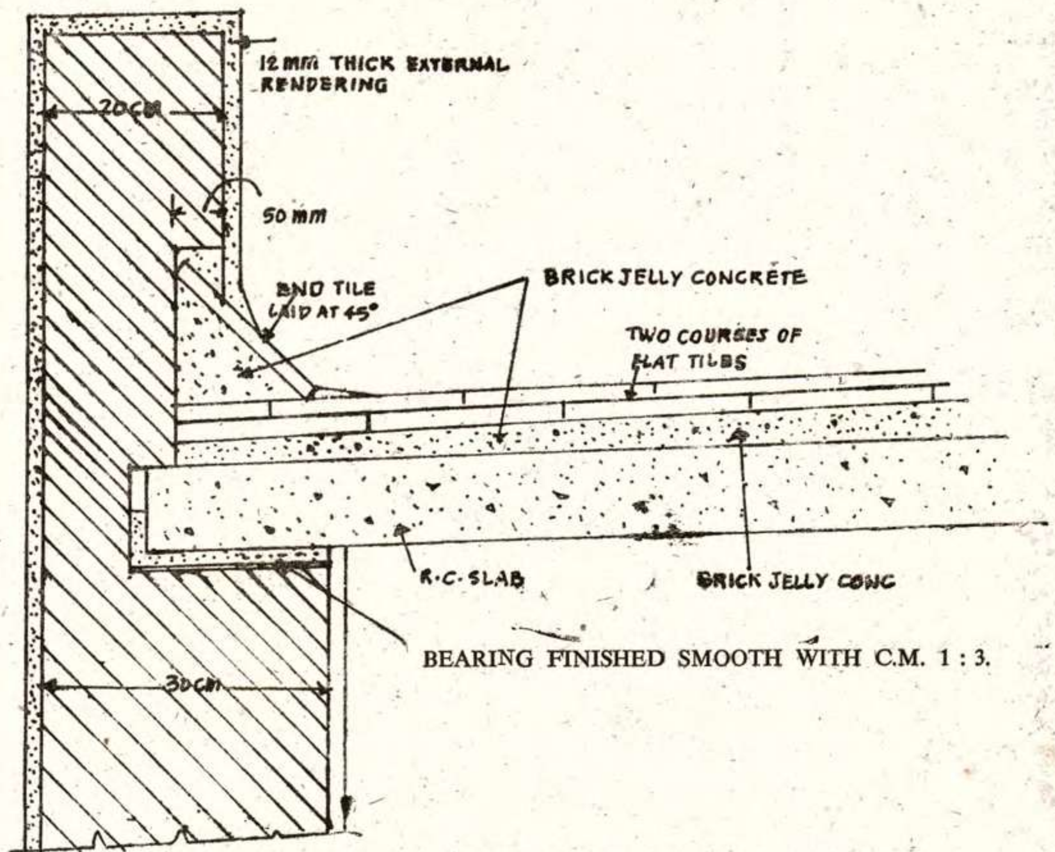


FIG. 8.1

SKETCH SHOWING THE METHOD OF LAYING TWO COURSES OF FLAT TILES FOR ROOF.

SKETCH SHOWING THE METHOD OF LAYING OF ONE COURSE OF PRESSED TILES FOR ROOF

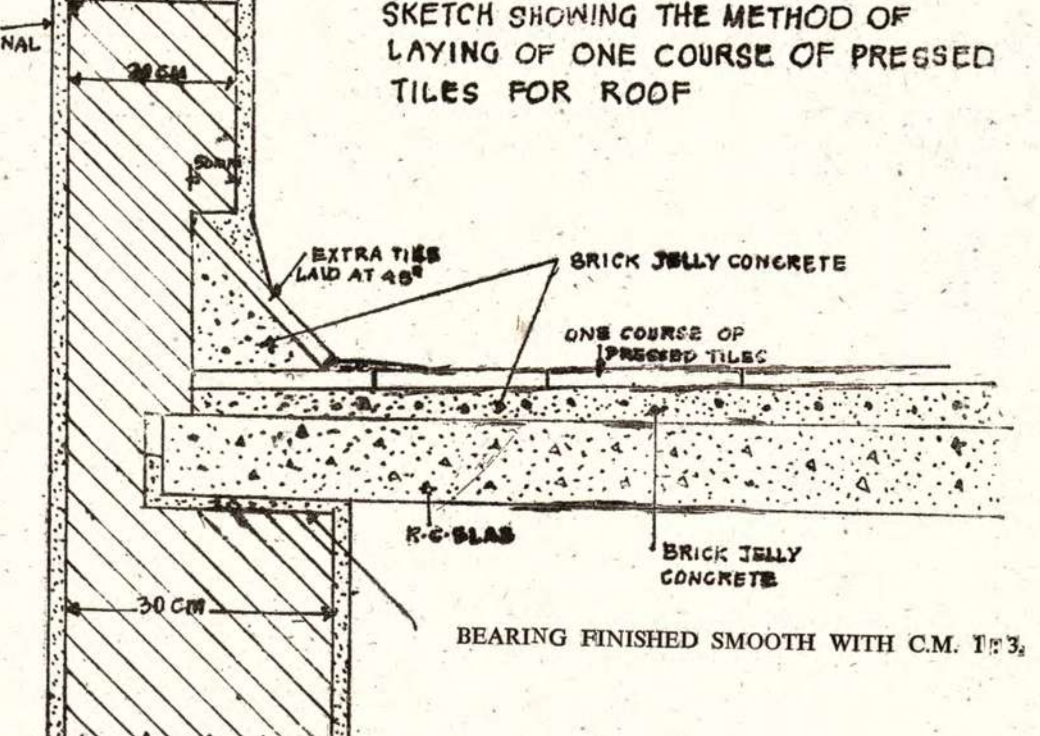
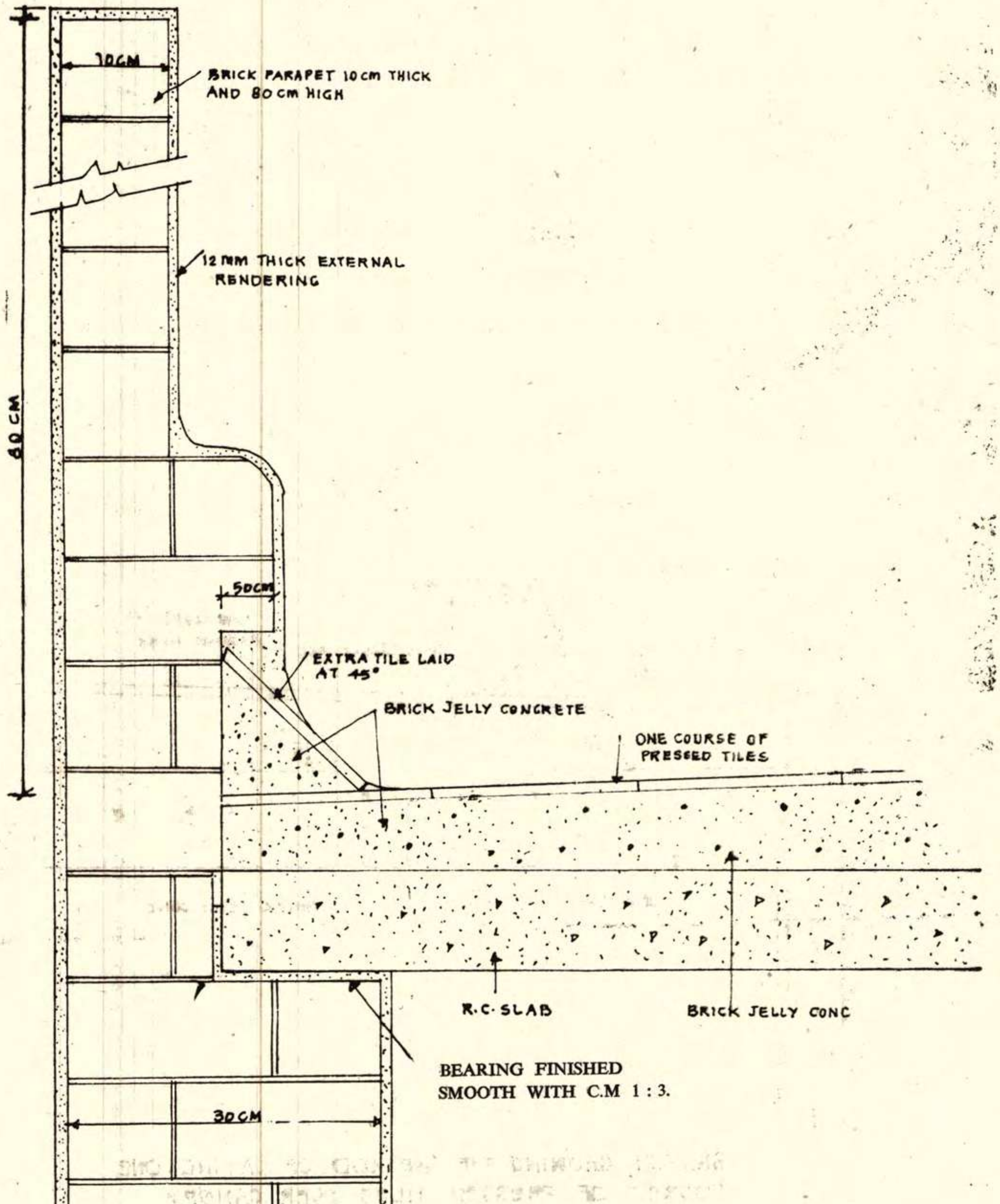


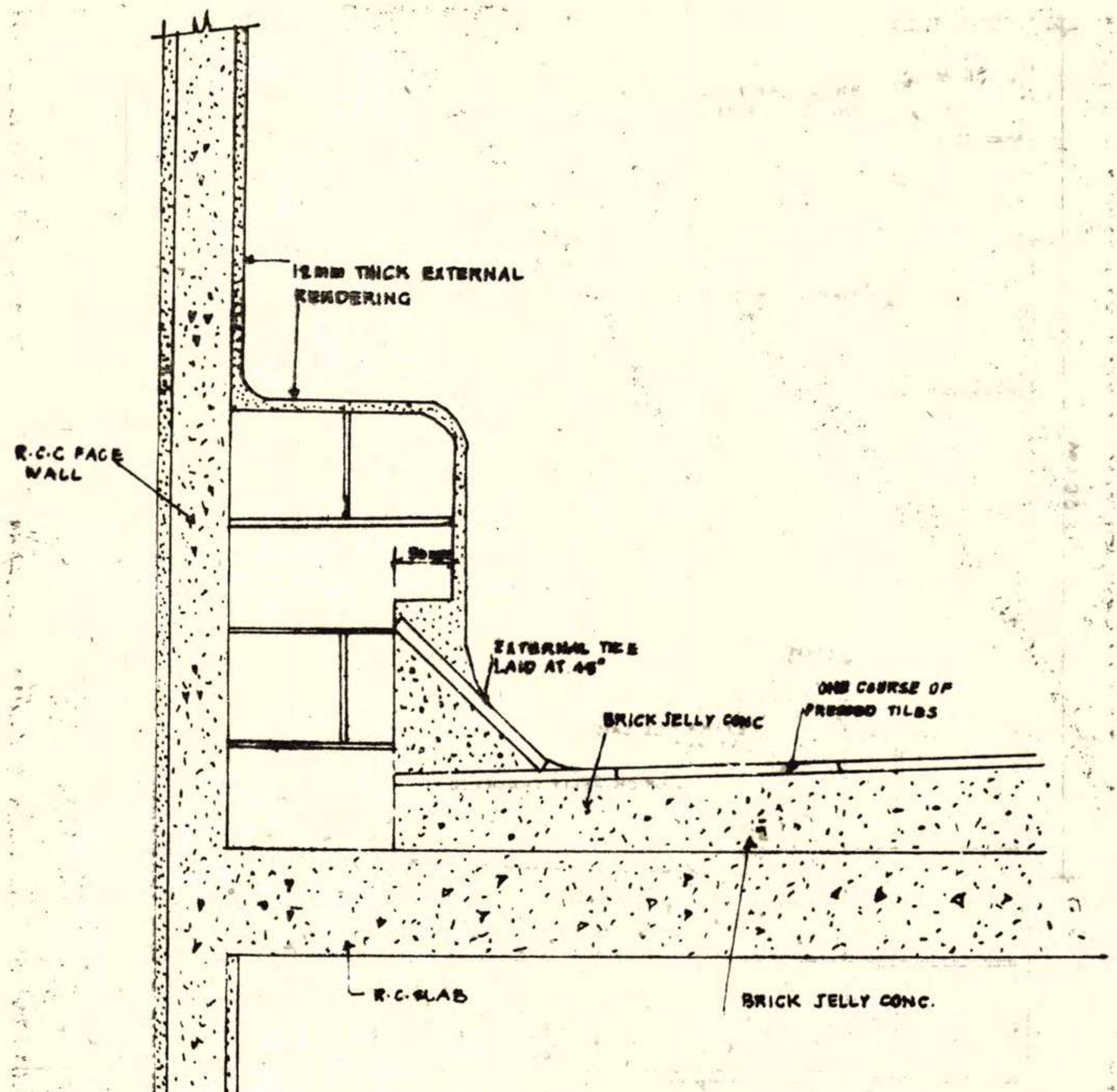
FIG 8-2



SKETCH SHOWING THE METHOD OF LAYING OF ONE COURSE OF PRESSED TILES FOR ROOF

FIG. 8.3

Scale 1 : 5



SKETCH SHOWING THE METHOD OF LAYING ONE COURSE OF PRESSED TILES OVER CANOPY, BALCONY ETC.

FIG: [illegible]

SCALE 1:50

SPECIFICATION No. 44-I.

TERRACED ROOFING WITH BRICK ON EDGE OR REINFORCED CONCRETE ROOFING 75 MM. CONCRETE AND ONE COURSE OF PRESSED TILES TO TOP.

Clause additional to "General" proceeding.

1. The work shall be executed similar to the standard specification No. 44-G or 44-H as the case may be except that the two courses of flat tiles shall be replaced by one course of pressed tiles, the laying and finishing being similar to that of flat tiles (vide fig. 8—1 and 8—2).

2. The roofing shall be measured in square metre.

3. Payment will be made as specified in the tender schedule

4. The area of the tiles for which payment is to be made shall be the exposed area of tiles at top. The additional brick jelly concrete and tiles laid at the junction of parapet with roof shall be measured and paid for separately.

SPECIFICATION No. 45.

COMPLETE SURFACE REPAIR TO LEAKY TERRACE ROOFS,

This specification is for renewing the surface of an old lime plastered terrace roof.

1. The lime mortar plaster shall be entirely removed and the joints in the existing course of flat tiles below thoroughly raked out. A new course of flat tiles shall be laid in standard specification cement mortar 1:3 mixed with crude oil as described below, the cement mortar keying well into the raked out tile joints beneath.

2. The cement and sand shall be first mixed dry. the cement will be weighed for each mix to ascertain its weight, in order to fix the quantity of non-volatile crude oil to be added, which should be 10 per cent of the weight of cement. The dry mixture shall be worked up well with the required quantity of crude oil and then water added and the mortar further well worked with the trowel. The tiles shall be bedded properly in this mortar with joints not wider than 6 mm. Before the work dries up completely the joints shall be raked out, and pointed over with cement mortar 1 : 3 mixed with crude oil (the crude oil being 10 per cent of the weight of cement), prepared as above. The joints shall be well rubbed over with thin bar trowels — and the excess mortar scraped off—until the surface of the pointing attains a black polish and becomes hard.

NOTE.—To repair cracks in terraces, the same process may be adopted.

OIL MIXED CEMENT MORTAR AND CONCRETE.

1. *Introduction.*—Ordinary cement mortar or concrete, because of its absorbtive qualities is used in some structures with only partial success. When made proof against the permeation of moisture, not only its field of use fulness rendered more universal but its efficiency is likewise greatly increased. A very simple method of damp-proofing cement concrete or mortar is by the incorporation of mineral oil residium with the mixture. Such an oil mixed with cement paste in small quantities entirely disappears in the mixture and does not separate from the other ingredients after the cement has become hard.

2. *Laboratory tests.*—Extensivelaboratory tests made to determine the physical properties of concrete and mortar containing various quantities of oil admixtures have yielded valuable results the more important of which are mentioned below :—

(*a*) The tensile strength of oil mixed cement mortar 1 : 3 is very little different from that of plain mortar, and shows a substantial gain in strength at 28 days and at 6 months over that at 7 days when the oil mixed does not exceed 10 per cent of the weight of cement.

(*b*) The times of initial and final set are delayed by the addition of oil; 5 per cent of oil increase the time of initial set by 50 per cent and the time of final set by 47 per cent.

(*c*) The crushing strength of mortar and concrete is decreased by the addition of oil to the mix. Concrete with 10 per cent of oil has 75 per cent of the strength of plain concrete at 28 days. At the stage of one year, the crushing strength of mortar suffers but little with the addition of oil in amounts up to 10 per cent.

(*d*) The toughness or resistance to impact is but slightly affected by the addition of oil in amounts upto 10 per cent.

(*e*) The stiffness of oil-mixed concrete appears to be but little different from that of plain concrete.

(*f*) Results of tests for permanent deformation indicate that no definite law is followed by oil - mixed concrete.

(*g*) Oil-mixed mortar and concrete containing 10 per cent of oil have very little absorption and under low pressures both are water-proof.

(*h*) Oil-mixed mortar containing 10 per cent of oil is absolutely water-tight under pressure as high as 2.8 kg. per sq.cm. Oil-mixed mortar is effective as water-proofing agent under low pressures when plastered on either side of porous concrete.

(*i*) Bond between plain bars and concrete is seriously effected by the mixture of oil. The bond of deformed bars is not so seriously affected but is somewhat decreased by the oil admixture.

3. Specification for crude oil for use with mortar is covered by Appendix D of IS 2110/62 and N.B.C. Appendix—Paragraph VII.

4. *Method of mixing.*—For most purposes where damp proofing is required 10 per cent of oil based on the weight of cement in the mixture is necessary and sufficient:—

(*a*) For making oil cement mortar or concrete, the required quantities of the various ingredients are collected separately. Taking sand and cement in the correct proportion, they are mixed together until the mixture appear to be of uniform colour. Water is then added to the mixture and the mass is again mixed to a mortar of mushy consistency. The correct quantity of oil is then added to the mortar and the mass turned again until there is no trace of oil visible on the surface of the mortar. The mortar is now ready for use.

(*b*) For concrete, the oil mixed mortar is combined with stone or gravel previously moistened and the mass is turned until all of the stone is thoroughly coated with the mortar and an uniform mix obtained.

(*c*) In a machine mixer, the cement, sand and water are first mixed to a mortar when alternate batches of oil and stone are added until the required quantity of oil is mixed, and then the remainder of the stone is added and mixed.

5. *Uses*—Oil-mixing cement mortar or concrete can be used advantageously where damp-proofing is required. On new works oil-cement plaster can be used as damp-proof course, as outside plastering for walls and as wearing courses for floors and roofs. Floors, roofs and walls of old structures can be made water-proof by the addition of oil-cement plaster. Concrete for foundation floors, water cisterns, retaining walls, etc., can be made damp-proof by the additon of oil. In reinforced cement concrete, addition of oil is not recommended as it affects bond strength seriously unless special deformed rods are adopted for reinforcement. Reinforced concrete slabs can however, be rendered water-tight by the application of a coat of oil-cement plaster on the surface—

(*a*) For new plastering work, the addition of mineral oil 5 per cent by weight of cement is all that is necessary. When the plaster is to be applied to be old work, the surface should be scrubbed thoroughly clean and made wet before the application of the oil-cement mortar. The bond between the old work and the new will be improved if the old surface be roughened with a stone hammer, it may be well also to apply a wash of grout, made by mixing cement with water to the consistency of cream, before laying the oil-cement mortar.

(*b*) For concrete, the quantity of oil to be used will be 10 per cent by weight of cement. Care should be taken not to use smooth rods for reinforcement and not to load the slab or beam before full strength is developed in, ie say 28 days, for the application of water-proofing coat of oil-cement plaster to a concrete surface the same specification has given above for plastering may be adopted.

(*c*) When two coats of plastering are adopted as in stucco work (with slap or pebble dash) the oil mix may be restricted to the first or scratch coat only.

SPECIFICATION No. 46.

Best Thatched Roofing 25 cm. Thick, including Bamboo Rafters, Bamboo Reepers and Bamboo Mats.

1. Rafter couples, strongly lashed with coir rope at top, notched slightly and spiked to wall plates shall be placed at 45 cm. intervals. The couple rafters shall be of strong closely knotted bamboos' 7.5 cm. to 10 cm. diameter, or such other larger size as the requirements may demand and shall project to a distance 45 cm. horizontally from the outside face of the wall., Thin bamboo reepers 20 mm to 25 mm. diameter shall be laid across the rafters 1 at 20 cm. spacing and securely tied with coir rope (or ,nailed as may be instructed) where the reepers cross every rafter. Over the reepers shall be laid the best quality of closely-woven bamboo mats, shiny surface downward, to completely cover the reepers and so secured to the reepers, that they will not be displaced while laying the thatch. This is best ensured by overlapping the edged of the mats and tying them down with split bamboo battens.

2. The grass shall be laid in three layers. The first layer may be of coarse grass and may be laid on loose and tied tightly down with bamboo battens, not more than 25 cm apart, with ties at spacing of 25 cm. The thickness shall be not more than 75 mm. The grass for the second and third coats shall be of long grass made up into tatties on the ground, each of sufficient thickness to form one-third of the finished coating. The grass is to be closely packed and tied with bamboo battens below and above, spaced, and with ties at intervals of 45 cm. each layer of tatties separately laid and tightly tied on the roof with ties at intervals of 25 cm along the battens. The whole surface of the finished roof shall be even without rises or hollows. The cave bundles are to be of the full thickness of the grass coating, evenly and tightly laid out off squarely neatly and perfectly straight.

N.B.—This latter paragraph may be modified as necessary for each locality by supplementary specification to suit the best type of thatching known to the local thatchers.

3. The ridge and hips will be finished off by a 25 cm roll of grass and both ridge and hips will be covered by strong bamboo battens firmly secured with coir rope to the bamboo below.

4. Valleys will be lined with plain galvanized iron sheeting not less than 1 metre wide which will be secured to the bamboo framing.

4.1. The finished roof shall be perfectly weather tight with no leakage whatever under heavy rains. It should not sink perceptibly with the weight of a man standing on it.

4.2. A pitch of not ness than half span will be usually adopted.

5. The rate for thatch roofing will include all work and materials as described above, except valley linings.

Note.—In repairs where a top coat has to be renewed, the entire top layer of grass shall be removed, hollows in the layer below shall be filled with new grass laid under the battens of the lower coat to which new tatties, wherever required, should be added. The new coat shall be then laid on as described above and new eave bundles provided, of the full thickness of the grass roofing.

SPECIFICATION NO. 46-A.

Best thatched roofing using Coconut Cadjan Madals.

1. Laying of rafters and reepers shall be done as specified in S.S. No. 46 specification for best thatched roofing.

2. Over the reepers, double new coconut cadjan madals shall be laid closely one over the other beginning at the eaves and working upwards and tying well each madal to the reepers. The top of the roof shall be finished off by laying two layers of cadjan madals longitudinally along the ridge with their centre exactly across the top of the ridge and bending the ends down on either side and tied down on either side to the bamboos below. The angle on the top shall not be so accute as to buckle the madals. At least 43 numbers of double coconut cadjan madals shall be use for every 10 sq. m. of thatched roof area. A pitch of not less than half span will be usually adopted.

3. The eaves and verges shall then be trimmed by cutting off the loose ends of cadjan madals. The roof when completed shall present a uniform appearance.

4. The finished roof shall be perfectly weather tight with no leakage whatever under heavy rains. It should not sink perceptibly with the weight of a man standing on it.

5. The rate for thatch roofing will include all work and materials as described above.

6. Trellising over thatched roof with 1/6 split new bamboo reepers, placed diagonally 60 cm. apart may be provided if so specified. The same shall be measured and paid for separately.

SPECIFICATION NO. 47.

Roofing with galvanized corrugated iron sheets.

1. The Gauge of sheets will be noted in the Schedule I.S.277/69 (extract under specification 15) and N.B. Code Appendix Part V refer to several thickness and weights.

1.1. *Galvanized corrugated iron sheets.*—The roofing shall consist of sound standard specification galvanized iron sheets of such gauge as will be specified in the tender notice. The sheets shall be uninjured in carriage either by rubbing of the zinc coating or otherwise. They shall have clean and bright surface, and shall be free from rust or white powdery deposit.

2. The sheets shall be laid on the roof with a lap of not less than 15 cm in length over the sheet below and the side laps shall extend over two corrugations, the laps being turned away from the usual direction of local heavy rains.

3. The sheets shall be riveted together with galvanized iron rivets and washers, or bolted together with 6 mm diameter galvanized bolts and limpet washers, The latter is more usual.

4. The rivets or bolts shall be placed at 30 cm intervals along with edge of the length of the sheet, or at such distance approximately 30 cm as will equally divide the sheets along their length. The bolts and rivets shall always be placed along the ridge of the corrugations. As the overlap exceeds to corrugations, these rivets or bolts shall be placed zig-zag so that the end of each of the two overlapping sheets shall be drawn tightly one against the other.

5. The horizontal joints of the sheets shall also be riveted or bolted together by means of rivets or bolts and washers, the rivets or bolts being placed, normally, on each alternate corrugation ridge.

6. The holes for the bolts shall be drilled or neatly and cleanly punched in the ridge from the outside inwards, so that a proper seating for the limpet washer is obtained. A punch and sheeter's dolly shall be used.

7. The roof covering shall be supported longitudinally by wooden or iron purlin. For permanent work, before laying the sheets on the roof they may be riveted on the ground to a length equal to the slant height of the roof—*vide* note 4 below. This riveted sheet may be lifted on to the roof and placed on the purlins, irrespective of the joints falling on the purlins. The second and other rows of sheeting shall be fixed as described above taking care that the horizontal joints do not fall in one line ; the sheets shall be carefully set on the purlins and fastened to them to galvanized iron hook bolts and limpet washers, clips, screws, or other fasteners, as may be approved by the Executive Engineer. 60 mm screws are used for wooden purlins and hook bolts for angle iron purlins. These screws or bolts are to be evenly spaced, two per sheet slope, over each purlin. The screws or bolts must always be placed along the ridges of the corrugations. The bolt holes must be slightly larger than the diameter of the bolt so as to allow contraction and expansion of the mass of the roof covering. These holes must be covered by lead washers, or bitumen and iron washers fitting tight to the shank of the bolts and extending 12 mm all round beyond the hole. Purlins shall also be provided along the eaves at each side to prevent the over lapping ends of the sheets from buckling or lying uneven only.

8. The maximum spacing of purlins for different gauges of sheet shall not exceed the following :—

Thickness.	*Roofing with sheets.*	*Roofing with Mangalore tiles over sheets.*	*Roofing with pan tiles over sheets.*	*Remarks.*
(1)	(2)	(3)	(4)	(5)
1.60 mm.	2.8 m.	2.1 m.	1.8 m.	This table is for 75 mm. corrugations 18 mm. deep.
1.25 mm.	2.4 m.	1.8 m.	1.5 m.	
1.00 mm.	2.0 m.	1.5 m.	1.2 m.	
0.80 mm.	1.8 m.	1.4 m.	1.1 m.	
0.63 mm-	1.6 m.	1.2 m.	1·0 m.	

9. All rivets, bolts, screws, etc. shall be set in white lead. The rivets shall be tightened and drawn closely and the heads spread evenly and equally, and properly hammered, and set down all round.

10. Wind ties consisting of continuous lengths of flat bars iron 50 mm X 6 mm or of suitable wooden battens if so specified, shall be fixed along the eaves of the roof, the ties being bolted or screwed down to the rafters in the same way as the sheets are fastened to the purlins. Slot holes will be cut in the wind ties to allow for expansion and contraction due to variation in temperature. In windy locations, such as open sheds or verandas, the Executive Engineer will also specify the measures to be adopted to secure the purlins themselves to the masonry or other parts.

11. Ridges and hips shall be covered with proper ready made 1.0 mm thick galvanized corrugated iron ridging vide standard specification for galvanized iron sheets having a minimum of 25 cm lap on either side. These shall be securely fastened down to the main roof in the same manner as the corrugated sheets are attached to each other and to the purlins. The capping or ridging shall be laid with an overlap of at least 25 cm at each joint between two lengths.

11.1. Valleys will be lined with 1.25 mm standard specification galvanized iron or zinc sheeting, 0.9 m wide, screwed down to 25mm planking laid beneath them—the sheet having 25 cm overlap.

11.2. The contract unit rate for the roofing per 10 sq. metres shall include the supply and fixing of the standard ridging for ridges and hips and sheeting for vallelys as specified above—unless it is otherwise described in the relevant schedule item or otherwise specified. The contractor shall therefore study the drawings t determine the lengths of such ridging and valley in lining to be supplied before he submits his tender rate.

12. Where the sheets have to be cut to suit the dimension of the roof, either along the slope or along the length, they shall be cut carefully with a straight edge and chisel.

13. For outside walls and partitions, the sheets may be fixed with a lap of one and a half corrugations. This may be obtained by reversing each alternate sheet in order that the sharp edge of the outer corrugation shall, in all cases, lie inwards into the outer hollow of the corrugation in the next sheet which gives a neat finish to the joint.

NOTE.—1. Where the nature of the work so justifies, the corrugation sheeting will be painted after erection with two coats of approved paint. There are suitable patent paints in the market which will adhere on galvanized surfaces.

A galvanized iron roof has been found to be 10° to 20° Fahrenheit cooler when painted white, than when left of its natural colour.

2. Corrugated iron sheets should not be built into gable and parapets, but should be bent up along the edge and suitable flashing provided, or a projecting drip course built, as part of the parape to cover the joints by at least 75 mm (This flashing is not included. in the roofing rate).

3. When corrugated sheets are used for temporary buildings, it is undesirable to make holes in them. The use of Windless clips avoids the necessity of making holes in the sheets.

4. When riveting is, done, the sheets should be riveted in set on the ground. Generally three sheets in the length and three or four in breath can be completed on the ground before they are hoisted on to the roof. In fixing the rivets, which will always be of galvanized iron, they will be passed through from below and held up firmly by a holster, resting on a block of wood placed on the ground. A lead washer fitting tight to the shank of the rivet and extending 12 mm all round beyond the edge of the hole will be put on, and the rivet head will be made over it with a light hammer and finished off with a capping tool. Care must be taken that the sheet is well supported underneath, and that no indentification is made on the upper surface of the corrugation.

4.1. When the different sets are hoisted on to the roof, they wil be riveted together in the same manner, careful blocking being done from below :

SPECIFICATION NO. 48.

ROOFING WITH GALVANIZED CORRUGATED IRON SHEETS AND PAN TILES OVER.

The corrugated iron roofing shall be executed to the standard specification for "Roofing with galvanized corrugated iron sheets" Over this roofing shall be laid dry, without mortar, standard specification pan tiles, in the same manner as detailed in the standard specification. "Best tiled roofing with pan tiles including teak reepers at 100 mm centres and lime borders complete" with the exception that (1) teak reepers are now unnecessary, (2) lime borders are omitted and (3) the number of tiles may be reduced to give overlap of half the tiles length both in lower and upper layer. The tiles shall start at 30 cm from the eaves unless otherwise specifed, resting against reepers fixed as for ordinary pan tiles roofing and screwed to the rafters in a similar manner, to the way wind ties are fixed. Ridges and hips will be finished as specified in the standard specification for pan tile roofing.

NOTE.—The area of the roofing is to be measured as per area of corrugated iron sheets below.

SPECIFICATION No. 49.

ROOFING WITH ASBESTOS CEMENT CORRUGATED OR SEMI-CORRUGATED SHEETS.

1.1. Specification for A.C. sheet roofing is given in IS 459/1970 and N.B. Code appendix Part V.

1.2. The contract unit rate for the roofing per 10 sq. metres shall include the supply and delivery of sheeting, ridging and fixing accessories with or without erection.

Fixing of sheets.—IS 3007/Part II/1965 and N.B. Code Appendix VII shall apply.

2.1. It is important when using unreinforced corrugated sheets on large roofs, in which there is likely to be some movement of the structure due to variations in climatic conditions, that expansion joints should be used in association with the sheets to permit any such movement being taken up. It is therefore desirable that the recommendations of the manufacturers on this point should be carefully followed. In cases where sheets have to be bolted through the lap, and on long stretches of roof, an expansion joint should be provided at the definite intervals recommended for each particular class of roof.

Ceilings—notes.

1. I.S. 2441/63 shall apply.

1.1. Methods of fixing timber ceilings are described in IS 5390/69 and N.B.C. Part VI Section 3.

SPECIFICATION No. 50.

12 MM. TEAKWOOD PLANK CEILINGS (TONGUED AND GROOVED PLANKING).

IS. 5390/69. paragraphs 4 and 7 of IS 2441/63 and N.B.C. Part VI Section 3 shall apply.

SPECIFICATION No. 51.

12 MM. TEAKWOOD PLANK CEILING WITH 35 MM. × 12 MM TEAK BATTEN.

IS 5390/69 and N.B. Code Part VI Section 3 shall apply.

EXTRACT FROM I.S. 459 — 1970.

Specification for unreinforced corrugated and semi-corrugated asbestos cement sheets.

4. *Dimensions and tolerances.*

4.1. The sheets shall conform to the dimensions and tolerances given in Table 1 and Fig. 1 and Fig. 2.

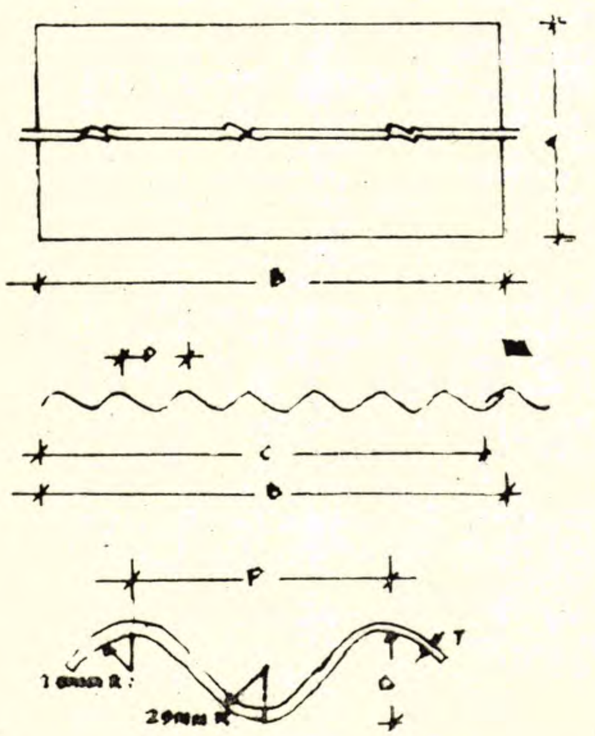


FIG 1 CORRUGATED SHEETS

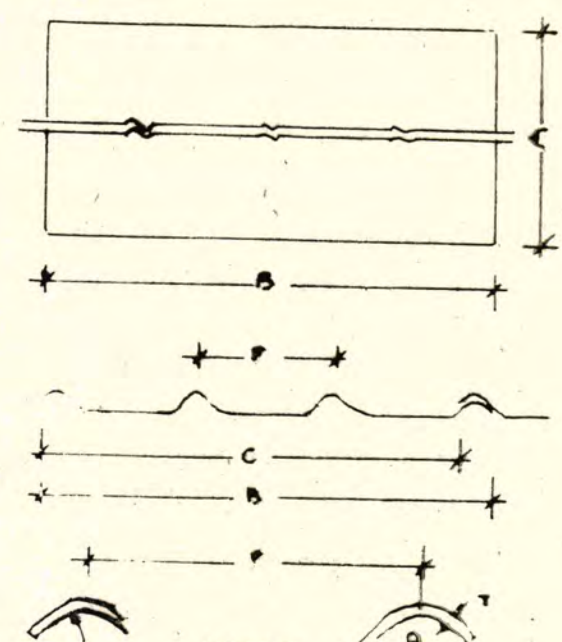


FIG 2 SEMI CORRUGATED SHEETS

TABLE 1—DIMENSIONS AND TOLERANCES OF CORRUGATED AND SEMI-CORRUGATED SHEETS.

(*Clause* 4.1.)

(*All dimensions in millimeters*)

Serial number and type of sheet.	*Depth of corrugation.*		*Pitch of corrugation.*		*Overall width.*		*Effective width.*		*Nominal thickness.*		*Length of sheet*.*	
	D	*Tolerance.*	*P*	*Tolerance.* **	*B*	*Tolerance.*	*T*	*Tolerance.*	*T*	*Tolerance.*	*A*	*Tolerance.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(i) Corrugated sheets	48	+ 3 — 5	146	+ 6 —2	1050	+10 — 5	1010	+10 — 5	6	+Free — 0.5	1750 2000 2500 or 3000	+ 5 —10
(ii) Semi-corrugated sheets	45	+ 3 — 5	338	+ 6 — 2	1100	+10 — 5	1014	+10 — 5	6	+ Free —0·5	1750 2000 2500 3000	+ 5 —10

* Intermediate metric sizes may also be manufactured by mutual agreement between the manufacturer and consumer.

** Tolerance given in this table for pitch of corrugation relates to measurement over six pitches for corrugated sheets and three pitches for semi-corrugated sheets.

EXTRACT FROM I.S. 654—1972.

Specification for Clay roofing, tiles, Mangalore pattern.

3. *Classification* :

3·1. Roofing tiles, Mangalore pattern, shall be of two classes namely, class AA and class A and shall be classified as per the characteristics as specified in Table 1.

TABLE 1—CLASSIFICATION OF ROOFING TILES.

(*Clauses* 3. 1, 6·53, 6·54, 7·1 *and* 7·3)

Serial number and Characteristic.	*Requirements.* *Class AA.*	*Class A.*
(i) Water absorption, per cent max	19	24
(ii) Breaking load, kg. min.	102	82
(*a*) Average	102	82
(*b*) Individual	91	68

4. *General quality* :

4·1. The roofing tiles shall be made from suitable clay of even texture and shall be well burnt. They shall be free from irregularities, such as twists, bends, cracks and laminations.

4·2. The roofing tile shall be free from impurities like particles of stone, lime or other foreign materials visible to the naked eye either on the surface or on the fractured face of the tile obtained by breaking the tile. However, occasional particles upto 2 mm in size may be permissible. When struck, the tile shall give a characteristic ringing sound and when broken the fracture shall be clean and sharp at the edges. The class AA tile shall be of uniform colour

4·3. *Shape* : When the roofing tile is placed on either face on a plane surface, the gap at the corners shall be not more than 6 mm

4·4. *Lugs* :

4·4.1. *Battern lugs* : The tile shall have at least 2 battern Lugs with base thickness (thickness at bottom) not less than 15 mm. and thickness at top not less than 10 mm. The projection from urface of the tile shall be between 7 and 12 mm. (see Fig.1).

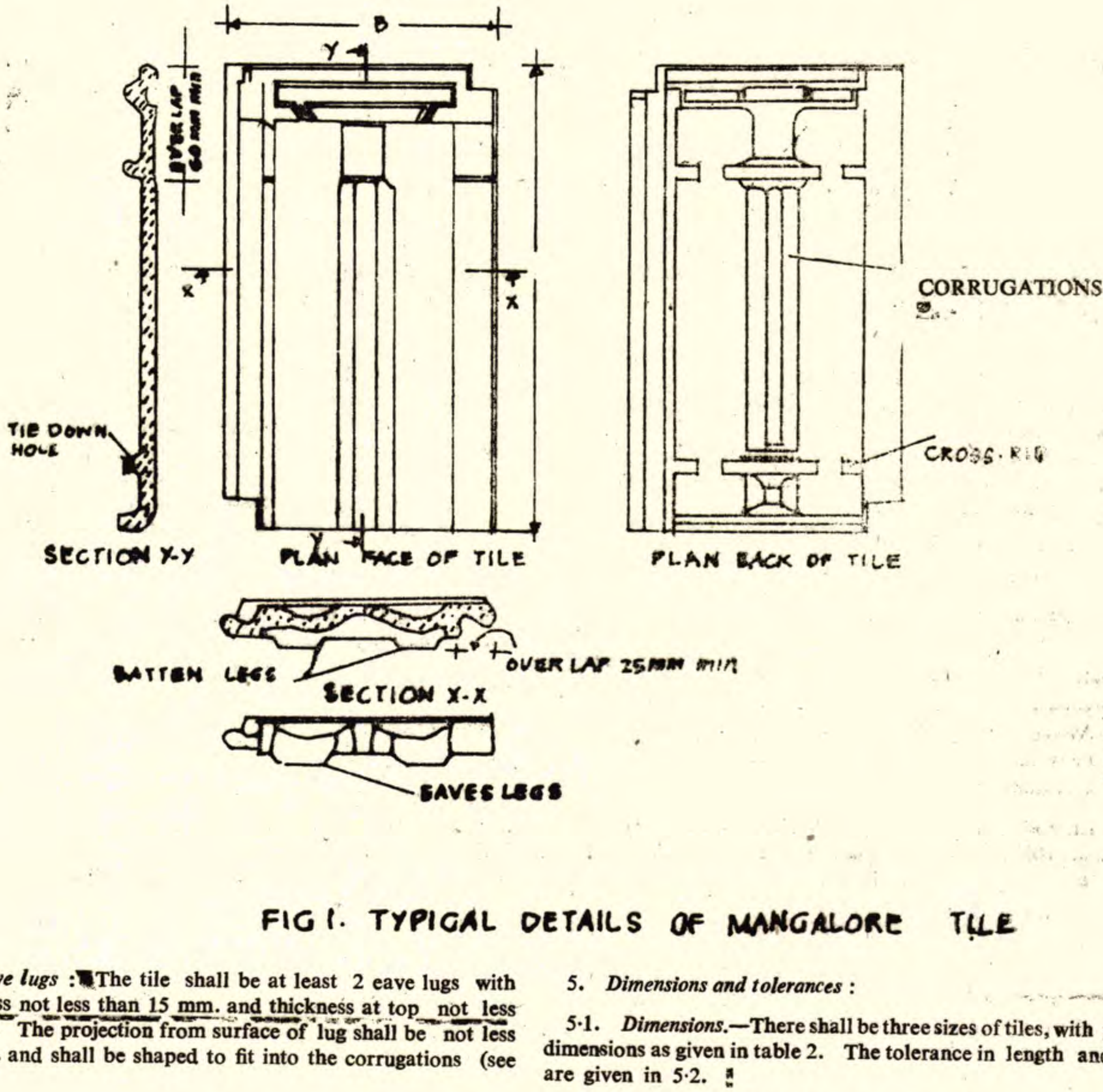


FIG I. TYPICAL DETAILS OF MANGALORE TILE

4·4·2. *Eave lugs* : The tile shall be at least 2 eave lugs with base thickness not less than 15 mm. and thickness at top not less than 10 mm. The projection from surface of lug shall be not less than 10 mm. and shall be shaped to fit into the corrugations (see Fig. 1).

4·5. *Corrugations and cross ribs*: The cross section of the roofing tile shall be such as to give the tile structural rigidity. This may be achieved by providing longitudinal corrugations with intermediate cross ribs or stiffeners (See Fig. 1).

4·6·. *Tie down hole* : At least one hole shall be provided in one of the cross ribs near the eave end of the tile for securing the tile o the reeper or batten with wire. The hole shall be clear and true and shall be not more than 2 mm. in diameter, but shall be large enough to pass a 1.6 mm. wire easily (See. Fig. 1).

5. *Dimensions and tolerances* :

5·1. *Dimensions.*—There shall be three sizes of tiles, with principal dimensions as given in table 2. The tolerance in length and width are given in 5·2.

TABLE 2 :- DIMENSIONS OF TILES.

Serial number.	*Overall length.*	*Overall width.*
(1)	(2)	(3)
1.	410 mm.	235 mm.
2.	420 mm.	250 mm.
3.	425 mm.	260 mm.

NOTE : If the maximum overlaps are kept, the tile at Serial number (1) is used for batten spacing upto 320 mm. Serial No. (2) upto 350 mm. and Serial number (3) upto 360 mm.. However, by reducing suitably overlaps in the tiles at Serial Nos. (1) and (2) these can also be used for batten spacing upto 360 mm.

5·1·1. The minimum overlap (see Fig. 1) shall be 60 mm. lengthwise and 25 mm. widthwise for each type of tiles.

5·2. *Tolerances.* – For measurement of variations in length/ width of tiles the difference between : –

(*a*) the overall length / width of three tiles (Measured in accordance with 5·2·1) and

(*b*) the length / width of a tile is calculated and this value shall be within the limits mentioned below :—

For tile sizes. in mm.	*Value of length. in* mm.	*Value for width. in* mm.
(1)	(2)	(3)
410 x 235	630 to 650	410 to 430
420 x 250	670 to 690	420 to 440
425 x 265	690 x 710	430 to 450

5·2·.1 Three tiles shall be selected at random from the sample selected under 6·3. All blisters, loose particles of clay and small projections shall be removed. These shall be arranged upon a level surface interlocked along length / width wise on straight line in tight position, and overall dimensions are measured (See Fig. 2).

5·3. *Weight.*—The average weight of the six tiles, when dried at 105 to 110°C to constant weight and weighed, shall be not less than 2 kg. and not more than 3 kg.

5·3·1. The weight of tile shall be noted correct to the nearest 0·01 kg.

EXTRACT FROM I.S. 2119–1962.

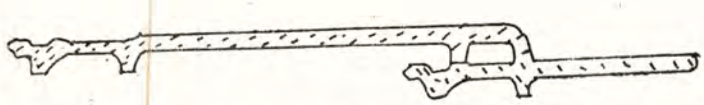
*Code of practice for construction of brick-*cum*-concrete composite (Madras Terrace) floor or roof.*

4. *Design considerations.*

4·1. *General.*—The Madras terrace floor or roof shall consist of the following components :—

(*a*) A layer of terrace-brick work laid on edge with lime mortar specified mix, supported on closely spaced wooden precast reinforced concrete or steel joists and having a suitable ceiling finish applied to the soffit of the terrace-brick work.

(*b*) A course of lime-brick jelly concrete laid to a specified thickness over the terrace-brick work and having the required floor or roof finish at the top ; and



2A. ARRANGEMENT OF THREE TILES LENGTH WISE IN TIGHT POSITION.

2B. ARRANGEMENT OF THREE TILES BREADTHWISE IN TIGHT POSITION.

FIG. MEASUREMENT OF TOLERANCES.

(*c*) Suitable floor and ceiling finish.

7. *Preparatory work.*

7·3. *Preparation of terraces bricks.*—The terrace bricks shall be kept immersed in water for atleast 4 hours before use in the work. The skin shall then be allowed to dry. This treatment is necessary to develop adhesion with mortar in the terrace-brick work.

9. *Laying of terrace bricks.*

9·1. After preparations as in 7-3, the terrace bricks shall be on edge in diagonal rows spanning over the joists. The laying shall start from one corner and proceed towards opposite corner. Each row shall be completed before the next one, adjacent to it, is started.

9·2. The bricks shall be laid in lime mortar of mix 1:1½ (lime putty, sand by volume). The thickness of mortar joints shall not exceed 1 cm.

9·3. During laying, the bricks shall be pressed against the adjacent row already laid so that it bonds well with the mortar and also partially develops lateral adhesion preventing it from slipping. To enhance the self-supporting arch action of the brick work, the bricks may be so laid as to obtain for the brick work a slight rise in between the joists, the rise being generally not exceeding 5 mm.

9.4. After laying, the brick work shall be cured by keeping it moist for a period of not less than 10 days so as to set properly

10. *Laying of lime-brick jelly concrete.*

10.1. After the terrace brick has set, a layer of lime-brick jelly concrete of mix 1:2½ (slaked lime-brick jelly by volume) shall be laid and spread to an average thickness of 10 cm.

10.2. After the lime-brick jelly conerete is laid, initial ramming shall be done with wooden rammer of weight not exceeding 2 kg so that the layer of lime concrete is consolidated to 7.5 cm. thickness. After this, the consolidation shall further be done with the hand beater (see 2.4) so that the concrete hardens and the beater makes no impression on the concrete and readily rebounds from the surface when struck on it.

10.3. After compaction, the surface shall be wetted by sprinkling or a solution prepared by soaking in water the dry nuts of Terminalia Chebula (Kadukai).

Note. –The solution of Kadukai may be prepared as follows : –

The dry nuts shall be broken to small pieces and allowed to soak in water.

The resulting liquor is decanted and used for the work.

If the surface during the process of compaction becomes so uneven that water lodges in pools, the surface shall be pricked up and fresh concrete spread and consolidated as necessary to obtain an even surface.

10.4. The concrete shall then be cured by sprinking water and allowed to harden for a period of not less than six days before laying the floor or roof finish.

11. *Finishing.*

11.2. The ceiling shall be finished with lime plaster of mix 1 : 2 or cement plaster of mix 1 : 3 as required. The plaster shall be in a single coat 12 mm thick.

11.3. The finished surface of the terrace and ceiling shall be cured with water for a period of not less than three weeks.

APPENDIX A.

(*Clauses* 2-3 *and* 5-4)

Specification for terrace bricks for use in Madras terrace work.

A.1. *Manufacture.*

A.1.1. The bricks shall be made from clay moulded to the rectangular shape and burnt in the same manner as for common building bricks. Either hand or machine moulding may be adopted.

A.2. *General quality.*

A.2.1. The brick shall be free from cracks and flaws and modules of free lime.

A.2.2. The defects in uniformity or the shape of the brick shall not be such as to cause difficulty in obtaining uniform courses while lying the terrace-brick work.

A.4. *Dimensions and tolerances.*

A.4.1. The size of the terrace brick shall be 15 x 7.5 x 2.5. cm.

A.4.2. When 20 whole bricks are measured together in accordance with the procedure given in 4.2.1. of I.S. 1077-1957 specification for Common Burnt clay building bricks, the dimensions of bricks shall be within the following limits:—

Length 290 to 310 cm.
Breadth 145 to 155 cm.
Thickness 45 to 55 cm.

EXTRACT FROM I.S. 2441-1963.

Code of practice for fixing ceiling coverings.

4.8. *Timber for ceiling frame work and beading.*—The timber shall be made from selected species that are found to be satisfactory in the local practice for such use. The timber shall be seasoned in accordance with IS : 1141–1958 code of Practice for Seasonings of Timber (Tentative). Timber for ceiling frame work shall not be less than 60 mm. in depth and 40 mm. in width, The beadings shall generally be of size 40 mm. x 12 mm. The timber shall be preservative treated in accordance with IS : 401–1961 Code of Practice for Preservation of Timber (Revised).

4.9. *Timber planks.*—The Planks shall be of seasoned timber wrought to required size. The plank thickness may vary from 15 mm. to 25 mm. The width of plank shall be 100 mm, to 150 mm. length not exceeding 3 m. each plank shall have tongue and groove for jointing. The planks shall preferably be well-planed on both sides for short lengths of not less than 10 cm. near each end. The planks shall be from the species of timber specified in IS : 883–1961, Code of Practice for use of Structural Timber in Building (Material, Grading and Design) (Revised) Seasoning shall be done in accordance with IS : 1141/1958. The planks shall also be preservative treated in accordance with I.S. 401/1961.

4.10. *Suspenders for ceiling frame work*—These may be fabricated from mild steel flats or other metal sections. They shall preferably be in two pieces so that the length of the suspender may be adjusted slightly during fixing of the ceiling frames. The shape at the top end shall facilitate a firm suspension from the structural floor above with proper anchorage.

Where mild steel flats are used as suspender, they shall be of one the following sizes:—

35 to 40 mm. x 6 mm. ; 45 to 50 mm. x 6 mm. or 60 to 65 mm. x 6 mm.

4.11. *Metal frame work.*—The frame work may also be made of sections of light metal, such as aluminium, the shape of cross section being such as to facilitate proper suspension and proper fixing of the ceiling coverings to them.

5.2. *Suitability of different types of ceiling covering* .

5.2.1. *Timber plank*—Timber plank coverings will be generally strong and stiff.

5.2.2. *Gypsum plaster board.* –These coverings will comtribute high fire resistance to the ceilings to which they are fixed. Gypsum boards, which are sensitive to moisture, shall not be used where excess of moisture is to be encountered .

5.2.3. *Plywood*—Plywood may be used for ceiling covering to obtain a continuous flush surface. Plywood ceiling shall preferably be fixed with beadings at appropriate spacings. If decorative, polished or waxed surface is desired, decorative plywood conforming to IS : 1328–1958 Specification for venered Decorative Plywood may be used. If coloured or painted surface is desired, plywood conforming to IS : 303–1960 specification for plywood for General purposes (Revised) may be used.

5.2.4. *Block boards and particle boards.* –Any of these types of coverings is durable, strong and stiff like timber plants with the additional advantages of providing a continuous flush surface, simplicity and speed of fixing. Beading shall preferably be provided at joints as in plywood. Joints may be butt-fitted on frame members. For decorative ceilings, decorative veneered matched panels may be used in either veneered particle boards or block boards. For ceilings to be painted, commercial, grade boards may be used. Particle boards will give additional sound absorbing and sound amping qualities.

5.2.5. *Asbestos cement building boards.*—These can be used even in situations where moisture is present, such as in bathrooms, kitchens etc. Asbestos cement boards of a special composition and special surface texture can be used for decorative acoustic and insulation purposes.

5.3. *Frame strength and stability.*

5.3.1. The frame to support the ceiling shall be designed for structural strength and stability taking into consideration the spacing of truss members and the sizes, weight and strength of ceiling coverings to be fixed.

5.3.2. Generally false ceiling to R.C.C. slabs may be provided to cover projecting beams, frames and slabs at different levels, and also service lines and installations.

Note. -In public halls where R.C.C. slabs are not provided in one level use of false ceiling shall achieve better finish, acoustic and thermal insulations concealed lighting, etc.

5.3.3. The suspenders used for supporting frame work for false ceiling to RCC slabs shall be a length sufficient to reach the ceiling frame, and shall be anchored adequately to structural concrete above so as to obtain the required support for the ceiling.

5.3.4. Where the members of ceiling frame work span more than 90 cm. centre to centre additional cross battens shall be provided to sttiffen them.

5.3.5. Ceiling boards whose weight is not more than 5 kg/m^2 may be fixed directly to RCC slabs by means of fixing plugs, bolts or other suitable devices.

7. *Fixing timber plank ceiling*.—

7.1. After fixing of the frame work in accordance with 5·3 the exposed length of suspenders shall be protected with anti-corrosive paint wherever necessary. Timber battens shall be treated with a preservative before use and the treatment shall be such that they do not leave any stain on the ceiling coverings.

7.2. The outer line of planks shall be accurately fixed in straight line joints. The plank joints shall be parallel and in perfect line. The first plank next to the wall shall be fixed cerefully and accurately very close to the wall, subsequent planks shall be jointed up (tongue and groove joint, see also 5.2.1.) with utmost care.

7.3. The counter sunk screw holes and the joints between the planks shallbe filled with putty or stopping.

466-3—49A

7.4. The beadings, wherever required shall be fixed to battens with screws of length 50 mm. or equal to double the overall thickness of the planks and beadings, whichever is larger. The overlap of the beadings shall be equal on either side of the two adjoining planks. The beading shall be mitred at junctions. The spacing of screws shall be staggered along its length so that each one is driven completely through one plank. Screws shall be countersunk and screw holes filled up with putty or stopping.

7.5. The ceiling shall be treated with a suitable wood finishing in accordance with IS. 2338 code of practice for Finishing of wood and Wood based materials in Buildings.

8. *Fixing gypsum plaster boards.*

8.1. The nails used for backing gypsum boards shall be of 2·5 or 2·65 mm size with a head diameter of 5'to 10 mm. The length of nails shall be as follows :

For 10 mm. thick board—about 30 mm.

For 12 to 16 mm. thick board 35 to 40 mm.

8.2. Only screws shall be used for fixing gypsum boards though nails may be used for initial tacking. The screws shall be countersunk. The sizes of screws shall be 2·39 or 2·74 mm. dia. (12 to 13 guage) and the length as follows :

For 10 mm. thick board—about 30 mm.

For 12 to 16 mm. thick board 35 to 40 mm.

The screw shall have 10 mm. minimum clearance from the edge of board. Steel screws without brass or nickel coating shall not be used.

8·3. *Jointing.*—The boards shall be fixed with a joint, clearance of about 6 mm. The joints shall always be in perfect line and plane. Jointing may also be provided in a decorative pattern.

8.4. *Finishing of joints.*—The joints shall be filled with gypsum plaster or other finishing materials recommended by the manufacturer of the boards. After filling the joints, a thick skin of the finishing materials shall be spread about 5 cm. vide on either side of the joint and on to it shall be trowelled dry a reinforcing scrim sloth about 10 cm vide. When metal scrim is used, a stiffer plaster will be necessary to enable the trowelling of the scrim down to the board (see Fig. 3) the joints may be left open also if desired.

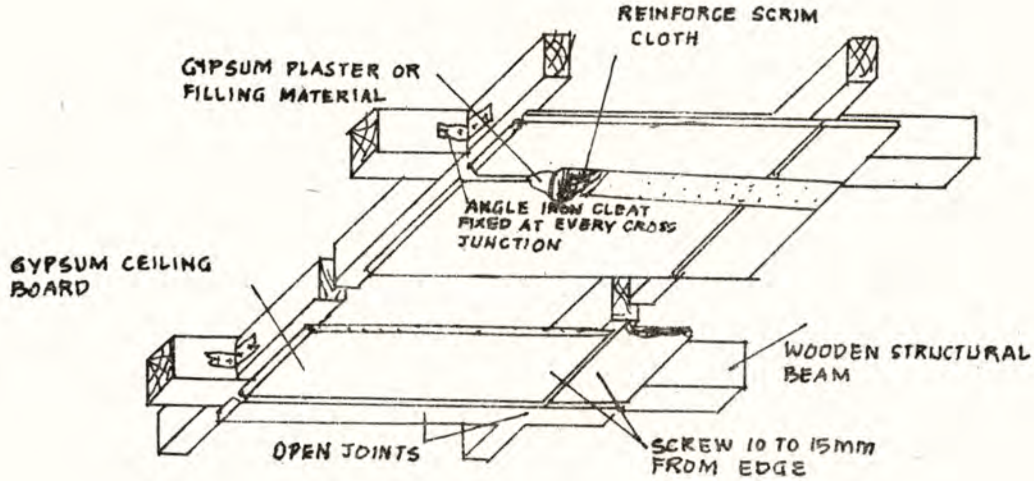


FIG. 3. FINISHING TREATMENT FOR JOINTS IN GYPSUM BOARD CEILING.

9. *Fixing fibre building boards* :

9.1. *Frame work.*—The frame work battens and cross battens supporting the ceiling shall be spaced according to the size of boards to be fixed.

9·2. The sizes of battens may range from 65 to 75 mm × 40 to 50 mm. and the spacing may range from 45 to 60 mm. for longitudinal battens and 60 to 120 cm. for cross battens depending on the size of boards.

The frame member shall be treated with a coat of preservative paint preferably odourless before the ceiling covering is fixed.

9·3. All the edges of the fibreboards shall be fixed to frame members by means of screws. Along the edge line of the board the serews shall be at a spacing of 7·5 cm. centre to centre and shall have a clearance of 10 mm. from the edge line. Along the lines of intermediate supports, the screws may be spaced at 15 to 20 cm. centre to centre. All the screws shall be countersunk.

9.3.1. The screws shall be rustless and greased before fixing steel screws, if used, shall preferably be coated with brass or nickel. The length of screws shall be as follows :—

For 3 to 6 mm. thick board—25 mm.

For 8 to 12 mm. thick board—30 to 35 mm.

9.4. *Jointing.*—The joints shall not be normally filled with plaster, but where the fibreboards (low or medium density boards) are to be cement plastered, the joints shall be left with a gap of about 6 mm, which shall be covered with scrim, bedded in cement plaster, before the finishing coat of plaster is applied.

9.4.1. The joints between fibreboards in the ceiling may be finished in various ways as described in IS. 1414–1962 code of practice for fixing wall coverings.

9.4.2. If the Fibreboards specially moulded in the edges are used the manufacturer's instructions for cutting at site shall be followed.

9.4.3. In the case of rebated edges, screwing shall not be done through the rebates.

9.4.4. Open joints may also be covered with strips of various materials such as the following :—

(*a*) Wood cover strips, about 35 to 45 mm. vide and 12 mm. or less thick ;

(*b*) Plain strips cut from standard sheets of the same materials as the boards, or mouldings of fibre boards separately procured for use as cover strips, or special types of moulded cover strips supplied by manufacturers of fibre boards ;

(*c*) Metal cover strips such as a aluminium or chromium plated metal ;

(*d*) Shaped plastic strip ; and

(*e*) Linen-backed adhesive strip.

The cover strips shall be screwed along the centre line of the joints so that the fixing of screws pass through the open joints. The spacing of screws shall be at 15 to 20 cm. centre-to-centre. Special types of coverstrip of fibreboard metal, plastic, etc., shall be fixed in accordance with the manufacturer's instruction.

Linen-backed adhesive strip may be fixed by wetting the linen and pressing over the edges of the boards.

10. *Fixing plywood, block boards or particle boards.*

10.1. *Frame work.*—The frame work battens and cross battens supporting the ceiling shall be spaced in sections determined, taking into consideration the size and shape of the board, the thickness of the board, including its strength and weight the pattern of the figure and grain matching in the case of decorative boards and other considerations specified in 5·3.

10.1.1. For boards in thickness 4 mm. to 10 mm, spacings vary from 45 cm. to 60 cm. for longitudinal battens and 60 cm to 130 cm for cross battens. For boards above 10 mm. thickness, the above spacings may vary from 60 cm. to 90 cm· for longitudinal battens and from 90 cm. to 130 cm. for cross battens.

10.1.2. The sizes of battens may range from 65 mm. to 75 mm. × 40 mm· to 50 mm.

10.1.3. After fixing, the frame work shall be checked with regard to the level position of its outside surface and for proper fixtures and joints.

10.2. The playwood or other boards shall be checked for correct size; squareness of adjacent sides and laying patterns. In the case of docorative boards, the pattern and figure matching should have been decided and put on paper, and b ards preferably numbered for their posi ions. Any board so required shall be cut to the req ired plan.

Where necessary, particularly when it is not sufficiently thick to be self-supporting from edge, to edge playwood may be stiffened along the edges and also in intermediate positions by stiles or narrow strips of wood, metal, plastic or other materials.

10.2.1. The boards shall be carefully lifted in a predetermined manner and fixed on to the frame by use of wood screws. All the edges shall be fixed to frame members by screws spaced 7.5 cm centre to centre for 4 mm to 6 mm thick plywood, for thicker boards the centre to centre spacing of these screws may be at about 15 times the thickness. The screws, shall have a clearance of 10 mm. from the edge line. At the lines of intermediate support, the screws shall be fixed at centre to centre spacing not exceeding 25 times the thickness. All the screws shall be countersunk.

10.2.2. The screws shall be fixed starting from one corner and extending to both sides to fix the board flat and level.

10.2.3. The length of the screws shall be as follows.

For boards upto 7 mm.	25 mm.
For boards above 7 mm. upto 12 mm.	35 mm.
For boards above 12 mm.	Thickness+20 mm.

10.2.4. The screws shall be rustless and greased before fixing.

10.3. Jointing—The boards shall be butt jointed with a minimum clearance of 2 mm.

10.3.1. The joints, if left open, shall be filled with painter's putty and brought to level or may be cut to V shape. They may also be left open, levelled or parallel grooved using plans and a chisel or a grooving cutter. The boards may also be pre-cut and edges rounded before fixing. In the case of decorative boards, the joints may be coloured to match the general colour and pattern of the ceiling boards.

10.3.2. The joint may also be rebate-jointed or jointed with tongue and groove as given in 7.2 screws shall in that case not be fixed through the rebate.

10.3.3. Alternatively, the open joints shall be covered by a moulding or strips as given in 9.4.5.

10.3.4. When fixing moulding in case of decorative boards, care should be taken that their colour, shape and size are selected appropriate to the decorative pattern of the ceiling.

10.3.5. Finishing—The ceiling after fixing shall be finished by hand sanding, where necessary, and given further finishes of waxing polishing, clear varnishing or painting in accordance with the instructions of the manufacturers of these boards. Finishing of wood surface shall be in accordance with I.S.: 2338—code of Practice for finishing of Wood and Wood based materials in buildings.

When plywood or other boards with finished surface is fixed, care shall be taken during handling and fixing operation not to disturb and spoil the uniformity of the manufacturer's finish.

11. *Fixing asbestos cement building boards.*

11.1. In fixing asbestos cement building boards, care shall be taken to avoid rigid fixing as this may cause cracking if the supporting structure expands or shrinks, The boards shall be fixed with screws to wooden grounds or fitted with the ceiling frame by means of metal channels and clips as illustrated in Fig. 4.

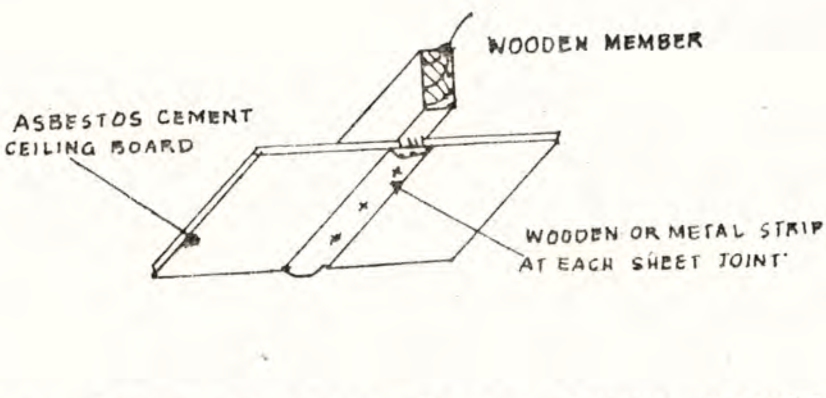


FIG 4. FIXING ASBESTOS CEMENT CEILING BOARDS TO WOODEN MEMBERS

11.2. The spacing of screws or other fixtures will depend on the size and weight of the asbestos board and shall be as advised by the manufacturers of these boards.

12. *Inspection.*

12.1. The special points for inspection during work should be—

(*a*) Quality of the coverings.

(*b*) soundness and rigidity of the supporting frame work.

(*c*) accuracy in level of the frame work and

(*d*) straightness of joints, and correct alignment of beadings.

Fixing and beading work along the junction lines between the ceiling and walls, and also at corner joints need special attention.

13. *Maintenance and repairs.*

13.1. Gypsum wall boards and asbestos cement boards will not ordinarily require any further finishes to maintain.

13.2. The protective finish on wooden planks, plywood, and other boards, of wood based materials shall be periodically renewed to prolong their life.

13.3. When replacement of planks and boards is necessary, such as in case of decay, distortion, bulging out, etc., the whole plank or board, part of which has been affected shall be removed at joint line and replaced and restored to original finish.

13.4. Replacement and repairs shall be done with special care. The repaired surface shall not show any difference from the original in fitting and fixing, beading and finishing, and protective treatment. Maintaining uniformity in finishing treatment in an important aspect during maintenance and repairs.

EXTRACT FROM I.S. 2690—1964.

Specification for burnt clay flat terracing tile.

2.1. *Terracing tile.*—A flat tile hand made or machine pressed made from fine well weathered or well prepared clay and burnt in a kiln, and which is capable of being laid level on a prepared base in one or more courses to provide satisfactory floor or roof finish

3. *Manufacture.*

3.1. The terracing tile shall be made from good clay of even texture and shall be uniformly well burnt. They shall be uniform in size and shape and shall be free from irregularities, such as twists, bends, cracks and particles of stones.

4. *Sizes.*

4.1. The size of terracing tiles and the tolerance shall be as given below :

(*a*) 20 x 20 cm; or 20 x 10 cm; or 15 x 15 cm.

(*b*) Thickness 15 mm or 20 mm and

(*c*) Tolerances :

Length and width	.. $\pm$5 mm.
Thickness	.. $\pm$2 mm.

EXTRACT FROM I.S., 2858—1964.

Code of practice for roofing with Mangalore tiles.

4. *Design considerations.*

4.3. *Reepers.*—The spacing of rafters shall not normally exceed 60 cm. unless the reepers are otherwise designed against sagging, taking into consideration the species of timber used and the load covering over them. The size of reepers unless otherwise designed shall normally be 5 X 2.5 cm. for Mangalore tiles laid over flat tiles over reepers and 5X 1.5 cm. for Mangalore tiles over reepers or over ceiling tiles laid on reepers.

4.5. *Strength and stability.*— While considering the strength and stability of the roof frame work supporting Mangalore tiled roof the following dead loads shall be taken into account :—

Description of roof.	*Rise/ span.*	*Dead weight of roof covering kg/m².*
(1)	(2)	(3)
Mangalore tiles embedded in mortar over flat tiles.	1/4 to 1/2	110
Mangalore tiles with flat tiles without mortar for embedment.	1/4 to 1/3	80
Mangalore tiles alone	1/4 to 1/3	90

4.6. *Roof drainage.*—No gutter or rain water pipe shall discharge water from one roof to another unless the discharge is from a small area such as a "Dormer". For detailed information relating to the disposal of rain water from roofs, reference shall be made to I.S : 2527—1963.

If a valley gutter is formed by means of sheet metal, the sheet shall be taken at least a distance of 30 cm. under the roof on either side of the gutter. Near a wall the sheet metal constituting the valley gutter shall be taken at least 7.5 cm. into the wall and set with cement mortar.

4.7. *Use of glass tiles.*—Glass tiles, usually of the same shape as the Mangalore tiles may be fixed in the same manner as other tiles at suitable spacing according to the requirements of roof lighting. Glass tiles of special types shall be laid in accordance with the instructions of the manufacturers of these tiles.

5. *Materials.*

5.0. The materials used in roofing with Mangalore tiles shall conform to 5.1 to 5.5.

5.1. *Mortar.*—The mortar for use in bedding ridge tiles as well as Mangalore tiles shall be :

Either composite mortar 1 : 2 : 9 (one part cement, two parts lime, nine parts sand) or lime mortar 1 : 3 (one part lime, three part sand).

Water used for making mortar shall be clean and free from deleterious materials.

5.2. *Mangalore tiles.*—These shall conform to IS : 654– 1962 and specification for clay roofing tiles, Mangalore pattern (revised).

5.3. *Ridge tiles.*– These shall conform to IS : 1464—1959.

5.4 *Ceiling tiles.*– Ceiling tiles for use with Mangalore tiles shall conform to IS : 1464—1959.

5.5 *Flat tiles,*—Flat tiles for use with Mangalore tiles shall have one of the dimensions equal to the gauge of the Mangalore tile.

5.6. *Glass tiles.*—These shall preferably be of the same shape as Mangalore tiles.

5.7. *Ventilating tiles.*—Tiles equal in size to one plain Mangalore tile or two tiles laid side by side after allowing for over lapping. These may be used to provide top ventilation in a room.

5.8. *Nails for fixing reepers.*—Nails used for fixing reepers or rafters shall be plain head nails of size 12 gauge (or 2.50 mm.) or 13 gauge (or 2.24 mm.) conforming to IS : 723—1961. The nails shall be galvanized. The length of the nails shall be such that a minimum penetration of 2 cm. will be obtained into the rafters when they are driven through.

5.9. *Sheet metal for valley gutters.*—This shall be of galvanized metal and of thickness not less than 1.2 mm.

5.10. *Reepers* : Reepers shall be of any species of structural timber given in IS : 883 - 1961.

and the size shall be in accordance with the design but shall in no case be less than the size as specified in 4—3. Reepers shall be treated for protection against decay and termites in accordance with IS : 401—1961.

5.11. *Wire for tying down the tiles* :—The wire shall be galvanized and shall conform to IS : 280—1962. Specification for mild steel wire for general purposes (Revised).

7. *Preparatory work.*

7.1. *For flat tiles.*—Before use in the roofing, the flat tiles shall first be prepared by immersing in water for two hours and air-drying before laying. The undersides of the flat tiles, may also, if so specified, be dipped in white wash mixed to a creamy consistency and the tiles then dried.

7.2. *For Mangalore tiles.*—Wherever Mangalore tiles are to be embedded in a mortar layer over flat tiles, the Mangalore tiles shall first be soaked in water for at least two hours before laying.

8. *Fixing of reepers.*

8.1. The reepers shall be fixed over the rafters at the specified or designed spacing and nailed. The nails shall penetrate at least 2 cm. into the rafters*. The reepers shall be nailed to the rafters by means of plain headed nails. Their length, shall be extended only by means of butt joint. The joint shall occur only over the rafters. The joints of no two adjacent rows of reepers shal come over the same rafter. At the eaves a tilting fillet shall be fixed f necessary (*see* Fig 1.).

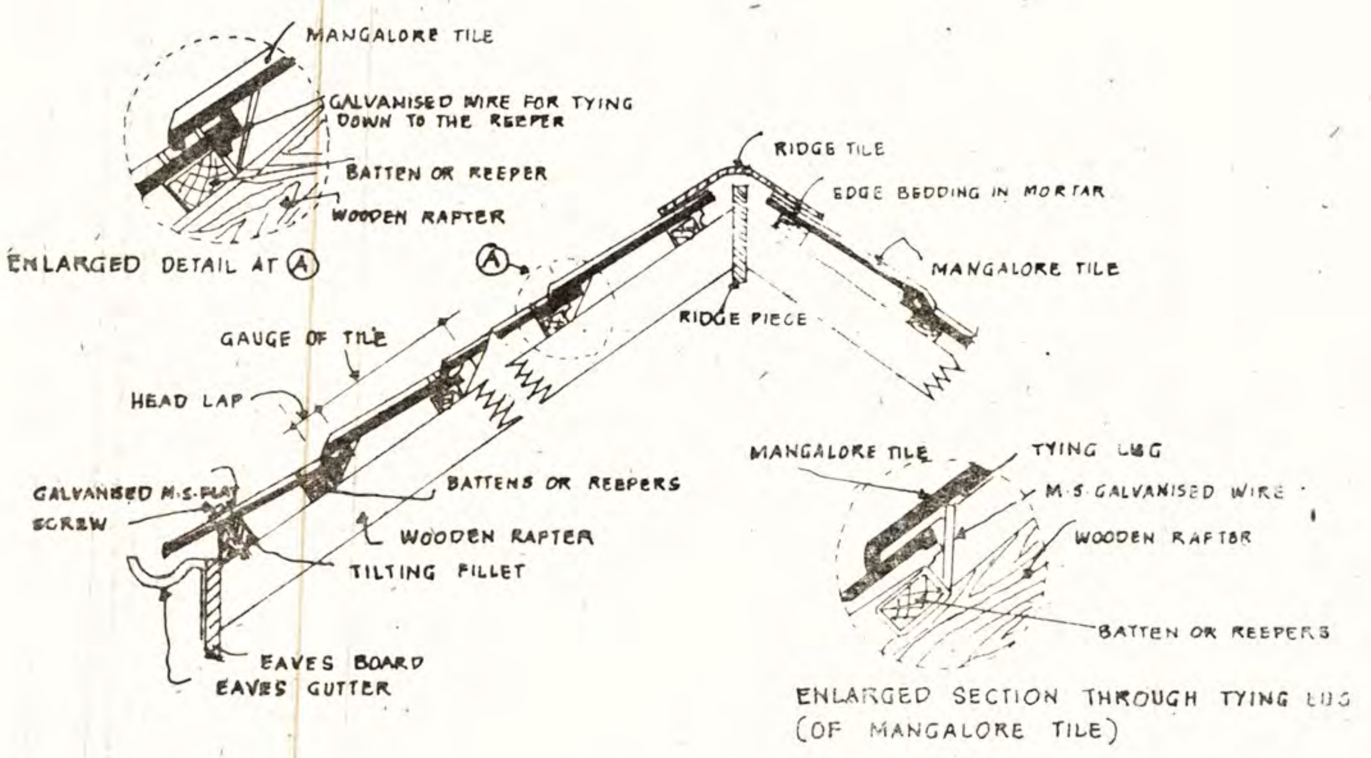


FIG. 1. DETAIL OF MANGALORE TILES LAID ON REEPERS

* They shall extend atleast over a length of three spans between the rafters.

9. *Laying of Mangalore tiles*.

9.1. The tiles shall be laid from the eaves towards the ridge properly interlocked according to the design of the tile. The tile shall be laid either directly over the reepers or over an under cover (*see* 9.1.1. and 9.1.2). The tiles shall be laid breaking joint that is, the left channel of the upper tile shall lie in the right channel of that below and shall fit properly one to another the catches resting fully against battens. The hips and ridges of the roof shall be covered with ridge tiles which shall be edge-bedded in mortar (*see* 5.1) as illustrated in Fig. 1. The mortar in edge bedding may be further finished with plaster of paint to match with the colour of the tiles. If the courses of roof tiles adjacent to the hip or to the ridge do not finish exactly underneath the ridge tiles, either purpose-made tiles or tiles cut to suitable shapes may be used. While finishing joints, gaps in the troughs of the roof tiles giving ridge or hip, if large enough, shall be neatly packed watertight using small pieces of chips of broken tiles and mortar. At eaves the lower most course of the tiles shall overhang the tilting fillet by a distance sufficient to ensure that the water drained off from the roof discharges clear off the eaves into the gutter.

9.1.1. *Protective measures against wind.*—A suitable arrangement shall be made to secure the ends of lower most course of tiles to the roof structure for preventing the tiles from being blown up by wind.

At least the bottom most layer of tiles, and preferably more number of layers above it, shall be tied to the reepers or other roof elements by means of galvanized wire.

The tiles at the eaves shall also be protected against lifting by means of a galvanized steel flat of size 4 cm. × 3 cm. fixed to the roof.

Mortar bands 20 to 25 cm. wide may also be provided over the tiled roof at a spacing of 2·5 to 3m for additional protection against wind. The mortar bands shall run along the roof slope.

9.1.2. *Laying Mangalore tiles over a flat tile undercover.*—The flat tiles shall first be prepared by immersing in water for two hours and dried before laying. The under-side of flat tiles shall also be dipped in whitewash mixed to creamy consistency and dried. The flat tile shall then be laid over the reeper. The mortar layer shall be spread over the flat tile to a thickness of not less than 2.6 cm. The Mangalore tiles shall also be soaked for two hours before laying in the roof. When the mortar layer is spread, the soaked Mangalore tiles shall be laid so as to be fully embedded in the mortar over the flat tiles.

Where the pitch of the roof is more than 30°, additional fillers hall be fixed to the reepers at a spacing of about one metre centres, so that the flat tiles laid between them are retained in position.

The Mangalore tiles may also be fixed over flat tiles without mortar edding if the work is so specified.

9.1.3. *Laying Mangalore tiles over ceiling tiles.*– Where a layer of ceiling tiles is to be laid as under cover the ceiling tiles shall be laid over the reepers and the Mangalore tiles shall be laid over them with appropriate interlocking between the tiles in the two layers.

9.2. *Alignment.*—The finished slope of the roof shall be uniform ridge to eaves. The eaves line and the ridge-line shall be perfectly straight, horizontal and parallel to each other.

9.3. *Junction between ridges and hips.*– The joints between hip and ridge tiles shall be grouted so as to be leak-proof. A metal saddle not less than 45 cm.² area may preferably be used underneath such junctions as additional protection against leakage.

9.4. *Work at valleys.*– Since valley is a particularly vulnerable part of the roof as its pitch is several degrees less than that of the general roof surface and it has to provide a channel for the water running down into it from two slopes on either side, special care shall be taken that a clear and an unobstructed channel is formed. Under cover (*see* 9.1.1 and 9.1.2) shall be provided for the courses of tiles adjacent to the valley.

The valley gutters shall be laid over the reepers and not nailed on to them from underneath. Two reepers of section 5×2·5 cm. shall be fixed over the metal sheets, 15 cm. away from the central line of the valley on either side so as to retain the tiles andmortar against falling into the gutter of the valley. On either side of the valley, the roof shall be plastered with cement mortar to a thickness of 12 mm and for a distance of atleast20 cm. so that rain water from the gutteris prevented from percolating through the tiles or the under cover to the underside of the roof (*see* Figure 5).

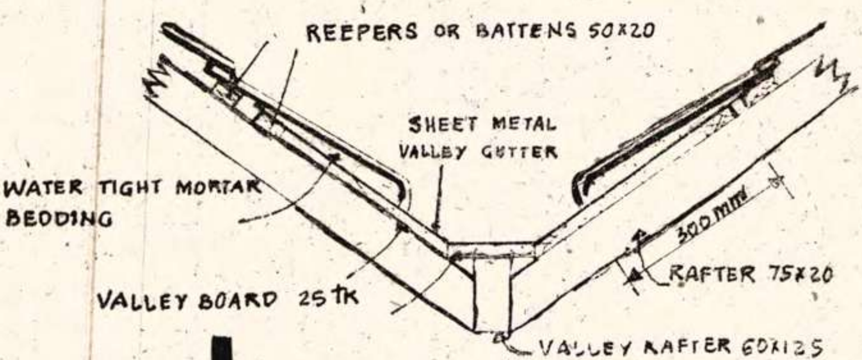
10. *Finishing edges around chimney stacks and skylights*:

10.1. In the case of chimney stacks and other similar features, full tiles shall be used around them and taken into the masonry. In addition, metal or bitumen flashing shall be used tocover the inter-section between the top edge of the tiling and any projection through the roof.

The flashing shall be turned against the projection and dressed down over the tile. The flashing shall be well tucked into either the joints in masonry or grooves in concrete, as the case may be, and shall be wedged and pointed.

11. *Treatment of junctions with wall*;

11.1 Junctions of the roof with walls shall preferably be treated for water proofing in accordance with the relevant Indian Standards for water-proofing and damp-proofing. Wherever special features like roof gutters and flashing s are not provided between the junctions of the roof and wall, the tiles shall be let into the wall to a depth of not less than 5 cm. and a drip moulding shall be provided at about 10 cm. height above the roof surface, and joints between the roof and the wall shall be grouted with a water proofing mortar such other materials (*see* Fig. 6).



ALL DIMENSIONS IN MILLIMETRES

FIG. 5 FIXING OF VALLEY GUTTER

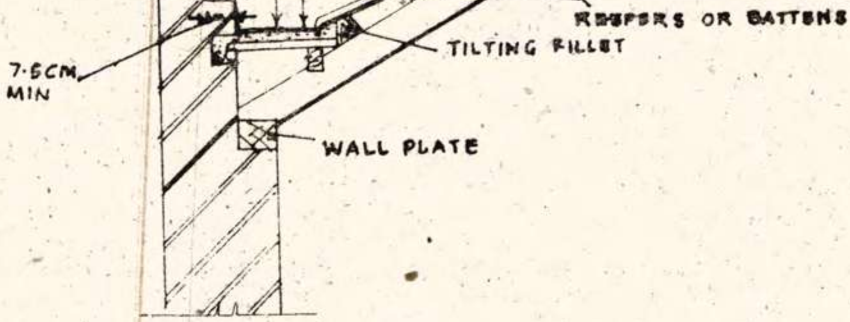


FIG 6. DETAIL AT THE JUNCTION OF THE ROOF WITH WALL [WHERE TILES THEMSELVES ARE USED FOR ROOF DRAINAGE]

EXTRACT FR M I.S. 3007 (PART I)—1964.

Code of practice for laying of asbestos cement sheets part I–corrugated sheets.

5. *Design considerations.*

5.1. In order to secure a sound and permanent roof with maximum economy, the requirements specified in 5.1.1. to 5.1.7. shall be followed.

5.1.1. *Roof plan.*—The roof plan shall be as simple as possible. Formation of hips and valleys should be avoided,as far as possible. Isolated projections above roof should be avoided at the design stage itself, as it is difficult to make the junctions between such projection, and the roof sheeting weather proof.

5.1.2. *Pitch of the roof.*—The pitch of roofs shall, wherever possible, be preferably not less than 18° should it, however, be found desirable to adopt roofs with a pitch less than 18° the values prescribed in 5.1.6 for the end laps between adjacent shall be correspondingly increased and/or the joints suitably sealed in accordance with the manufacturer's. recommendations or the instructions of the engineer in-charge.

5.1.3 *Purlins.*—All purlins shall be in one plane and shall be properly anchored to the supprting structure. Special care shall be taken that the sheets do not deflect at the intermediate purlins in an attempt to make the sheets bear on such purlins.

5.1.3.1 *Spacing of purlins.*—The spacing of purlins shall be arranged to suit the standard lengths of sheets but shall not exceed the following:—

Thickness of sheet.	*Distance between purlin centres.*	
	For roof covering.	*For side cladding.*
mm.	m.	m.
6	1.4	1.7
7	1.6	1.9

5.1.3.2. Ridge purlines shall be fixed 77 mm. to 115 mm. from the apex of the roof, that is, from the bolt point.

5.1.4. Additional trimmers or bridging shall be used between purlins at all points where considerable roof traffic is likely to occur, for example, adjoining valley or box gutters, below glazing and around chimneys, ventilators or other uptakes. This should be done on new roofs and when re-covering or repairing existing roofs. Similarly, when a course of sheets of smaller length necessitating closer purlin spacing is required to make up a roof slope, it is desirable to arrange the closer purlin spacing at eaves rather than at edges as this will bring additional support where it is most required.

5.1.5. Hip and valley runners should be provided, fixed flush with the top face of purlins and spanning between them, to give adequate support to the raking cut edges of roof sheets at hips and valleys. The runners should run parallel to the edges of the sheeting and placed so as to permit the fixing of the sheets and hip covering accessories.

5.1.6. Laps—The sheets shall be laid with a side lap of half corrugation (see Fig.). For normal roof pitches (that is, inclinations greater than or equal to 18°) the end laps (see fig. 2) in sheets shall not be less than 150 mm. For low roof pitches (that is, inclinations less than 18°) or for normal pitched roof in exposed positions, the end laps shall be increased and it is desirable to consult the manufacturers in such cases. The side lap shall as far as possible be sheltered from the prevailing wind direction. The free over hang at eaves, measured as the length of sheet from its lower edge to the centre of bolt holes shall not be more than 300 mm for 6 mm thick sheets and 400 mm for 7 mm thick sheets.

5.1.6.1. Wherever four corners of sheets overlaps, two of them shall be mitred in the manner deseribed in 8.3.4 and 8.3.5, in order to secure a perfect fit.

5.1.7. In order to avoid under, width of flashing, the sheets should finish at abutments as far as possible with an upturned edge.

8. *Laying and fixing of sheets.*

8.1. Sawing and Drilling.– Sheets shall be cut as necessary with a wood saw. Holes in the sheets shall be drilled, they shall on no account be punched. The latter method not only splays out the aperture thus weakening the material at vulnerable points, but is also likely to commence a fracture of the sheet which will ultimately open out in weathering. The holes for fixing shall be 2 mm larger than the diameter of the fixing bolts, and shall always be drilled through the crown of the corrugation and not on the valleys.

8.1.1. Holes for fixing the sheeting shall be drilled in the centre of the end lap of sheets to suit the purlins, that is on the centre line of the purlins if these are of timber and square head coach screws are used, or as close as possible to the back of the purlins, if J or L bolts are used with steel angles or precast concrete or timber purlins. It is recommended therefore, to drill the holes on the roof with the sheeting laid in the correct position. No hole shall be nearer than 40 mm to any edge of a sheet or an accessory.

8.2. *Fixing accessories.*

8.2.1. The satisfactory service of the roofing depends to a great extent upon the efficiency of fixing accessories. It is therefore important that particular attention is paid to the proper selection and use of fixing accessories. The fixing accessories shall conform to the requirements of IS 730–1956.

8.2.2. Galvanized iron.—J-Type hook bolts or cranked hook bolts, and nuts bearing on galvanized iron washers and bitumen washers shall be used for fixing sheets on angle iron purlins.

8.2.3. Galavanized iron L-type hook bolts and nuts bearing on galvanized iron washers and bitumen washers shall be used for fixing sheets on R. S. joist, precast concrete or timber purlins.

8.2.4. Galavanized iron coach screws bearing on galvanized iron washers and bitumen washers shall be used for fixing sheets on timber purlins.

8.2.5. Galavanized iron bolts and nuts bearing on galavanized iron flat washers and bitumen washers shall be used for stitching on the sheets, fixtures like ridge cappings, corner pieces, ventilators north-light curves, etc.

8.2.6. Where sheets are laid on tubular purlins the fixing bolt should be designed to encompass at least half the tube peripher and precautions should be taken to prevent its rotation. Sections other than angles and tubes may require an adopted form of hook bolt.

8.2.6.1. Direct fixing of sheets to drilled metal frame work o by stud welding is undesirable as it tends to restrain movement of sheets.

8.2.7. It is essential that the bolt holes are made water tight by the use of bituminous felt washers in conjunction with suitable galavanized iron washers. These form essential accessories to good fixing work. Fixing bolts and screws shall be 8 mm or more in diameter and the nuts of the hook crank bolts (or heads of coach screws) shall bear on galavanized iron washers (flat. curved or diamond pattern) which in turn shall be embedded on bituminous felt washers (round or diamond pattern corresponding to the shape of galavanized iron washer). The screw or nuts shall be tightened sufficiently only to seat the bitumen washer over the corrugations, so that natural movement in the sub-structure of the roof may not damage the sheeting.

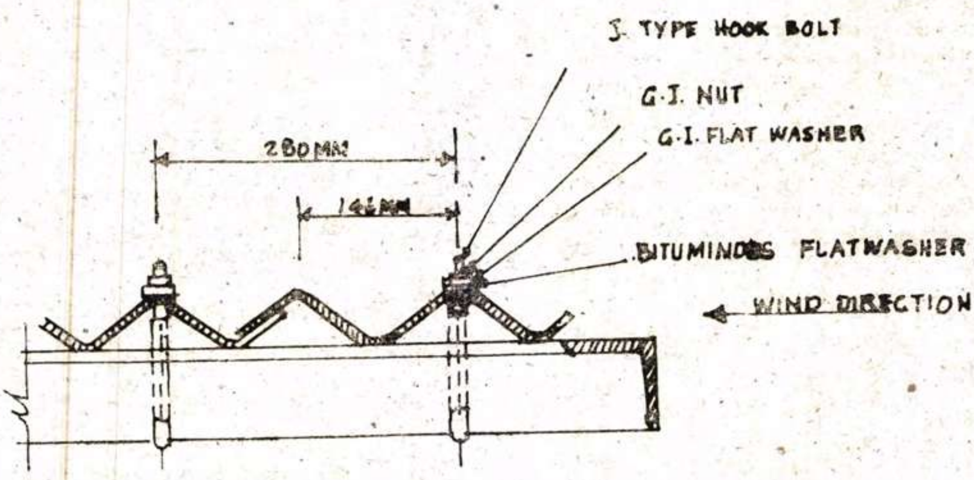


FIG. DETAIL OF SIDE LAP

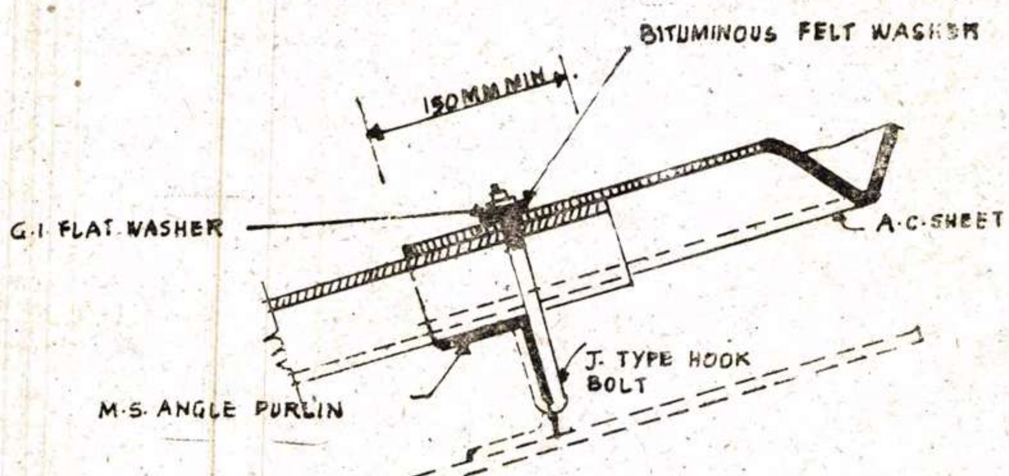


FIG. 2. DETAIL OF END LAP

666-3—50A

8.2.7. (1). The length of the J bolt or crank bolt shall be 75 mm longer than the depth of the purlin for single sheet fixing and 90 mm longer than the depth of the purlin where two sheets overlap or where ridges or other accessories are to be fixed with the sheet. The minimum length of square head coach screwfor timber purlins shall be 110 mm. The number and length of bolts and the number of bitumen and galvanized iron washers for fixing asbestcs cement corrugated sheets shall be as given in Table 1.

8.2.8. The galvanized iron flat washer shall generally be 25 mm in diameter and 1·6 mm thick with hole to suit the required size of fixing accessory and the bitumen washer shall be 35 mm in diameter and 1·5 mm thick with hole to suit the required size of fixing accessory. For other shapes of galvanized iron and bitumen washers suitable sizes as approved by the Engineer-in-charge may be used.

8.2.9. Ridge cappings shall as far as possible, be secured to the ridge purlins by the same bolts which secures the sheeting. Other asbestos cement accessories such as barge boards, eaves filler pieces and apron flashing pieces, shall be secured either to the supporting structure or to the sheeting by roofing bolts.

8.3. *Laying the sheets.*

8.3.1 Before the actual laying of sheets is started, the purlin spacing and the length of the sheets shall be checked to ensure that the arrangements will provide the laps required and the specifie overhand at the eaves.

TABLE 1—NUMBER AND LENGTH OF BOLTS AND NUMBER OF BITUMINOUS FELT AND GALVANIZED IRON WASHERS.
(*Clause* 8.2.7)

Serial number and situation.	*Number of bolts and Bituminous washers and galvanized iron washers.*	*Length of Bolt.*
(1)	(2)	(3)
(i) At Horizontal (end) laps of sheets. At eaves when filler pieces are uesd. At ridge when corrugated sheets and ridge pieces and secured by the same bolt.	Twice the number of sheets in one horizontal course.	Depth of purlin plus 90 mm
(ii) At eaves when filler pieces are not used. At ridge when corrugated sheet and ridge pieces are not secured by the same bolt.	Twice the number of sheets in one horizontial course.	Depth of purlin plus 75 mm
(iii) At intermediate purlins where horizontal laps do not occur.	Twice the number of sheets in one horizontal course.	Depth of purlin plus 75 mm.

8.3.2. The sheets be laid with the smooth side upwards and with the side and end laps as given in 5.1.6 (See Fig. 1 and 2). The courses ofsheets shall be so laid that the corrugations run in continuous straightlines.

8.3.3. If a building is in an exposed position and is subject to driving winds, and rains it is advisable to commence laying the sheets o m the end opposite to the direction of prevailing winds.

8.3.4. Asbestos cement corrugated sheets shall be laid, starting at the eaves either from left to right or from right to left depending upon the prevailing direction of the wind. If laid from left to right, (see Fig. 3) the first sheet shall be laid uncut, but the remaining sheets in the bottom row shall have the top left hand corners cut or mitred. The sheets in the second and other inter-mediate rows shall have the bottom right hand corner of the first sheet cut, all other sheets except the last sheet shall have the both the bottom right hand corner and top left hand corner cut. The last sheet shall have only the top left hand corner cut. The last or the top row sheets shall all have the bottom right hand corner cut with the exception of the last sheet which shall be laid uncut. If the sheets are laid from right to left, the first sheet shall be laid uncut and the remaining procedure shall be reserved.

8.3.5. The mitre described in 8.3.4. is necessary to provide a snug fit where four sheets meet at a lap. It is cut from a point 15 cm. (or whatever the length of the end lap may be) up the vertical side of the sheet to a point, 4.5 cm. along the horizontal edge. Thus cutting shall be done with an ordinary wood saw at site.

8.3.6. The ends of all sheet at to the eaves shall be supported and the support shall be placed as near to the margin of the sheets as practicable. The maximum free overhang at the eaves shall be not more than the limits specified in 5.1.6.

8.3.7. Hook bolts, crank bolts or square head coach screws of at least 8 mm. size shall be fitted with a galvanized iron washer and a bituminous washer of suitable shape to fit the outer face of sheet and inserted through holes of corresponding size (see 8.1) drilled in the crown of the corrugation. One bolt or screw shall be used on each side of side lap (see Fig. I) nuts or screws shall be tightened lightly at first, and then fully tightened when a dozen or more sheets have been laid. On no account shall the fixing screws or the nuts on fixing bolts be screwed down too tightly, and care shall be taken not to deflect sheets at the intermediate purlins in an attempt to make the sheets bear on such purlins.

9. *Fixing of accessories.*

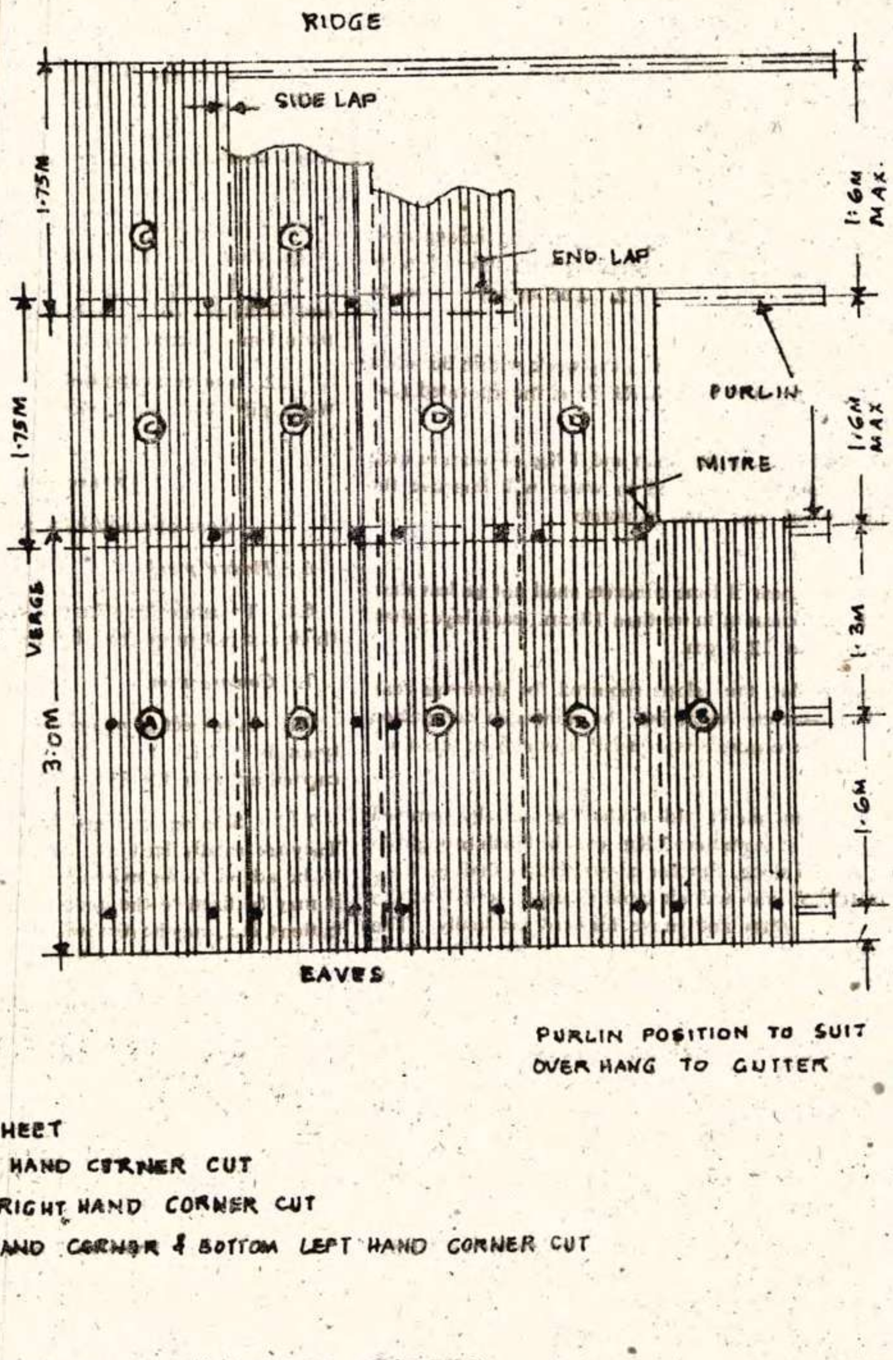
9.1. *General.* Moulded asbestos cement accessories should be selected as far as possible from the range of standard patterns. Special fittings if required, should be designed to conform closely to the sheet profile. When the use of moulded accessories is impracticable, other methods as approved by the Engineer-in-charge may be employed.

9.1.1. Roofing accessories should be secured to the roof or wall cladding as far as possible, by the same bolts which secure the sheets.

9.2. *Ridge capping.*—Ridge capping should also be secured to the ridge purlins as far as possible by the same bolts which secure the sheets. Where this is not possible, each wing of the ridge capping should be adequately secured to the sheets by roofiing bolts.

11. *Maintenance.*

11.1. The roof covering shall be periodically examined, any broken units shall be replaced promptly and flashings redressed, if necessary, Roof coverings which have been painted or coated to protect them from chemically laden atmosphere shall be repainted from time to time.



A. UNCUT SHEET

B. TOP LEFT HAND CORNER CUT

C. BOTTOM RIGHT HAND CORNER CUT

D. TOP LEFT HAND CORNER & BOTTOM LEFT HAND CORNER CUT

FIG. 3. LAYING OF SHEETS
(SHEET LAID FROM LEFT TO RIGHT)

EXTRACT FROM I.S. 3036 –1965.

Code of practice for laying lime concrete for a water-proofed roof finish.

5. *Preparation of lime concrete.*

5.1. One part of slaked lime and two parts of *SURKHI* by volume shall be mixed on a water-tight platform. This shall then be sprinkled with the required quantity of water and shall be well ground in a mill or using mechanical grinders (see Note under 5.2).

5.1.1.1. If hydrated lime is used adjustment shall be made in the proportioning and preparation in the same manner as explained in I.S. 1625—1962.

5.2. The lime concrete shall be obtained by throughly mixing the aggregate and lime-*SURKHI* mortar in the proportions of 2½ : 1 parts by volume. Burnt brick aggregate shall be soaked throughly in water for a period not less than six hours before use in the concrete mix.

NOTE. –Lime concrete can also be prepared by mixing the aggregate inclusive of brick dust obtained during breaking with slaked lime in the same proportions by volume as in 5.2. The aggregate shall be thoroughly soaked before use.

5.3. The lime concrete shall be used in the work within 36 hours of the preparation of lime mortar if *SURKHI* is incorporated (*See* I.S. 2541—1964).

NOTE.—Addition of 12 Kg. of bar soap and 4 Kg. of alum in each cubic metre of lime concrete dissolved in water will improve the waterproofing quality of the lime concrete.

6. *Laying.*

6.1. The average thickness of lime concrete shall not be less than 10 cm. In case the thickness is more than 10 cm., each layer shall not be more than 10 to 12.5 cm.

6.1.1. If the roof is flat, the slope required for drainage may be given in the lime concrete layer, but the minimum compacted thickness (*see* 6.2.) of the concrete layer shall nowhere be less than 7.5. cm.

6.2. After the lime concrete is laid, it shall be initially rammed with a rammer weighing not more than 2 Kg. and the finish brought to the required evenness and slope. Further consolidation shall be done using wooden *THAPIES*, who will sit close together, and beat the surface lightly and in rhythm and move forward gradually. The beating will normally have to be carried on for at least seven days until the THAPI makes no impression on the surface and rebounds readily from it when struck.

6.2.1. If the surface during the process of compaction becomes so uneven that water lodges in pools, the surface shall be pricked up and fresh lime concrete spread and consolidated as it necessary so as to ensure proper slopes and levels are being maintained.

6.2.2. Special care shall be taken to properly consolidate the concrete at its junction with the parapet wall.

6.2.3. During compaction by hand beating, the surface shall be sprinkled liberally with lime water and small proportion of sugar solution (*see* Note 1) or a solution prepared by soaking in water the dry nuts of terminalia chebula (*see* Note 2) should be added to the lime water for obtaining improved water-proofing in the concrete. On completion of beating, the mortar that comes on the top shall be smoothened with a trowel or float, if necessary, with the addition of sugar solution.

NOTE 1.—The sugar solution is prepared in the northern parts of this country by mixing about 3 Kg. of jaggery and 1½ Kg. of "*BAEL*" fruit to 100 litres of water.

NOTE 2.—The solution of Terminalia Chebula (*KADUKAI*) may be prepared as follows :—

The dry nuts shall be broken to small pieces and allowed to soak in water. The general practice is to have a proportion of 60 gr. of *KADUKAI* 200 gr. of jaggery and 40 litres of water for $10m^2$ work. The solution is brewed for 12 to 24 hours. The resulting liquor is decanted and used for the work.

6.3. *Curing.*—The lime concrete after compaction shall be cured for six days or until it hardens by covering with a thin layer of grass or straw which shall be kept wet continuously.

7. *Finish.*

7.1. In extreme climates where there is a considerable expansion and contraction, two layers, of tiles may be put or the top of the lime concrete. The tiles should be jointed with an impervious mortar. For such a finish, maintenance will be confined to the top most finish only.

7.2. The protection against water penetration for the roof finish is enhanced by efficient drainage of surface water.

7.2.1. For this purpose, the slope of the terrace with lime concrete and tile finish shall not be less than 1 in 60 and the slope in the case of plain lime concrete finish shall not be less than 1 in 50.

7.2.2. For every $40m^2$ of roof area one 100 mm diameter rain water pipe shall be provided.

EXTRACT FROM I.S. 5390-1960.

Code of practice for construction of timber ceilings.

6. *Timber planks.*

6.1. To minimize effects of shrinkage and swelling 15 to 20 mm. thick and not more than 100 mm. wide timber planks shall be used.

7. *Construction.*

7.1. In respect of manner of fixing, ceilings may be the following types as in 7.1.1. to 7.1.3. The design of timber ceilings shall be carried out as in I.S. 883—1966.

7.1.1. Sloping ceilings fixed immediately below the roofing. They are usually fixed just above the purlins. If a ceiling is required to be added to an existing roof with common rafter construction, it may be fixed to the underside of the rafters or the roofings and battens, etc., may be removed the ceiling fixed above the rafters and the battens and roofing refixed.

7.1.2. Horizontal closed ceiling below roofs and floors, In this type any of the materials (except corrugated galvanized sheets) may be used and fixed to the underside of the floor or roof.

7.1.3. Horizontal open ceiling below roofs and floors–Pieces of timber called "fillet pieces" or fillets (about 4 cm^2) are nailed to the sides of the bridging joists of floors or tie beams of the wooden frames, planks, etc., are then nailed to the fillets from below.

EXTRACT FROM I.S. 277-1969.

Specification for galvanised steel sheets.

(Plain and corrugated).

4. *Manufacture :*

4.1. Galvanized steel sheets shall be made by galvanizing black sheets or cold rolled sheets or coils made from good quality low carbon mild steel, free from cracks, pittings, blisters, laminations, twists, scales and other surface defects. Sheets shall be cleanly sheared.

4.1.1. Black sheets or cold rolled sheets or coils required for galvanizing shall, in all cases, be either annealed or normalized, unless otherwise specified.

4.2. Galvanizing shall be carried out by first pickling the black sheets or by cleaning the cold rolled coils in line and then dipping them in a bath of molten zinc at a temperature suitable to produce a complete and uniformly adhesive coating of zinc. The zinc ingots used for galvanizing shall conform at least to grade Zn 98 of I.S. 209-1966 (*see* also I.S. 2629—1969).

5. *Freedom from defects.*

5.1. Galvanized plain sheets shall be reasonably flat and free from twist. Galvanised corrugated sheets shall be free from twist or buckle and shall have uniform corrugations, true in depth and pitch and parallel to the sides of the sheet. The galvanized coating shall be clean, even and free from ungalvanised spots and other defects (some of these defects have been described in I.S. 2629—1966).

6. *Dimensions and weights.*

6.1. Dimensions and weights of galvanized sheets shall be as given in Table 1.

6.1.1. Galvanized steel sheets with dimensions and weights other than those specified in Table 1 may be supplied subject to mutual agreement between the purchaser and the manufacturer.

6.2. *Corrugations.*—The depth of corrugation shall be 18 mm (nominal) and shall have a pitch of 75 mm. (nominal) (*see* Fig. 1.).

6.2.1. The number of corrugations shall be 8, 10 or 11 per sheet. The overall width of the sheet before and after corrugation shall correspond to the dimensions as given in Table 2.

7. *Tolerance on dimensions.*

7.1. No sheet shall be smaller in length than the specified dimension, A maximum tolerance of plus 0·5 per cent (not less than 10 mm.) in length may be allowed.

7.2. The diagonal distances between the opposite corners of any sheet shall not differ by more than 20 mm.

7·3. The tolerance on the weight of an individual sheet shall be ± 10 per cent and tolerance on each bundle of sheets shall be $+5$ per cent.

7.4. *Tolerance on corrugations.*—The corrugations shall be subject to the following tolerances :—

On depth	± 1.5 mm.
On pitch	± 2.0 mm.
On overall width after corrugation	± 10 mm.

7.5. *Sizes of sheets.*—The sheets shall be of the following sizes :—

Length m.	*Width.* m.
1.8	0·75 or 0·90
2.2	
2.5	
2.8	
3.0	

7.5.1. The sheets may also be supplied in sizes other than those specified above as per agreement between the purchaser and the manufacturer.

8. *Bend test.*

8.1. *Test samples.*—Test pieces, preferably 'L' shaped, 230 mm long and 75 to 100 mm. wide, shall be cut both along and across the direction of rolling.

8.1.1. Bend test pieces shall be selected at the rate of one set of 2 for every 500 sheets or part thereof.

8.2. *Requirements.*—Samples of galvanized steel sheets selected as described in 8·1 shall withstand bending through 180° round a mandrel having a diameter specified in 8.2.1. without peeling or flaking of zinc coating. Bend test shall be done upon and across the direction of rolling.

8.2.1. The diameter of the mandrel around which the test specimen is bent, shall be equal to the thickness of the number of sheets specified in Table 3.

9. *Zinc coating.*

9.1. The weight of coating referred to in this specification shall represent the total weight of zinc., both sides inclusive.

9.2. On any sample selected at random from the delivery in accordance with 10·1, the coating for the different classes shall be within the limits specified in Table 4.

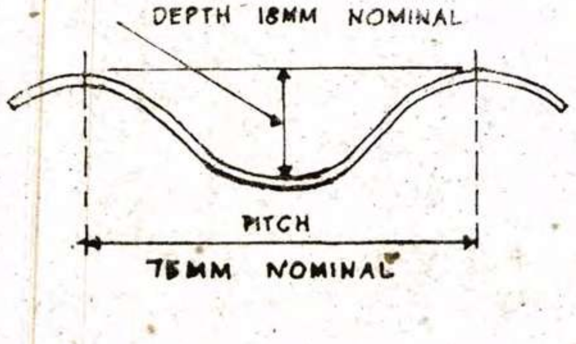


FIG 1. DEPTH AND PITCH OF CORRUGATION

TABLE I—DIMENSIONS AND WEIGHTS OF GALVANISED SHEETS.

[CLASS 1—750 G. OF ZINE (SPELTER) COATING PER SQUARE METRE, BOTH SIDES INCLUSIVE.]

(Clause 6.1.)

Size m. × m.	Area m².	Thickness of sheet.														
		1.60 mm.			1·25 mm.			1·00 mm.			0·80 mm.			0.63 mm.		
		Kg. per sheet.	Sheet per bundle.	Kg. per bundle.	Kg. per sheet.	Sheet per bundle.	Kg. per bundle	Kg. per sheet.	Sheet per bundle.	Kg. per bundle.	Kg. per sheet.	Sheet per bundle.	Kg. per bundle.	Kg. per sheet.	Sheet per bundle.	Kg. per bundle.
		13.31 kg./m².			10. 56 kg./m².			8. 60 kg./m².			7.03 kg./m².			5·70 kg./m².		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
1·8 × 0·90	1·62	21·56	5	107·8	17·10	6	102·7	13·93	8	111·5	11·39	10	113·9	9·23	12	110·7
2·2 × 0·90	1·98	26·35	4	105·4	20·91	5	104·6	17·03	7	119·2	13·92	8	111·4	11·29	10	112·9
2·5 × 0·90	2·25	29·95	4	119·8	23·76	5	118·8	19·35	6	116·1	15·82	7	110·7	12·82	9	115·3
2·8 × 0·90	2·52	33·54	3	100·6	26·61	4	106·4	21·67	5	108·4	17·72	6	106·3	14·36	8	114·9
3·0 × 0·90	2·70	35·94	3	107·8	28·51	4	114·0	23·22	5	116·1	18·98	6	113·9	15·39	7	107·7
1·8 × 0·75	1·35	17·97	6	107·8	14·26	7	99·8	11·61	9	104·5	9·49	12	113·0	7·69	14	107·6
2·2 × 0·75	1·65	21·96	5	109·8	17·42	6	104·5	14·19	8	113·5	11·60	10	116·0	9·40	12	112·8
2·5 × 0·75	1·88	24·96	4	99·8	19·80	5	99·0	16·12	7	112·9	13·18	9	118·6	10·69	10	106·8
2·8 × 0·75	2·10	27·95	4	111·8	22·18	5	110·9	18·06	6	108·4	14·76	8	118·1	11·97	9	107·7
3·0 × 0·75	2·25	29·95	3	89·8	23·76	4	95·0	19·35	5	96·8	15·82	7	110·7	12·82	8	102·6

TABLE I—DIMENSIONS AND WEIGHTS OF GALVANIZED SHEETS—*cont.*

[*Class* 2—600 *g. of Zinc (Spelter) coating per square metre, both sides inclusive.*]

Size m × m.	Area m²	Thickness of sheet. 1·60 mm. 3·16 kg./m².			1·25 mm. 10·41 kg./m².			1·00 mm. 8·45 kg./m.²			0·80 mm. 6·88 kg./m²			0·63 mm. 5·55/kg/m²		
		Kg. per sheet.	Sheet per bundle.	Kg. per bundle.	Kg. per sheet.	Sheet per bundle.	Kg. per bundle.	Kg. per sheet.	Sheet per bundle.	Kg. per bundle.	Kg. per sheet.	Sheet per bundle.	Kg. per bundle.	Kg. per sheet.	Sheet per bundle.	Kg. per bundle.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
·8 × 0·90	1·62	21·32	5	106·6	16·86	6	101·2	12·69	8	109·5	11·15	10	111·5	8·99	12	107·9
2·2 × 0·90	1·98	26·06	4	104·2	20·61	5	103·0	16·73	7	117·1	13·62	8	108·9	10·99	10	109·9
2·5 × 0·90	2·25	29·61	4	118·4	23·42	5	117·1	19·01	6	114·1	15·48	7	108·4	12·49	9	112·4
2·8 × 0·90	2·52	33·16	3	99·5	26·23	4	104·9	21·29	5	106·4	17·34	6	104·0	13·99	8	111·9
3·0 × 0·90	2·70	35·53	3	106·6	28·11	4	112·4	22·82	5	114·1	18·58	6	111·5	14·98	7	104·9
1·8 × 0·75	1·35	17·77	6	106·6	14·05	7	98·4	11·41	9	102·7	9·29	12	111·5	7·49	14	104·9
2·2 × 0·75	1·65	21·71	5	108·6	17·18	6	103·1	13·94	8	111·5	11·35	10	113·5	9·16	12	109·9
2·5 × 0·75	1·88	24·68	4	98·7	19·52	5	97·6	15·84	7	110·9	12·90	9	116·1	10·41	10	104·1
2·8 × 0·75	2·10	27·64	4	110·6	21·86	5	109·3	17·74	6	106·4	14·45	8	115·6	11·66	9	104,9
3·0 × 0·75	2·25	29·61	3	88·8	23·42	4	93·7	19·01	5	95·0	15·48	7	108·4	12·49	8	99·9

TABLE I: DIMENSIONS AND WEIGHTS OF GALVANIZED SHEETS

[*Class 3—450 g. of Zinc (Spelter) coating per square metre, both sides inclusive.*]

Size m x m.	*Area m^2*	*Thickness of Sheet.* 1.60 mm			1.25 mm			1.00 mm			0·80 mm			0.63 mm		
		Kg. per sheet.	*Sheet per bundle.*	*Kg. per bundle.*	*Kg. per sheet.*	*Sheet per bundle.*	*Kg. per bundle.*	*Kg. per sheet.*	*Sheet per bundle.*	*Kg. per bundle.*	*Kg. per sheet.*	*Sheet per bundle.*	*Kg. per bundle.*	*Kg. per sheet.*	*Sheet per bundle.*	*Kg. per bundle.*
		13.01 kg/m^2			16.26 kg/m^2			8.30 kg/m^2			6.73 kg/m^2			5.40 kg/m^2		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
1·8 x 0·90	1·62	21·08	5	105·4	16·62	6	99·7	13·45	8	107·6	10·90	10	109·0	8·75	12	105·0
2·2 x 0·90	1·98	25·76	4	103·0	20·31	5	101·6	16·43	7	115·0	13·33	8	106·6	10·69	10	106·9
2·5 x 0·90	2·25	29·27	4	117·1	23·08	5	115·4	18·68	6	112·1	15·14	7	106·0	12·15	9	103·6
2·8 x 0·90	2·52	32·79	3	98·4	25·86	4	103·4	20·92	5	104·6	16·96	6	101·8	13·61	8	108·8
3.0 x 0·90	2·70	35·13	3	105·4	27·70	4	110·8	22·41	5	112·0	18·17	6	109·0	14·58	7	102·1
1·8 x 0.75	1·35	17·56	6	105·4	13·85	7	97·0	11·20	9	100·8	9·09	12	109·0	7·29	14	102·1
2.2 x 0·75	1·65	21·47	5	107·4	16·93	6	101·6	13·70	8	109·6	11·10	10	111·0	8·91	12	106·9
2·5 x 0·75	1·88	24·39	4	97.6	19·24	5	96·2	15·56	7	108·9	12·62	9	113·6	10·12	10	101·2
2·8 x 0·75	2·10	27·32	4	109·3	21·55	5	107·8	17·43	6	104·6	14·13	8	113·0	11·34	9	102·1
3·0 x 0·75	2·25	29·27	3	87·8	23·08	4	92·3	18·68	5	93·4	15·14	7	106·0	12·15	8	97·2

TABLE I—DIMENSIONS AND WEIGHTS OF GALVANIZED SHEETS

[*Class 4 — 375 g. of Zinc (Spelter) coating per square metre, both sides inclusive.*]

Size m x m	*Area m²*	*Thickness of Sheet.* 1·60 mm, 12·94 *kg/m²*			1·25 mm, 10·19 *kg/m²*			1·00 mm, 8·22 *kg/m²*			0·80 mm, 6·66 *kg/m²*			0·63 mm, 5·32 *kg/m²*		
		Kg. per sheet.	*Sheet per bundle.*	*Kg. per bundle.*	*Kg. per sheet.*	*Sheet per bundle.*	*Kg. per bundle.*	*Kg. per sheet.*	*Sheet per bundle.*	*Kg. per bundle.*	*Kg. per sheet.*	*Sheet per bundle.*	*Kg. per bundle.*	*Kg. per sheet.*	*Sheet per bundle.*	*Kg. per bundle.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
1·8 x 0·90	1·62	20·96	5	104·8	16·51	6	99·1	13·32	8	106·6	10·79	10	107·0	8·62	12	103·4
2·2 x 0·90	1·98	25·62	4	102·5	20·18	5	100·9	16·28	7	114·0	13·19	8	105·5	10·53	10	105·3
2·5 x 3·90	2·25	29·12	4	116·5	22·93	5	114·6	18·50	6	111·0	14·98	7	104·9	11·97	9	107·7
2.8 x 0·90	2·52	32·61	3	97·8	25·68	4	102·7	20·71	5	103·6	16·78	6	100·7	13·41	8	107·3
3·0 x 3·90	2·70	34·94	3	104·8	27·51	4	110·0	22·19	5	111·0	17·98	6	107·9	14·36	7	100·5
3.6 x 0·90	3·24	41·93	..	..	33·02	..	..	26·63	..	..	21·58	..	..	17·24	..	..
1·8 x 0·75	1·35	17·47	6	104·8	13·76	7	96·3	11·10	9	99·9	8·98	12	107·9	7·18	14	100·5
2·2 x 0·75	1·65	21·35	5	106·8	16·81	6	100·9	13·56	8	108·5	10·99	10	109·9	8·78	12	105·4
2·5 x 0·75	1·88	24·26	4	97·0	19·11	5	95·6	15·41	7	107·9	12·48	9	112·4	9·98	10	99·8
2·8 x 0·75	2·10	27·17	4	108·7	21·40	5	107·0	17·26	6	103·6	13·99	8	111·9	11·17	9	100·5
3·0 x 0.75	2·25	29·12	3	87·4	22·93	4	0·7	18·50	5	92·5	14·98	7	104·9	11·97	8	95·8
3·6 x 0·75	2·70	34·94	..	..	27·51	..	..	22·19	..	..	17·97	..	..	14·36	..	..

NOTE.—Bundles of weight other than that specified in the table may also be supplied subject to mutual agreement between the purchaser and the manufacturer. In such cases, the tolerance on weight of each bundle of sheets shall be ± 5 per cent.

TABLE 2—DETAILS OF CORRUGATIONS.

(*Clause* 6.2.1.)

Number of corrugations.	*Nominal overall width of sheet measured, between crowns of outside corrugations.*	
	Before corrugation.	*After corrugation.*
	mm.	*mm.*
(1)	(2)	(3)
8	750	660
10	900	800
11	1000	885

TABLE 3—DIAMETER OF MANDREL FOR BEND TEST.

(*Clause* 8.2.1.)

Zinc (Spelter) coating g/m^2	*Thickness of sheet, mm.*				
	1·60	1·25	1·00	0·80	0·63
	(Diameter of Mandrel, Expressed as the Number of Times the Thickness of Sheet.)				
(1)	(2)	(3)	(4)	(5)	(6)
750 ..	10	10	11	12	14
600 ..	8	8	9	10	11
450 ..	6	6	7	8	8
375 ..	4	4	5	6	5

TABLE 4 : LIMITS OF ZINC COATING.

(*Clauses* 9.2 *and* 10.2.0)

Class.	*Specified coating (Nominal)*	*Minimum coating by diagonal triple spot test.*	*Minimum coating single spot test*
	g/m^2	g/m^2	g/m^2
(1)	(2)	(3)	(4)
1	750	625	550
2	600	500	425
3	450	350	300
4	375	275	250

10. *Coating test.*

10·1. *Test Samples* : One set of three samples, each 50 × 50 mm or 50 mm diameter shall be selected at random from one sheet for every 500 galvanized sheets or part thereof. In case of galvanined sheets produced from black sheets one set of three samples shall be taken from an extremity of each diagnal whereas in case of galvanised sheets produced from cold rolled coils, one set of three samples shall be cut–one being from the middle of the width of sheet and one each from each side of sheet and in no case closer than 100 mm from the edge of the sheet.

11. *Retests.*

11.1. If the sample selected in accordance with 8.1 and 10.1 fail to comply with the requirements of 8.2, 9.2 and 10·2, further test samples may be selected at random at the rate of two sets for every 500 sheets or part thereof, for retest in respect of each failure. The additional tests shall be carried out in the same manner, as the original tests.

11.2. If any of the retest, sample fails to meet the requirements of this specification, the entire batch of sheets represented by the sample shall be deemed as not conforming to this standard.

SECTION IX

PLASTERING, POINTING WHITE-WASHING COLOUR-WASHING AND DISTEMPERING

SECTION IX.

PLASTERING, POINTING, WHITE WASHING, COLOUR WASHING AND DISTEMPERING.

CONTENTS.

SECTION IX.

PLASTERING, POINTING, WHITE WASHING, COLOUR WASHING AND DISTEMPERING.

INDIAN STANDARDS EXTRACTS.

SECTION IX.

PLASTERING, POINTING, WHITE-WASHING, COLOUR WASHING AND DISTEMPERING.

Plastering—Notes.

The specifications laid down in I.S. 2402/63 regarding external rendered finishes shall apply.

SPECIFICATION NO. 52.

PLASTERING WITH LIME MORTAR—ONE COAT.

15 *mm thick*.

(Brick Masonry.)

1. For application of lime plaster finish I.S. 2394/1965 shall apply. If the mortar has become set or hardened before being used, it shall be rejected and removed from the work spot.

2. Should the mortar perish through neglect of watering or for other fault of the contractor, the work shall be removed and redone at the contractor's expense; or should the contractor fail to water the work to the satisfaction of the officer-in-charge of the work, the latter may supply the requisite men to water the work properly and charge the cost to the contractor.

3. I.S. 1200/1971 Part XII shall apply for measurement of plastering.

SPECIFICATION NO. 53.

PLASTERING WITH LIME MORTAR-TWO COATS, 20 *mm*. THICK.

1·1· Specification for plastering with lime mortar-two coats covered by I.S. 2394/1965 shall apply.

SPECIFICATION NO. 54.

PLASTERING WITH LIME MORTAR-THREE COATS, 35 *mm*. THICK.

1·1. Specification for plastering with lime mortar, Three coats covered by I.S. 2394/1965 shall apply.

SPECIFICATION NO. 55.

PLASTERING WITH SURKI MORTAR.

1·1. Specificaton for plastering with surki mortar—One or two coat-covered by I.S. 2394/1965 shall apply (Particularly ref. paras 12 and 13 of I.S. 2394/1965).

SPECIFICATION NO. 56 AND 57.

PLASTERING WITH CEMENT MORTAR.

1·1. For plastering stone masonry, the specifications laid down in I.S. 1661/1972 shall apply.

466 3—52

2. Should the mortar crack, or perish through neglect of watering or for other fault of the contractor, the work shall be removed and redone at the contractor's expense or should the contractor fail to water the work to the satisfaction of the officer-in-charge of the work the latter may supply the requisite men to water the work. properlly and charge the cost to the contractor.

3. Where thread lining is to be done, it shall be done to the instructions of the Executive Engineer.

SPECIFICATION NO. 57-A.

CEMENT LIME PLASTERING.

1·1. Specification for plastering with cement-lime mortar covered by I.S 1661/1972 shall apply.

SPECIFICATION NO. 58.

MADRAS—PLASTER.

1·1. Specification for "Madras Plaster" covered by I.S. 2394/65 shall apply.

SPECIFICATION NO. 59.

MUD PLASTER.

1.1· For mud plaster ; none but well tempered clay, or brick earth, free from vegetable mould, gravel, or roots, shall be used. The clay is to be shifted fine and thrown into a pit with chopped straw and cowdung in such proportions as may be ordered. It is then to be well mixed and flooded with water and left for a week or two, after which it is to be floated on as for lime plaster, only in thin coats (minimum two coats) any extra thickness required being given by increasing the number coats and not the thickness of each. The first coat must be allowed to set, but not to become dry before the subsequent coats are laid. Smoothen the subsequent coat with a wooden float and finally polish with a trowel. The contract rate will be for the finished thickness required.

Pointing (Remarks on).

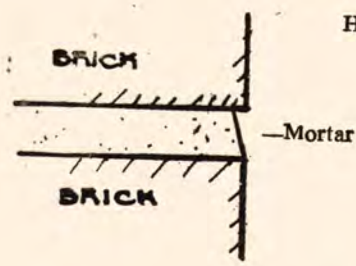
1·1. Specification pointing covered by I.S. 1597 PART (I)/1967 (particularly para 7) shall apply.

2. The joints should be rubbed smooth with a "nayla" or pointing tool to form a hard skin having a continous union with the hearting.

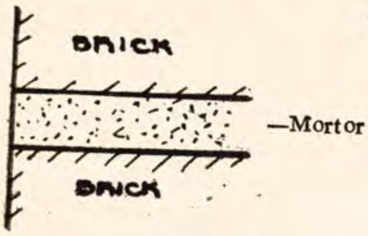
3. The horizontal joint for brick work, and coursed masonry shall be weather struck with a trowel on a straight edge and all superfluous mortar removed as shown below for brick work :

4. Vertical joints will be finished with a hard skin similar to the horizontal joints, only flush and not struck vide sketch below for brick work :—

HORIZONTAL JOINT



VERTICAL JOINT



5. Random rubble joints will be finished flush in the absence of any modifying specification or schedule item, i.e., pressing the motar well into the joint and rubbing smooth as in clause 2 above, restricting the mortar to the width of the joint-the finished joint surface being flush with the face of the wall.

6. No extra payment over the rate for masonry will be paid for the method of finishing joints described above.

7. Finishing joints as described above is all that is necessary, and if done while the work is in progress, before the mortar has set, the joints look as well and neat as any pointing.

SPECIFICATION No. 60

Pointing with Lime Mortar (1 : 1½).

1.1. Specification on pointing covered by I. S. 2212/1962 (Particularly paragraph 5) shall apply. For extract of I. S. See Section 5.

2. The mortar required for pointing work shall be ground as instructed for pointing work, in the standard specification for the lime mortar, using 1 part standard specification lime and 1½ parts standard specification sand. The raked joints shall be filled with mortar, well pressed into the face of the wall and rubbed smooth. When finished, the mortar pointing shall be restricted to the width of the joints and all superfiuous mortar shall be removed with a trowel.

3.When sufficiently air-dried to allow of rubbing, the pointing shall be rubbed over with thin bar trowels until a shinning polish is given to the mortar surface of the joint.

SPECIFICATION No. 61

Pointing with Surki Mortar (1 : ½ : 1).

1.1 The work shall be executed as specified for "pointing with lime mortar" except that surki mortar of proportions 1 lime, ½ Surki and 1 sand and otherwise conforming to the standard specification or Surki mortar will be used instead of lime mortar.

SPECIFICATION No. 62

Pointing with Cement Mortar (1 : 3)

1.1 The work shall be executed as specified for "Pointing with lime mortar" except that Portland Cement mortar using 1 Portland Cement and 3 sand, and conforming to the standard specification for Portland Cement mortar, shall be used instead of lime mortar The work shall be executed as rapidly as possible (and not again touched, after it has begun to set) and kept wet for 7 days thereafter If other proportion of cement mortar is to be used, it will be so defined in the relevent schedule item.

SPECIFICATION No. 63

White washing.

1.1. Specification laid down in I.S. 6278/1971 shall apply.

2. Each coat of white wash is to be allowed to dry and should be inspected by the Subordinate in charge before applying the next coat.

3. The contractor shall take precaution to prevent white wash being splashed on the wall, floor and other surfareces and articles not to be white washed. The contractor shall clean all such items to the satisfaction of the Executive Engineer at his own cost. Ladders, poles, scaffolding, etc. shall be shod with gunny bags to prevent damage or scratching of the walls and floor.

SPECIFICATION No. 64

Colour washing.

1.1. Specifications laid down in I.S. 6278/1971 shall apply.

SPECIFICATION No. 65

Distempering.

1.1. Specification for distempers laid down in I. S. 427/1975 and I.S. 428/1969 shall apply.

1.2. *Wall surface.*—Plaster should present a fine polished surface and be absolutely dry before distempering is commenced. The walls must be well-cleaned down as no pleasing effect can ever result from the use of distemper unless the ground to be worked upon is perfectly clean. Inequalities and small holes such as nail holes shall be filled with gypsum, and allowed to set hard before the distemper is applied. No extra payment will be given for this cleaning and filling, unless there is separate schedule provision made for the same, in view of the magnitude of the work to be done.

2. *Mixing.*— Unless otherwise ordered by the Executive Engineer the mixing of the distemper shall be carried out in accordance with the instructions issued by the manufacturers of the particular brand of distemper that is specified to be used.

3. *Application.*

3.1 One coat shall be applied unless otherwise defined in the relevant schedule item or otherwise ordered by the Executive Engineer In applying, dip the brush in the distemper and stroke crosswise on the wall and immediately stroke perpendicularly, then stop.

3.2. It is recommended that two men shall work together, one going round the room applying the distemper from the ceiling downwards as far as he can reach; and the second man following him applying the distemper below.

3.3 In this way, it is easier to join up and avoid patchy overlaps.

4. *Brushes*.

4·1. The contractor shall use proper distemper brushes as supplied by firms dealing in distemper. The brushes shall, each day after work, be washed in hot water and hung up to dry.

4.2 Old brushes caked with dry distemper shall not be allowed on the work.

Notes on distempers :

(*a*) None of the distempers will stand exposure to heavy rain, nor can any of them be described as washable. No attempt should be made to wash distempered walls during the monsoon.

(*b*) Distempers should, however, only be used in dry climates as they give poor results in wet localities. To get the full advantage out of these distempers, it is necesary to apply a priming coat as recommended by the makers. Distempers grow dark with age.

(*c*) Distempers should not be mixed in a larger quantity than is acturally required for a day's work and hot water should be used in preference to cold water in preparing the mixutre.

(*d*) On new lime plastered walls, distempers should be applied in two coats over one coat of priming.

(*e*) On old lime plastered walls covered with one or two coats of hard dry white wash free from effloresence or "kalar", one coat of distemper without priming should be used but only distempers which are lime-proof should be used.

(*f*) When the lime plaster is very smooth and no priming coat is used, a coating of warm glue should first be applied, but if rough, a coat of Spanish white or chalk mixed with a solution of glue is employed to render the surface smooth, the coating when dry, being rubbed as clean and as even as possible.

(*g*) For local made distempers a priming coat of milk (0·75 kg. per 10 m^2) may be used with good results.

(*h*) Distempers should be applied in dry weather with a broad stiff brush, and the first sort coat should be allowed to thoroughly dry before the next is laid on. The first coat should always be of a lighter tint and should be applied with care. The brushes used should never be allowed to rest on the bristles and after use they should be carefully and thoroughly cleaned.

(*i*) Great care should be taken in choosing a suitable colour for a light or a dark room.

SPECIFICATION NO. 65-A.

CEMENT PAINTING.

(1) Specification for cement paint laid down in I.S. 5410-1969 shall apply.

(2) *Surface preparation.*—Any previous coating, lime work, loose materials and dirt shall be removed throughly by scrapping and washing. In case where cement paint was previously used, only a slight scrapping with sand paper is necessary to remove all fungus, or organic matters which may be present.

The surface shall be wet thoroughly with clean water. When the surface starts drying and there is no sign of water on the wall (The surface must feel damp to touch) the surface is ready for application

NOTE.—On a new surface or in very dry atmosphere where the water is either sucked in or evaporated very fast, wet the surface with water until a uniform drying is noted. Concentrate only on those parts which are drying earlier than the rest carry on until uniformity in drying is observed.

(3) *Mixing*.—Unless otherwise ordered by the Executive Engineer the mixing of the cement paint shall be carried out in accordance with the instructions issued by the manufacturers of the particular brand of cement paint that is specified to be used.

(4) *Application*.—The water mixed cement paint shall be kept well stirred before and during use and shall be applied within one hour of preparption. Use flat brush and more horizontally or vertically to ensure perfect covering. While applying the first coat brush hard into the surface to seal up all cavities or pores which may be present. For the second coat apply similarly but finish with a vertical movement taking care to see that the paint is spread evenly over the surface. During application frequent stirring should be done to ensure homogeneous composition.

(5) *Curing*.—24 hours after the first coat has been applied the surface shall be saturated with water. The second coat shall be applied when the surface is damp to touch. Rewatering the sufrace shall be done with ample water after 24 hours to ensure perfect setting of the paint film.

The number of coats necessary shall be as decided by the Executive Engineer.

(6) *Weather*.—Wherever possible, the application of cement paint shall take place in the shade. If this is impossible, the painted surface shall be wetted with a fine water spray after 4 to 5 hours. Painting during rainy seasons shall be done taking precuation that the painted surface are not hit by rain for a minimum of 3 to 4 hours as the paints are liable to wash off if rain occurs within two to three hours.

EXTRACT FROM I.S. 5410-1969.

Specification for cement paint, colour as required.

1. *Scope*.

1.1. This standard prescribes the requirements and the methods of sampling and test for cement paint, colour as required. The material is intended for use on walls, ceilings, and as an interior or exterior decorative and protective finish.

2. *Terminology*.—

2.1. For the purpose of this standard, the definitions given in I.S.: 1303-1963 shall apply.

3. *Requirements*.—

3.1. *Composition*.—The material, on analysis as prescribed in Appendix A, shall show a chemical composition as given below. The composition of the bulk supply shall be similar to that of registered sample :

	Percent by Weight.
Portland cement	60 min.
Hydrated lime	25 mix.
Alkali resistant pigment ..	3 to 7.
Water repellants hygroscopic salts fungicides.	In suitable proportions to produce a material to satisfy the require ments of this standard.

3.1.1. *Freedom from organic binders.*—The materials shall be free from organic binders, when tested as prescribed in Appendix B

3.2. *Preparation for use.*—The material shall be in the powder form, free from lumps that are not friable and when mixed with required volume of water shall be suitable for use on porous surfaces of masonry, concerete, stucco, common brick and rough plaster work, except gyspum plaster. The surface to which the paint is applied shall be free from chalking or other extraneous matter which interfere with the adhesion of the paint to the surface.

3.3. The water mixed paint shall be kept well stirred during use and shall be applied within one hour of preparation. The surface to be painted shall be wetted with water before application.

3.4. *Durability.*—When prepared and tested for normal outdoor exposure as prescrbied under C. 4, a general breakdown of the film prepared from the registered sample, shall not occur in less than 18 months.

NOTE.—As a precaution against inadevertent accidents, the outdoor exposure test (C. 4) shall be carried out in duplicate.

3.5. The material when mixed with equal volume of water shall also comply with the requirements given in Table 1.

TABLE I—REQUIREMENTS FOR CEMENT PAINT, COLOUR AS REQUIRED.

Serial number and Characteristic.	*Requirement.*	*Method of test ref. to*	
		Appendix.	Cl. *No. in I.S.* :* 101-1964.
(1)	(2)	(3)	(4)
(i) Drying time (hardening) and recoating properites.	Not more than 24 hours.	D	..
(ii) Finish	Smooth and matt.	..	7·5
(iii) colour	Close match to the specified I.S. colour or as agreed to	..	11
(iv) Fastness to light (using panels as in C.1.1.1.).	To pass the test.	..	12
(v) Residue on sieve (on dry material) percent by weight, Max.	3.0	E	..
(vi) Resistance to dry rubbing.	To pass the test.	F	..
(vii) Water repellancy ..	To pass the test.	C	..
(viii) Pot life of mixed paint	Not less than 1 hour.	H	..
(ix) Keeping properties (on dry material).	Not less than 1 year.	..	31

*Methods of test for ready mixed paints and enamels (second revision).

3.6. *Optional Requirements.*

3.6.1. Spreading Capacity, Spreading Time and Opacity—In addition, if agreed to between the purchaser and the supplier, the spreading capacity, spreading time and opacity shall be determined in accordance with relevant methods of test as given in I.S. : 101 1964 and the results recorded on the sample offered for approval against the specification. In the case of supplies offered against approved sample to this specifications, these characteistics shall be within 90 pre cent of the approved sample.

4. *Packing and marking.*—

4.1. *Packing.*—Unless otherwise agreed to, the dry material shall be packed in polyethylene bags in suitable metal containers.

4.2. *Marking.*—Each container shall be marked with the following :

(*a*) name of the material ..

(*b*) Name of the manufacturer and/or trade mark; if any .. .. ..

(*c*) Weight of the material; and .. .. ..

(*d*) Month and year of manufacture .. ..

4.2.1. The containers may also be marked with the I.S.I. Certification Mark.

NOTE.—The use of the I.S.I. Certification Mark is governed by the provision of the Indian Standards Institution (Certification Marks) Act, and the Rules and Regulations made thereunder. Presence of this mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard, under a well-defined system of inspection, testing and quality control during production. This system, which is devised and supervised by I.S.I. and operated by the producer has the further safeguard that the products as actually marked are continuously checked by I. S. I. for conformity to the standard. Details of conditions,under which a licence for the use of the I.S.I Certification Mark may be granted to manufacturers or processors. may be obtained from the Indian Standards Institution.

5. *Sampling.*

5.1. Representative samples of the material shall be drawn as prescribed under 3 of IS : 33-1963

6. *Test methods.*

6.1. Tests shall be conducted according to the methods prescribed in IS : 101-1964 and Appendices A to H to this standard. References to the relevant clauses of I.S. : 101-1964 are given in 3.6.1. and column 4 of Table 1 and to Appendices in 3·1, 3·1·1., 3·4 and column 3 of Table 1.

6.1.1. For match against IS colour, IS : 1650-1960 shall be used

6.2. *Quality of reagents.*—Unless specified otherwise, pure chemicals and distilled water (*See* IS : 1030-1960) shall be employed in tests

NOTE.—"Pure chemicals" shall mean chemicals that do not contain impurities which affect the results of analysis.

EXTRACT FROM I.S. 427 — 1965

Specification for distemper, dry, colour as required (*Revised*)

1. *Scope.*

1.1. This standard prescribes the requirements and the methods of sampling and test for dry distemper, colour as required. The material is used as a flat finish for interior decorative purposes on walls, ceilings, etc.

2. *Terminology.*

2.1. For the purpose of this standard, the definitions given in IS. 1303—1963 shall apply.

3. *Requirements.*

3.1. *Form and condition*.—The material shall be in the term of a fine dry, homegeneous powder free from odour of putrefaction as such and when mixed with water.

3·2. *Composition*—The material shall consist of suitable pigments extenders lime-proof tinters, water-soluble binders and preservatives mixed in suitable proportions to comply with the requirement of this standard.

3.3. The material, when mixed with an adequate quantity of water, shall also comply with the requirements given in Table 1.

3.4. *Optional requirements.*—In addition, if agreed to between the purchaser and the supplier, the spreading capacity, spreading time and wet capacity shall be determined in accordance with the relevant methods of test as given in I.S. 101—1964 and the results recorded on the sample offered, or approval against the specification. In the case of supplies offered against any approved sample to this specification, these characteristics shall be within 90 per cent of the approved sample.

TABLE 1—REQUIREMENTS FOR DISTEMPER, DRY, WHEN MIXED WITH ADEQUATE QUANTITY OF WATER, COLOUR AS REQUIRED.

(*Clause* 3·3.)

Serial number and characteristic.	*Requirement.*	*Method of test refer to Column number in*	
		Appendix.	*I.S. 101—1964*
(1)	(2)	(3)	(4)
(i) Drying time, hard*dry*.	Not more than 3 hours on a 150 × 150 mm. neat, cement block.	..	7·1, 7·2 and 7·3
(ii) Consistency ..	Smooth and uniform mixture suitable for application by brushing.	..	7·4
(iii) Finish	Smooth and matt	..	7·5
(iv) Colour	Close match to the specified I.S. colour where specified.	..	11
(v) Fastness to light.	To pass the test	..	12
(vi) Residue on sieve, percent by weight, Max.	5·0	A	..
(vii) Resistance to dry rubbing.	To pass the test .. .	B	..
(viii) Re-coating properties.	Do. ..	C	..
(ix) Behavious towards lime.	Do. ..	D	..
(x) Keeping properties.	Not less than one year ..	..	31

4. *Packing and marking.*

4·1. *Packing*—The material shall be suitably packed as agreed to between the purchaser and the supplier.

4·2. *Marking.*—The containers shall be marked with the name of the material; manufacturer's name and trade-mark, if any; Weight of the material; lot and batch number.

4·2·1. The containers may also be marked with the I.S.I. Certification Mark.

4·3. Other details of packing and marking shall be in accordance with the instructions given by the purchaser.

5. *Sampling.*—

5·1. Representative samples of the material shall be drawn a prescribed under 3 of I.S. 33—1963.

5·2. *Number of tests.*—Tests for all characteristics specified shall be conducted in the composite sample.

5·3. *Criteria for conformity.*—The lot shall be considered as conforming to the specification, if the composite sample satisfies all the requirements specified in the standard.

6. *Test methods.*

6·1. Tests shall be conducted as prescribed in 3·1, 3·2 and in columns 3 and 4 of Table 1.

6·1·1. For matching to I.S. colour I.S. 1650—1960 shall be used.

6·2. *Quality of reagents.*—Unless specified otherwise, pure chemicals and distilled water (*see IS.* 1070—1960) shall be employed in tests.

NOTE. "Pure chemicals" shall mean chemicals that do not contain impurities which affect the result of analysis.

EXTRACT FROM I.S. 428 —1969.

Specification for distemper, oil emulsion, colour as required

(First Revision).

1. *Scope.*

1·1. This standard prescribes the requirements and the methods of sampling and test for distemper, oil emulsion. The material is used as a flat finish for decorative purposes on walls and celings where frequent washing may become necessary.

2. *Terminology.*

2·1. For the purpose of this standard, the definitions given in I.S. 1303—1963 shall apply.

3. *Requirements.*

3·1. *Form and condition.*—The material shall be in the form of a homogeneous paste, free from odour of putrefaction as such and when mixed with water.

3·2. *Composition.*—The material shall be of the oil emulsion type, containing suitable preservatives, and of such a composition as to comply with the requirements of this standard.

3·3. The material when thinned in the proportion by weight of four parts of paste with one part of water, shall also comply with the requirements given in Table I

3·4. *Optional requirements.*—In addition, if agreed to between the purchaser and the supplier the spreading capacity, spreading time and capacity shall be determined in accordance with the relevant methods of test as given in I.S. 101-1964, and the results recorded on the sample offered for approval against specification. In the case of supplies offered against any approved sample to this specification, these characteristics shall be not less than 90 per cent of the approved sample.

4. *Packing and marking.*

4·1. *Packing.*—Unless otherwise agreed to between the purchaser and the supplier, the material shall be packed in suitable metal containers.

4·2. *Marking.*—The containers shall be marked with the name of the material, manufacturer's name and trade-mark, if any ; weight of the material ; and lot, batch number and date of manufacture.

4·2·1. The containers may also be marked with the I.S.I. Crertification Mark.

4·3. Other details of packing and marking shall be inaccordance with the instructions given by the purchaser.

TABLE 1— REQUIREMENTS FOR DISTEMPER, OIL EMULSION, COLOUR AS REQUIRED.

(*Clause* 3·3.)

Serial number. and characteristic.	*Requirement.*	*Method of Test refere to Cl. number in.* Appendix	I.S. 101 1964.
(1)	(2)	(3)	(4)
(i) Drying time, hard dry.	Not more than 3h on a 150 × 150mm.neat cement block.	..	7·1, 7·2 and 7·3.
(ii) Consistency	Smooth and uniform mixture suitable for application by brushing.	..	7·4
(iii) Finish	Smooth and matt ..	..	7·5
(iv) Colour	Close match to the specified I.S. Colour or to approved sample where I.S. colour is not specified.	..	11
(v) Fastness to light ..	To pass test	..	12
(vi) Residue on sieve, per cent by weight, Max.	1,0	A	..
(vii) Resistance to dry rubbing.	To pass test	B	..
(vii) Recoating properties.	Do. ..	C	..
(ix) Resistance to alkali.	Do. ..	D	..
(x) Washability	Do. ..	E	..
(xi) Keeping properties ..	Not less than one year.	..	31

5. *Sampling.*

5·1. Representative samples of the material shall be drawn as prescribed under 3 of I.S. 85—1960.

5·2. *Number of tests.*—Tests for all characteristics specified shall be conducted on the composite sample.

5·3. *Criteria for conformity.*—The lot shall be considered as conforming to the specification, if the composite sample satisfies all the requirements specified in the standard.

6. *Test methods—*

6·1. Tests shall be conducted as prescribed in I.S. 101—1964 and Appendices A to E. References to appendices and relevant clauses of I.S. 101—1964 are given in columns 3 and 4 of Table 1.

6·1·1. For matching to I.S. Colour, I.S. 1650—1960 shall be used.

6·2. *Quality of reagents.*—Unless specified otherwise, pure chemicals and distilled water (*see* I.S. 1070—1960) shall be employed in tests.

NOTE.—" Pure chemicals " shall mean chemicals that do not contain impurities which affect the results of analysis.

EXTRACT FROM I. S. 1,200 (PART XII)—1971.

Method of measurement of building and civil engineeringworks

Part II plastering and pointing.

3. *Plastering.*

3·1. The work of plastering shall be classified according to the material used and each classification shall be measured separately. The following particulars shall be given for each classification :—

(a) Mix of Mortar;

(b) Number of coats and thickness of each coat;

(c) Nature of surface treatment;

(d) Nature of base;

(e) Curved work, conical work, spherical work and eliptical work stating the radius; and

(f) Any special treatment of base.

3·1·1. The description shall include arises, internal rounded angles, external chamfers and or rounded angles not exceeding 80 mm in girth.

3.1.2. In case of fibrous plaster particulars of methods of application and of treatment of joints shall also be given.

3·1·3. Work in repairs shall be so described stating the average thickness of any dubbing, if any.

3·1·4. Work on old surfaces shall be so described stating the thickness of dubbing if any.

3·2. Plastering on roofs, ceiling and walls shall be measured separately.

3·3. Removing plaster by scraping or otherwise shall be measured separately in square metres separately.

3·4. Plastering in isolated widths or in widths not forming part of general plastering work (as in bands, cornices, sunk panels, etc.) shall be measured as below :

(a) 30 cm or below in width/girth in running metres; and

(b) width girth above 30 cm in square metres.

3·5. Plastering at a height greater than 10 m above ground/datum level shall be measured separately in stages of 5 m height except interior plastering in case of building which shall be measured separately for each storey.

3·6. All plastering shall be measured in square metres unless other wise described.

3·7. Fair joints and cutting to edges shall be measured separately in running metres or alternatively described and included in the item.

3·13. Architraves, mouldings, ceiling ribs and cornices shall cach be measured separately. Length shall be measured in running metres at the centre of girth. Girth shall be measured along curve of moulding.

3·13·1. Moulded cornices and coves shall be measured in square metres, the area being arrived at by multiplying length by girth.

3·14. Forming letters or figures in plaster shall be enumerated stating the height.

3·15. Plastering on lathing shall be measured separately stating number of coats and the thickness of each coat.

3·15·1. Lathing shall be fully decribed and measured net; wood and steel lathing shall be measured separately.

3·15·2. Laps, gauge, and mesh of steel lathing shall be stated, no allowance being made for laps or cutting.

3·15·3. Size of laths, their distance apart and the kind of timber shall be stated in the case wood lathing.

3·15·4. Connector lathing shall be measured separately.

4. *Pointing.*

4·1. Proportions of the materials shall be described. The varoius type of pointing shall be measured separately. Pointing on different types of walls, floors, roofs, etc., shall be measured separately. The type and material of surface to be pointed shall be described.

4·2. Pointing in single detached joints for flashings shall be measured in running metres.

4·3. Pointing brick and tile work with mortars of matching shades shall be measured separately.

4.4. Pointing shall be measured in square metres.

4·5. Removing pointing by raking or otherwise shall be measured in square metres.

4·6. *Deductions.*

4·6·1. For jambs, soffits, sills, etc., for openings not exceeding 0·5 sq. m. each in area; for ends of joists; beams; posts; girders; steps; etc., not exceeding 0.5 sq. m. each in area; and for openings not exceeding 3 sq.m. each deductions and additions shall be made in the following manner;

(a) No deduction shall be made for ends of joists, beams, posts, etc., and openings not exceeding 0.5 sq. m. each, and no addition shall be made for reveals, jambs, soffits, sills, etc., of these openings.

(b) Deductions for openings exceeding 0.5 sq. m. but not exceeding 3 sq. m. each shall be made as follows and no addition shall be made for reveals, jambs, soffits, sills, etc., of these openings;

(i) When both faces of wall are pointed with the same type of pointing, deduction shall be made for one face only.

(ii) When two faces of wall are pointed with different types of pointing or if one face if plastered and the other pointed, deductions shall be made in the plaster or pointing on the side of frame for door, window, etc., on which the width of reveals is less than that on the otherside, but no deduction shall be made, from plaster or pointing on the other side.

(iii) When only one face is treated and the other face is not treated, full deduction shall be made if the width of the reveals on the treated side is less than on the untreated side, but if the width of the reveal is more then no deduction shall be made not any addition shall be made for reveals, jambs, soffits, sills, etc.

(c) In cases, of openings of area above 3 sq.m. each, deductions shall be made for opening but jambs, soffits and sills shall be measured.

NOTE.—In calculating areas of openings extra width of rebated reveal if any shall be excluded.

4·7. Raking out joints shall be measured in square metres or alternatively included in description of item.

4.7.1. Raking out single detached joint shall be measured separately in running metres.

EXTRACT FROM I. S. 1597 (PART I) —1967.

Code of practice for construction of stone masonry— Part I rubble stone masonry.

7·10. *Jointing and Pointing.*—All joints shall be full of mortar. Pointing shall be avoided as far as possible, but where unavoidable it shall be carried out as the work proceeds using the same mortar as for bedding. If carried out by raking out the joint later on after hardening specially prepared mortars shall be used. The maximum thickness of joints shall be 20 mm for random rubble and 10 mm. for square rubble. The various types of pointing are shown in Fig. 10 of I.S. 2212--1962 (See Sec. 5).

EXTRACT FROM I. S. 1661 —1972.

Code of practice for cement and cement-lime plaster finishes on walls and ceilings.

4. *Materials, tools and accessories*:

4·1. The following materials, conforming to relevent India Standard specifications, shown against them, shall be used.

(*a*) Cement conforming to I.S. 269-1967 or I.S. 455-1967.

(*b*) Lime class B and C conforming to I. S. 712-1964.

(*c*) Sand conforming to I.S. 1542—1960.

7·2. *Number of plaster coats.*

7·2·1. The ideal number of coats, where practicable, is two, namely the undercoat followed by a finishing coat. It is reconized, however, that much successful work has been carried out in the past with- plaster finishing coats with a single coat on reasonably plane back- grounds of bricks, concrete and similar materials. However, for very rough surfaces, such as rough- stone masonry, three coat plastering may be necessary. Metal lathing normally requires a three coat plaster finish for successful results. Renovation work on wood laths should also be carried out in three coats.

7·2·2. The range of coats normally employed for different back- grounds is as follows :

Background.	*Number of coats.*
Brickwork or hollow clay tiles	2 or 1
Concrete cast in situ	2 or 1
Building blocks	2 or 1
Wood or metal lath	3 or 2
Fibre building Board (insulating board)	2 or 1
Wood Wool slabs	2 or 1
Cork slabs	2 or 1
Uneven and rough stone masonry	3 or 2

7·3. *Thickness of plastering.*

7·3.1. Finishing coats (and single coat work, where employed) shall be of such minimum thickness as just to provide a sufficient body of material to harden satisfactorily under the site conditions in any particular case.

7·3·2. The total thickness of two-coat work exclusive of keys or dubbing out shall be generally about, but shall not normally exceed 20 mm and it shall not exceed 15 mm in the case of in-situ concrete soffits. The thickness of three-coat work shall be about, but shall not normally exceed 25 mm.

7·3·3. The thickness of an individual coat shall generally be as ecommended in Table 2.

7·4. *Recommended plaster specifications.*

7·4·1. A list of specifications for mixes suitable for various situations is given in Table 2, with covers single coat work which is used generally and also two and three coat works suitable for special situations. The lime in the mixes specified in Table 2 and in 7.4.2. is assumed to be measured as lime putty, but if it is measured as dry hydrated lime. the proportion of lime in any mix shall be slightly higher than is indicated and a suitable adjustment shall be made as indicated in 7·4·1·1.

11. *Preparation of plaster.*

11·1. *Proportioning* :

11·1·1. The material used in the preparation of plastering mixes may be measured by Volume using gauge boxes.

11·1·2. Cement shall be measure by weight. For the pupose of proportioning, one cubic metre of cement shall be taken to weight 1440 kg. approximately.

11·1·3. Proportioning of lime may be done by measurement of volume as lime putty or dry hydrated lime before the preparation of putty. The mix proportion of lime, unless otherwise stated, generally refers to the volume of putty.

NOTE.1— Lime putty weights about 1280 kg/m^3.

NOTE 2.— One M^3 of dry hydrated lime normally gives about 0·8 to 0·9 m^3 of lime putty.

11·1·4. *Quantity of water* : For general cement plaster work with 1:3 proportion the quantity of water required is about 70 percent by weight of cement. This may however, very depending on the following factors and adjustment shall be done as explained in I.S. 2250-1965.

(*a*) The nature and conditions of the fine aggregate;

(*b*) The temperature and humidity at the time of working;

(*c*) Richness of the mix, namely whether rich or leaner than 1:3

(*d*) The varying quantities of lime in composite mortars; and

(*e*) The use of admixtures added for improving the workability.

11·2. *Mixing.*

11·2·1. *Cement-lime plaster* : The cement lime plaster shall be prepared by mixing dry in the required proportions of cement and sand. Lime putty mixed with water shall then be added to the mix and the contents mixed for sometime until a satisfectory mortar is obtained.

11·2·2. *Cement plaster :* Cement and sand shall be mixed dry in the required proportions to obtain a uniform colour. Water shall then be added to get the required consistency for the plaster.

11·2·3. Cement lime plaster shall be used within two hours after the addition of water to cement provided it is kept agitated or turned over at intervals of at least 20 min. Cement plasters shall be used within half an hour after the addition of water. Any mortar or plaster whcih is partially set shall be rejected and removed forthwith from the site.

11.2.4. Mixing may be done either manually or mechanically. ' Hand mixing' shall be carried out on a clean, water-tight platform During mixing the mortor shall be heed back and forth for 10 to 15 min. after the water is added. In ' machine mixing' the mixer shall run at least 5 min. after placing all the ingredients in the drum.

11.2.4.1. Machine mixing is preferable to hand mixing for all mortars.

TABLE 2 : RECOMMENDED PLASTER SPECIFICATIONS.

(*Clause* 7.3.3. *and* 7.4.1.)

Serial No. and No. of coat of plaster.	*Situation.*	*Mix. (Proportion by volume).*	*Thickness.*
(1)	(2)	(3)	(4)
(i) Single coat plaster ..	Both internal and external.	1 : 0 : 3 1 : 0 : 4 1 : 0 : 6 1 : 1 : 6 1 : 2 : 9	10 to 15 mm.
(ii) Two coat plasters :	Do.		
(a) Backing coat ..		1 : 0 : 3 1 : 0 : 4 1 : 0 : 6 1 : 1 : 6	10 to 12 mm.
(b) Finishing coat ..		1 : 0 : 3 to 6. 1 : 1 : 6 1 : 2 : 9	3 to 8 mm.
(iii) Three coat plasters.	Very rough surface ; both internal and external.		
(a) Base coat		1 : 0 : 3 1 : 0 : 4 1 : 0 : 6 1 : 1 : 6	10 to 15 mm.
(b) Second coat ..		1 : 0 : 3 to 6. 1 : 1 : 6 1 : 2 : 9	3 to 8 mm.
(c) Finishing coat ..		Fat lime and fine sand or marble dust in equal proportions.	3 to 5 mm.

NOTE 1.—Where two or three coat plasters are adopted, as far as possible the mix for the under coats should contain coarse sand conforming to grading zone II of I.S. 383–1970 and having fineness modulus not less than 2·0.

NOTE 2.—For single coat plaster the fineness modulus of sand should be as far as possible 1·5 and conforming to grading Zone IV of I.S. 383–1970. Where only fine sand is available the fineness modulus of sand may be improved by mixing the required percentage of coarse sand. The strength of plaster mix gets reduced with the reduction in the fineness modulus of sand.

NOTE 3.—Other mixes of cement/lime and sand may also be adopted depending on the quality of sand available and local conditions provided the strength conforms to any of the above mixes given in Table 2.

EXTRACT FROM I.S. 2394 –1965.

Code of practice for application of lime plaster finish.

8.6. *Number of Coats*—For normal backgrounds, one coat is adequate for ordinary finish and two coats for high class finish. However, in special situations or where background is very rough and uneven, three coats may be necessary as discussed in clause 8.6.1.

8.6.1. Cases where the nature or location of background influences the choice with regard to the number of coats are as follows :

(*a*) Wood lathing normally requires three coat plaster finish for satisfactory results.

(*b*) Three coats of plaster may be necessary for finishing uneven stone masonry.

(*c*) Where very coarse sand is used in the lime plaster, finishing the surface with lime punning may be necessary.

(*d*) In case of plastering on ceiling and soffit, generally one coat will be sufficient but for ceiling of floors or roofs constructed with rough stone slabs which are not adequately dressed and where there are undulations in the surface two coats will be necessary.

8.6.2. The range of coats, normally employed for different backgrounds are as follows :

Brick work (internal and external)	1 or 2
Stone work (internal and external)	2 or 3
Concrete blocks	1 or 2
Wood laths	2 or 3
Soffits and ceilings	1 or 2

8.7. *Thickness of Plastering*—The thickness for plaster work exclusive of key or dubbing out shall generally be as given in Table 1.

TABLE 1 : THICKNESS FOR PLASTER WORK.

Serial No. and Type of work.	*First coat.*	*Second coat.*	*Third coat.*
(1)	(2)	(3)	(4)
	mm.	mm.	n.
(i) Brick masonry :			
(*a*) Single coat work	15	..	
(*b*) Double coat work ..	10	10	..
(ii) Stone masonry	15	10	..
(iii) Stone masonry (very rough surface).	15	10	10

8.8. *Surface finish.*—Internal plasters are usually finished to a smooth surface. Lime punning or neeru finish is necessary to obtain a smooth surface over coarse plaster where otherwise white or colour wash will not give good appearance.

8.9. *Effect of atmospheric conditions*—The ideal conditions for application of plaster are gentle warmth coupled with moderate ventilation. Extremes of all kinds should be avoided as far as possible. The effect of prevailing weather at the time of plastering or during the setting, drying and hardening period is similar for lime plaster as for cement or cement lime plaster. For effect of various atmospheric agencies clause 8·7 of I.S. 1661–1960—may be referred.

9. *General precautions in plastering.*

9.1. *Roughness.*—The roughness of background improves the bond of plaster. This is particularly important in case of soffits and ceilings. A smooth surface may be roughened by wire brushing, if it is not hard ; or by hacking if it is hard. After roughening the surface care shall be taken moisten the surface sufficiently before plastering. as otherwise the freshly exposed surface may tend to absorb considerable amount of water from the plaster. In case of special back-grounds, wood lath, expanded metal lathing, wire netting, etc., may be fixed to provide key to the plaster.

11. *Preparation of back-ground for application of lime plaster.*

11.1. For durability of plaster it is vital to obtain a satisfactory bond between the background and the first plaster coat and also to ensure that the bond is maintained subsequently. Necessary preparation of the background shall be done to fulfil the requirements mentioned in 11.2 to 11,4.

11.2. Except for rough and uneven surfaces all joints in the brick masonry on the fair side shall be raked out to a depth of not less than 12 mm. while the mortar in the joints is still green. All joints in the brick and concrete block masonry shall be raked out.

11.3. Roughening and cleaning of the background surface shall be carried out as in 9.1. and 9.2. Where necessary dubbing shall be carried out as explained in 9.3.

11.4. The masonry shall be allowed to dry out for sufficient period so that initial drying shrinkage is fairly complete and suction adjustment is possible during plastering *(See* 9.4.). The background should be moistened before the application of plaster. Differential movements between the background and the plaster due to moisture change will cause cracking of the plaster, as explained in 9.5. Major part of such movements shall be allowed to set in before the plaster is applied, as for example, by giving in the case of moisture movement sufficient drying interval to the background. In concrete construction hacking shall be properly done for good adhesion of the plaster to the background. Hollow concrete blocks and foam concrete blocks shall only be lightly wetted before the application of plaster.

12. *Preparation of lime mortars for plastering.*

12.1. *Proportioning.*—Materials to be used in the preparation of lime mortar shall be measured by volume-gauge boxes. Proportioning of lime shall be done by measurement of volume as lime putty. In case the measurement is done on quick lime or hydrated/dry slaked lime, their quantity shall be such as to yield the required volume of lime putty (*see* Note).

NOTE.—The lime in mortar mixes is assumed to be measured as lime putty. If it is measured as hydrated dry slaked lime, the proportions of lime in any mix shall be slightly higher than that is indicated and a suitable adjustment shall be made as indicated in **12.1.1.**

12.1.2. The recommended mix proportions for lime mortars for plaster work shall be as given in Table 2.

TABLE 2 : RECOMMENDED MIX PROPORTIONS.

(*Clause* 12.1.2.)

Serial No. and Type of coat. (1)	*Mix proportion.* (2)	*Class of lime.* (3)
(i) Dubbing and first coat (Both for external and internal surfaces).	1 lime : 2 to 3 sand	A and B.
	or	
	1 lime—1 Surkhi 1 to 2 sand.	C
	1 lime : 2 to 3 Surkhi (for first coat in the case of two coat work).	C
(ii) Second coat	1 lime : 2 to 3 sand ..	C
(iii) Neeru finishing coat ..	Fat lime and fine sand ground in equal proportions.	C

NOTE.—Lime plastered finishes are not suitable for external surfaces in areas of heavy rainfall.

13. *Application of lime plaster.*

13.0. *General.*—It is an advantage to plaster the ceiling first and then to plaster the walls starting from the top and working downwards. This will permit the removal of scaffolding as early as possible.

13.1. To ensure even thickness and a true surface, plaster about 15 × 15 cm. shall be first applied, horizontally and vertically, a not more than 2 metre intervals over the entire surface to serve a gauges. The surfaces of these gauged areas shall be truly in the plane of the finished plaster surface. The mortar shall then be laid on the wall, between the gauges with trowel. The mortar shall be applied in a uniform surface slightly more than the specified thickness. This shall be beaten with thapies to ensure thorough filling of the joints, and then brought to a true surface, by working a wooden straight edge reaching across the gauges with small upward and sideways movements at a time. Finally the surface shall be finished off true with a trowel or wooden float according as a smooth or a sandy granular texture is required. Excessive trowelling of overworking the float shall be avoided. During this process, a solution of lime putty shall be applied on the surface to make the latter workable. All corners, arise, angles and junctions shall be truly vertical or horizontal as the case may be, and shall be carefully finished. Rounding or Chambering corners, arises junctions, etc. shall be carried out with proper templates to the sizes required.

13.1.1. In suspending work at the end of the day, the plaster shall be left out clean to line both horizontally and vertically. When recommending the plastering, the edge of the old work shall be scraped clean and wetted with lime putty before plaster is applied to the adjacent areas to enable the two to propertly join together. Plastering work shall be closed at the end of the day on the body of of wall and not nearer than 13 cm to any corners or arises. It shall not be closed on the body of features such as plaster bands and cornecies nor at the corners or arises. Horizontal joints in plaster work shall not also occur on parapet tops and copings, as these invariably lead to leakages. Nor portion of the surface shall be left out initially to be patched up later on.

13.1.2. Some times, ends of scaffolding ballies have to be housed n the wall which is being treated with plaster. In such cases, after the ballies are taken out, the hole or holes left in the wall shall be filled up with bricks and mortar and the patch plastered up true, even and smooth in conformity with the rest of wall so that no sign of of any patch work shows out.

13.2. *One Coat Plaster work.*

13.2.1. Masonry walls on which plaster is to be applied directly shall be clean and dry with the joints raked to a depth of at least 12 mm before applying the first coat. The surface shall be damped evenly to control suction which is an essential treatment for securing first class work. The plaster shall be of specified thickness and carried out to the full length of wall on to the natural breaking points like doors and windows.

13.2.2. The mortor used for the plastering shall be stiff enough to cling and hold when laid ; for ceiling the mix is required to be stiffer than that used for walls. On soffits the mortar shall be laid in long even spreads outwards from the operator overlapping each trowel full and using sufficient pressure to force it into intimate contact with the background. On walls the mortar shall be laid in long even spreads upwards and across, overlapping each trowel full using sufficient pressure to force it into intimate contact with the background.

13.2.3. On relatively smooth background the mortor may have to be dashed on to ensure adequate bond for it when applied with a trowel. Dashing of the first coat aids in securing intimate bond by excluding air which might otherwise be trapped behind the plaster. The dashing of the first coat shall be done using a strong whipping motion at right angles to the face of the wall.

13.2.4. The plaster shall be laid in a little more than the required thickness and levelled with a wooden float. The plaster shall be trowelled hard and tight forcing it into joints to obtain a good bond, and surface rubbed smooth with a plasterer's trowel.

13.2.5. The plaster shall be water cured as described in 14.

13.3. *Two coat Plaster work.*

13.3.1. *First coat.*-The first coat of the specified thickness shall be applied in a manner similar to one coat plaster mentioned in 13.2. Before the first coat hardens its surface shall be beaten up by edges of wooden tapers and close dents shall be made on the surface. This helps the plaster in several ways ; the cracks are closed, the mortor is compacted, and driven home into the joints and the dents serve as a key to the subsequent coat. The subsequent coat shall be applied after this coat has been allowed to set for three to five days depending upon weather conditions. The surface shall not be allowed to dry during this period.

13.3.2. *First coat on wooden Lath and Metal Lathing.*—The mortar shall be stiff enough to cling and hold when laid, and shall then be applied by laying and spreading diagonally across the lath work overlapping each trowel full and using sufficient pressure to force it through the lath work to enable it to lap on the other side. The material shall be laid as uniformly as possible. The average thickness shall not exceed 10 mm. This coat shall be allowed to stand to get firm before denting.

13.3.3. *Second coat.*-The second coat shall be completed to the specified thickness in exactly the same manner as for the first coat. The finishing coat shall be laid with a mason's trowel to an average thickness of 5 mm.

13.3.4. Curing shall be done as described in 14.

13.4. *Three Coat Plaster work.*—The first two coats shall b applied in a manner as explained in 13.2. and 13.3. The third coat shall be completed to the specified thickness in the same manner as for the second coat and shall be cured as in 14.

14. *Curing.*

14.1. Curing shall be started 24 hours after finishing the Plaster. The plaster shall be kept wet for a period of 7 days. During this period it shall be suitably protected from external damages. The dates of plaster shall be legibly marked on the various sections of the walls so that curing for the specified period there after can be watched.

15.2. *Application of "Madras plaster".*

15.2.1. *Madras plaster.*—This is a special plaster finish applied in three or more coats to obtain a smooth polished surface in places where shall lime and fine sand are easily available.

15.2.2. *First coat.*—The first coat of lime plaster shall be applied to the wall as specified in 13.2. This shall be allowed to set for two or three days and then the surface, secured thoroughy in diagonal lines crossing each other. The plaster shall be kept constant watered till it is nearly set and then the second and third coats may be applied as in 15.2.3. and 15.2.4.

15.2.3. *Second coat.*—One coat, about 5 mm thick, of the mix specified in 15.2.3.1. shall be applied and brought to an exact level surface, with long wooden floats or where required, with curved moulds. The surface of the undercoat shall be watered, if necessary before, applying this coat.

15.2.3.1. The mix shall consist of the following :

Shell lime (Slaked)	12 parts	By volume
Fine white sand	9 parts	
Powered marble	1 part	

The sand shall be ground very fine. The marble also shall be ground fine and sifted through muslin. The materials shall be mixed with water and kept in a heap, well wetted for two days.

15.2.4. *Third Coat.*-The same mix as used for the second coat shall be ground on flat stone slabs with stones, rollers to the consistency of fine river and mud and applied to a thickness of about 2 mm over the second coat, which shall be wetted before hand.

The surface of the third coat shall be polished first with trowels and then with very hard smooth stones. While the polishing operation is in progress soap, stone powder contained in the muslin bags shall be dusted on the surface. The operation shall be continued till a high smooth polish is obtained.

15.2.5. Curing shall be done as explained in Clause 14.

EXTRACT FROM I.S. 2402—1963.

Code of practice for external rendered finishes.

6.12. *Number of coats.*—Normally one coat is sufficient for ordinary buildings in dry or moderately wet climates. For important building or for buildings in areas of heavy rainfall and for uneven background two coats will be required. For pebble dash and rough cast at least one undercoat will be necessary.

6.13. *Function of different coats and their recommended thickness*:

6.13.1. *Undercoats.*—Undrecoats serve various purposes. They provide a means of straightening or levelling an uneven surface they seal the surface of the wall and are often the most important part of the treatment in preventing rain penetration ; they provide a surface of even suction and satisfactory adhesion for the finishing coat, and they prevent *'grinning'* of joints or of areas of differing suction through the finishing coat. An undercoat in any part shall have a thickness of not less than 8 mm. nor more than 12 mm. If greater thickness is required to build up, an even surface, additional undercoats shall be used as required. For coloured cement renderings, the undercoat must be admixed with water proofiing compound to provide a water-proofing base.

6.13.2. *Final or finishing coat.*-The thickness of the final or finishing coat will be governed to some extent by the texture required but will normally be 3 to 8 mm. as finished. Some of the fine textured machine applied finishes may be as thin as 3 mm.

6.13.3. *Single coat rendering.*—In the case of dense background, such as of cement concrete, or where surface of the background is very even (as for example, walls built with hollow concrete blocks) or buildings subjected to moderate or light exposure conditions, wood-flat rendering can be applied in one coat. It shall not exceed 18 mm or be less than 6 mm in thickness in any part. But extreme care shall be taken in preparing the surface of the background as explained in 8.1.1. to ensure adequate bond between the rendering and the background.

EXTRACT FROM I.S. 6278—1971

Code of practice for white washing and colour washing.

2. *Materials.*

2.1. *Lime.*—Lime used for white washing shall be freshly burnt-Class 'C' lime (fat lime) and white in colour conforming to I.S. 712-1964.

2.2. *Water.*—Water shall be clear, free from all organic and suspended impurities—Potable water is most suitable for the purpose.

2.3. *Gum or glue.*

2.4. *Sodium chloride.*—shall conform to either I.S. 253-1964 or Grade II of I.S. 797-1967.

2.5. *Ultramarine blue or indigo*—shall conform to I.S. 55-1950.

2.6. *Pigments.*

2.6.1. *Yellow and red-ochre.*—The Ochres shall conform to I.S. 47-1950. The solid lump shall be crushed to powder.

2.6.2. *Blue vitriol.*—Fresh crystals of hydrous copper sulphate (Blue vitriol) shall conform to I.S. 261-1966 and shall be grounded to fine powder.

4. *Preparation of surfaces*

4.1. *New Surfaces.*—The surface shall be thoroughly cleaned of all dirt, dust, mortar, drops and other foreign matter before white wash is to be applied.

4.2. *Old surface* :

4.2.1. Surfaces, where the same colour wash is to be repeated—Old surfaces already whitewashed or colour washed shall be broomed to remove all dust and dirt. All loose scales of lime wash and other foreign matter shall also be removed. Where heavy scaling has taken place the entire surface shall be scraped clean. This will also apply where a colour wash has to be given as an already white-washed

4.2.2. Surfaces, where different colour wash is to be applied—Old colour wash on surface shall be entirely removed before white-wash or different colour wash is applied. The surface shall be prepared by brushing or by scraping or by other suitable means to produce clean surface and shall be broomed to remove dust, dirt, etc.

4.2.3. *Old surfaces spoiled by smoke.*—The surface shall be scraped with steel wire-brushes or steel scrapers. The surface shall then be broomed to remove all dust and dirt and shall be washed with clean water.

4.2.4. *Old and grease spots*—Old and grease spots shall be removed by a suitable chemical and smooth surfaces shall be rubbed with wire brushes.

4.2.5. All unsound portions of the surface plaster shall be removed to full depth of plaster in rectangular patches and plastered again after raking the masonry joints properly. Such portions shall be wetted and allowed to dry. They shall then be given one coat of whitewash.

4.2.5.1. All unnecessary nails shall be remeved, the holes and cracks filled with lime putty or plaster of paris to make the surface smooth.

4.2.6. When whitewashing old surfaces, if the surface was found to be infected with mould growth, it shall be treated in accordance with 4.2.6.1.

4.2.6.1. Any growth of moulds moss shall be removed by scraping with steel scraper and ammoniacal copper soluation consisting of 15 gm. of copper carbonate dissolved in 60 ml. of liquor ammonia in 500 ml. water, shall be applied to the surface and allowed to dry throughly before applying whitewash or colour wash. An alternative to ammoniacal copper soluation treatment may consists of 2 percent sodium pentachlorophenate soluation in water.

4.2.7.—Local areas affected by efflorescence, shall be initially treated in accordance with the method described in C-3 of I.S. 2395 (Part (I) 1966 and then applied with whitewash or colour-wash.

5. *Preparation of whitewash and colour wash.*

5.1. *Preparation of whitewash.*—Whitewash shall be prepared from fat lime conforming to I.S. 712-1964. The lime shall be slaked at site and shall be mixed and stirred with about five litres of water for 1 Kg. of unslaked lime to make a thin cream. This shall be allowed to stand for a period of 24 hours and this shall be screened through a clean coarse cloth. Add 1 Kg. of gum dissolved in hot water to each m^3 of lime cream. About 1·3 kg. of sodium chloride dissolved in hot water may be added for every 10 kg. of lime. Small quantity of ultra-marine blue (up to 3 gm per kg. of lime) shall be added to the last two coats of whitewash solution and the whole solution shall be stirred thoroughly before use.

NOTE 1.—The addition of sodium chloride(common salt) to lime wash helps in quick carbonation of calcium hydroxide making the coating hard and rub-resistant.

NOTE 2.—For exterior work the whitewash or colour wash that will adhere well to stone and masonry surface may also be prepared by scattering one part by weight of tallow in small lumps over 12 parts of quick lime, slaking it with only just sufficient water to form a thick paste, stirring occasionally to assist in dispersing the tallow and allowing it to stand until cool. The resultant paste shall then be let down to thin wash, which is strained through a coarse cloth. If tallow is not obtainable, then linseed oil or caster-oil about 10 per cent by weight of dry lime may be used. If the oil does not sponify and incorporate with lime, it should be heated up until the oil disappears. The oil forms with lime an insoluable soap which when once dry, will not wash off with heavy rain,. In case of colourwash, mineral colours, such as oxide of iron, red and yellow colours, based on chrominum oxide and carbon black not affected by lime may be added. Use of linseed oil is likely to give slight yellow tinge to whitewash.

5.2. *Preparation of colour wash.*—Sufficient quantity cf colour wash enough for the complete job shall be prepared in one operation to avoid any difference in shade. The basic whitewash solution shall be prepared in accordance with 5.1. Mineral colours not affected by lime shall be added to the whitewash solution as prepared in 5.1.

6. *Application of whitewash and colour wash.*

6.1. *Application of whitewash.*—White wash shall be applied with *MOONF* brush or other brush to the specified number of coats. The operation for each coat shall consist of a stroke of the brush given from the top, downwards, another from the bottom upwards over the first stroke, and similarly one stroke horizontally from the right and another from the left before it dries ; Each coat shall be allowed to dry before the next coat is applied. No portion of the surface shall be left out initially to be patched up later on. The brush shall be dipped in whitewash pressed lightly against the wall of the container, and then applied by lightly pressing against the surface with full swing of hand.

6.1.1. The whitewashing on ceiling should be done prior to that on walls.

6.1.2. For new work, minimum two coats shall be applied so that the surface presents a smooth and uniform finish through which the plaster does not show. The finished dry surface shall not show any signs of cracking and peeling and the whitewash shall not come off readily on the hand when rubbed.

6.1.3. For old work, after the surface has been prepared as in 4.2, a coat of whitewash shall be applied over the patches and repairs. Then one, or two more coats of white wash shall be applied over the eantire surface. The whitewash surface shall present a uniform finish through which the plaster patches do not show.

6.2. *Application of Colour wash*:—The colour wash shall be applied in accordance with the procedure given in 6·1. For colour washing on new works, after the surface has been prepared as in 4·1. The first primary coat shall be of whitewash and the subsequent coat (minimum two) shall be of colour wash ; and the entire surface shall present a smooth and uniform finish. To start with 0.1. m² of the prepared surface shall be colour-washed with the first coat of white wash and subsequent coats of colour-wash solution in full numberof coats and the shade so obtained shall be examined before the entire work of colour-washing is taken up in hand. It shall be noted that small area of colour wash will appear lighter in shade than when the same shades are applied to large surfaces.

6.2.1. For Colour washing an old work, after the surface has been prepared as in 4·2 a coat of colour wash shall be applied for the patches and repairs. Then the specified number of coats of colour wash shall be applied over the entire surface. The colour wash surface shall present a uniform colour shade. No primary coat is needed for old surface bearing colour of the same shade.

6.2.2. On surfaces requiring a change of colour, after the surface has been prepared as in 4·2·2 two coats of whitewash shall be applied before application of specified number (minimum two) of coats of colour-wash of the new shade.

7. *Protective measures.*

7.1. Surface of doors, windows, floors, articles of furniture, etc, and such other parts of the building not to be whitewashed or colour-washed shall be protected from being splashed upon. Such surfaces shall be cleaned of whitewash or colour-wash splashes, if any.

SECTION X

PAINTING, VARNISHING, ETC.

SECTION X

PAINTING, VARNISHING, etc.

CONTENTS.

466 3—54

SECTION X.

PAINTING, VARNISHING, *etc.*

INDIAN STANDARD—EXTRACTS.

SECTION X

PAINTING, VARNISHING, *etc.*

SPECIFICATION No. 66.

PAINTING.

1. *Materials.*—(*a*) All paints, oils and other materials and labour for the painting shall be provided by the contractor and included in his rate per 10 square metre, unless otherwise defined in the scheduled item wording or relevant supplementary specification.

NOTE.—In most cases, the Executive Engineer will issue the paints, raw and boiled linseed oil and other ingredients at a place and price to be noted in the tender notice and the tenderer will be asked to quote his price for finished work based on the above departmental supply.

(*b*) When the contractor is specifically permitted to obtain the paint by direct purchase and not by purchase from the department the paint shall be obtained by the contractor, and inspected by the Public Works Department officer in charge of the work, in the original containers as issued by the manufacturer, before the containers are opened by the contractor.

(*c*) When the contractor is instructed or permitted to mix paint from stiff paint pastes, he shall proceed as follows :—

Preparing a pot of paint.—Take sufficient stiff paint from the cask or tin, and cover what is left in the cask or tin with a layer of water. Place it in a clean paint pot with linseed oil (raw, boiled, or pale boiled, as the case may be) and mix up with a stick, then add the other ingredients. Then (when a colour is desired) add the necessary stainer or pigment and mix up again thoroughly. Then take a second clean paint pot, cover it with canvas tied on tightly and work the mixed paint through this canvas, with a brush, into this second paint pot. Take off the canvas cover and the paint is then ready for use, except when a flat finish is desired for the final coat, when a little more turpentine may be added.

(*d*) Specifications for oil paste laid in IS. 86 to IS. 100/1950 shall also apply.

(*e*) Specifications for linseed oil laid in IS. 75/67, IS. 77/50 and IS. 78/50 shall also apply.

(*f*) Specifications for turpentine laid in IS. 533/54 shall apply.

2. *Preparing the surface for painting.*—(i) *For new wood work.*—Specifications for painting new wood work laid down in IS. 2338 (Part I)/67 shall apply (Particularly ref. Para. 6).

(ii) *For old wood work.*—Specifications for "Maintenance Painting" laid down in IS. 2338 (Part II)/67 shall apply. (Particularly ref. para. 4.2 and Table 3).

If the old painted surface is blistered or flaked, it will be necessary to completely remove the old paint, before repainting.

This will be specified in the tender notice, and sepereate scheule rate provided, unless the painting item expressly states that the rate to be quoted shall be inclusive of removing old paint.

Old paint shall be removed in the manner specified in the tender notice. When no specification for method of removal is mentioned in the tender notice, it shall be removed by burning with an ordinary painters' blow-lamp, or by covering the surface with kerosene oil or other paint remover and then burning ; afterwards scraping off the paint. It can also be removed by applying a solution composed of—

Soft soap ..	..	.. 1/2 part.
Potash ..	..	.. 1 part.
Quicklime	..	.. 1/2 to 1/3 part.

The soap and potash are to be first dissolved by boiling in water. The lime is then added and the whole applied hot covering the paint, which will be removed with the solution. The solution must be left on for 12 to 24 hours after which the paint may be removed by washing with hot water.

Another method is as follows :—The solution with the ingredients noted below should be mixed in the proportion given against each and stirred until the bubbling ceases—applakaram 700 grams, washing soda 700 grams, slaked shell lime 1/70 cubic metre and sufficient water to make it into liquid form to flow freely.

The surface from which the paint is to be removed should be coated thickly using a whitewash brush and the solution left on for about 3 hours or so. The surface should then be washed first with water using sand and a coconut husk brush and afterwards washed clean with a good washing soap and water, using a boot brush. The surface should be allowed to completely dry up before repainting.

When the old paint has been thoroughly removed, the surface shall be washed, rubbed down, and holes, etc., stopped, as specified above for new wood work. If, the solvent for removal contains alkali a weak acid such as dilute vinegar should be used in washing down to neutralise the alkali. Care must be taken that the wood is not burnt in spots if a blow lamp is used. All greasy places shall be brushed over with turpentine, and then washed with soap and water.

(iii) *For new iron and steel work.*—Specifications for painting new iron and steel work laid down in IS. 1477 Part I/71 shall apply.

(iv) *For old painted surface, iron and steel work.*—Specifications for "maintenance painting" for steel work laid down in IS. 1477 Part I 71 shall apply.

(v) *For plastered surface.*—Specifications for painting on plastered surfaces laid down in IS. 2395 Part I/66 and Part II/67 shall apply.

3. *Application.*—No paint shall be applied until the articles have been passed for painting by the Public Works Department officer in immediate charge of the work.

The paint shall be laid on evenly and properly by means of crossing and laying off, the latter in the direction of the grain for wood work and care shall be taken that the paint is of such consistency that it runs easily from the brush. The paint must not be allowed to settle in the cans : to prevent this, each painter shall have in his paint can a small smooth stick, with which the paint shall be stirred occasionally. If a skin has formed on the top of the paint, it shall be carefully removed before the paint is used. To prevent mixed paints from drying or skinning over, they should be kept constantly covered with a thin film of water. The paint shall not be stirred with the painting brush.

Specifications laid down in IS. 1477 Part II/71 shall also apply (Particularly ref. Appendix A).

No hair marks from the brush or clogging of paint shall be left on the work or puddles in the corners of panels, angles of mouldings, etc.

In painting (or varnishing) doors and windows, the putty round the glass shall also be painted (or varnisheed, as the case may be) but the glass must not be smeared. Stains of paint in glass panes, etc., shall be carefully removed by applying a little turpentine and the whole work left in a clean condition.

4. *General.*—For painting, varnishing, wood-oiling, etc.—All painting and varnishing shall be neatly and care fully finished. Any damage done by dropping or smearing paint or varnish shall be made good by the contractor at his own cost. Superfluous patches or stains of paint or varnish shall be removed by means of turpentine.

Method of measurement laid down in IS. 1200 Part XV/1968 shall apply.

5. *Rate.*—The contract rate for painting per 10 m^2 shall include the cost of paint; preparing surface to be painted, brushes, cleaning materials and labour, the whole complete in accordance with this specification for the number of coats specified (including scaffolding, etc.—*vide* General conditions of contract) unless other method of payment is specified or defined in the relevant schedule item.

(When old paint is to be removed, a separate schedule item should be provided.)

SPECIFICATION No. 66-A.

PAINTING PRIMING COAT ON WOOD, IRON OR PLASTERED SURFACES.

1. *Materials.*

1.1. The priming coat for wood work, iron work or plastered surface shall be as specified in the description of the item.

1.2. The priming coat shall be prepared at the site of work, or ready made primer of approved brand and manufacture shall be used.

1.3. Where primer for wood work is to be mixed at site, it shall be prepared from a mixture of red lead, white lead and double boiled linseed oil in the ratio of 0.7 kg : 0.7 kg : 1 litre.

1.4. Where primer for steel work is to be mixed at site, it shall be prepared from a mixture of red lead, raw linseed oil and turpentine in the ratio of 2.8 kg : 1 litre : 1litre.

1.5. The specifications for the base material and thinner for mixed on site primers shall be as follows :—

(*a*) *White lead.*—The white lead shall be pure and free from adulterants like barium sulphate and whiting. It shall conform to IS : 103-1950 as amended from time to time.

(*b*) *Red lead.*—This shall be in powder form and shall be pure and free from adulterants like brick dust etc. It shall conform to IS : 102-1950 as amended from time to time.

(*c*) *Raw linseed oil.*—Raw linseed oil shall be lightly viscous 5 but clear and of yellowish colour with light brown tinge. Its specific gravity at a temperature of 30° C shall be between 0.923 and 0.928. The oil shall be mellow and sweet to the tests with very little smell The oil shall be of sufficiently matured quality. Oil, turbid or thick, with acid and bitter taste and rancid odour and which remains sticky for a considerable time shall be rejected. The oil shall conform in all respects to IS : 75—1950 as amended from time to time. The oil shall be of approved brand and manufacture.

(*d*) *Double boiled linseed oil.*—This shall be more viscous than the raw oil, have a deeper colour and specific gravity between 0·931 and 0·945 at a temperature of 30° C. It shall dry with a glossy surface. It shall conform in all respects to IS : 77-1950 as amended from time to time. The oil shall be of approved brand and manufacture.

(*e*) *Turpentine.*—Mineral turpentine i.e., petroleum distillate which has the same rate of evaporation as vegetable turpentine (distillate product of Oleoresin of Conifers) shall be used. It shall have no grease or other residue when allowed to evaporate. It shall conform to IS : 83—1950 as amended from time to time.

1.6. All the above materials shall be of approved manufacture and brought to site in their original packings in sealed condition.

2. *Preparation of surface.*

2.1. *Wood work.*—The wood work to be painted shall be dry and free from moisture.

The surface shall be thoroughly cleaned. All unevenness shall be rubbed down smooth with sand paper and shall be well dusted. Knots, if any shall be covered with preparation of red lead made by grinding red lead in oil and mixing with strong glue size and used hot.

The surface treated for knoting shall be dry before painting is applied. After the priming coat is applied, the holes and indentation on the surface shall be stopped with glazier's putty or wood putty (for specifications for glazier's putty and wood putty see sub-paras 9·33 and 13·37·1·2 CPWD specification respectively). Stopping shall not be done before the priming coat is applied as the wood will absorb the oil in the stopping and the later is therefore liable to crack.

2.2. *Iron and steel work.*—All rust and scales shall be removed by scraping or by brushing with steel wire brushes. Hard skin of oxide formed on the surface of wrought iron during rolling which becomes loose by rusting, shall be removed.

All dust and dirt shall be thoroughly wiped away from the surface.

If the surface is wet, it shall be dried before priming coat is undertaken.

2.3. *Plastered surface.*—The surface shall ordinarily not be painted until it has dried completely. Trial patches of primer shall be laid at intervals and where drying is satisfactory, painting shall be taken in hand. Before primer is applied, holes and undulations, shall be filled up with plaster of paris and rubbed smooth.

3. *Application.*—The primer shall be applied with brushes, worked well into the surface and spread even and smooth. The painting shall be done by crossing and laying off.

4. *Other details.*—The specifications for "Painting (General) shall hold good so far as they are applicable.

SPECIFICATION No. 66-B.

PAINTING WITH SUPERIOR QUALITY READY MIXED PAINT OVER G. I SHEETS.

1. *Paints.*—Superior quality ready mixed paint, suitable in painting over G. I. sheets, of approved brand and manufacture and of the required shade shall be used.

2. *Preparation of surface.*

2.1. *New work.*—(*a*) The painting of new G. I. sheets shall not usually be done till the sheets have weathered for about a year. When new sheets are to be painted before they have weathered, they shall be treated with a mordant solution prepared by mixing 38 gm. of copper acetate in a litre of soft water or 13 gm. hydrochloric acid in a solution of 13 gm. each of copper chloride, copper nitrate and ammonium chloride dissolved in a litre of soft water. This quantity of solution is sufficient for about 235 sq. m. to 280 sq. m. of area and is applied for ensuring proper adhesion of paint. The painting with the mordant solution will be paid for separately.

(*b*) Before painting weathered G. I. sheets, rust patches shall be completely cleaned with coarse emery paper and brush. All grease marks also shall be removed and the surface washed and dried and rusted surface shall be touched with red mixed paint of red lead.

2.2. *Old work.*—(*a*) If the old paint is firm and sound, it shall be cleaned of grease, smoke, etc. The surface shall then be rubbed down with sand paper and dusted. Rusty patches shall be cleaned up and touched with red lead.

(*b*) If the old paint is blistered and flaked, it shall be completely removed. Such removal shall be paid for separately and painting shall be treated as on new work.

3. *Application* —The number of coats to be applied shall be as in the description of item. In the case of C. G. I. sheets, the crowns of the corrugations shall be painted first and when these get dried the general coat shall be given to ensure uniform finish over the entire surface without the crowns showing signs of thinning.

The second or additional coats shall be applied when the previous coat has dried.

4. *Other details.*—The specifications for "Painting (General)" shall hold good so far as they are applicable.

SPECIFICATION No. 66–C.

SPRAY PAINTING WITH FLAT WALL PAINT ON NEW WORK INCLUDING PRIMING COAT.

1. *Materials.*—The priming coat shall consist of "Distempering primer" or "Cement primer" as specified in the description of the item. They shall be of approved brand and manufacture.

The flat wall paint shall be of approved brand and manufacture and of the required shade.

2. *Preparation of the surface for priming coat.*—The surface shall be thoroughly cleaned of dust, old white or colour wash by washing and scrubbing. The surface shall then be allowed to dry for at least 48 hours. It shall then be sand papered to give a smooth and even surface. Any unevenness shall be made good by applying putty, made of plaster of paris, mixed with water on the entire surface including filling up the undulations and then sand papering the same after it is dry

3. *Applicantion.*

3.1. *Primer Coat.*—The specified primer shall be painted or sprayed over the surface in an even and uniform layer.

Note. —Flat wall paint shall normally be applied on walls 12 months after their completion, in which case, Distemper primer will suffice. If the walls are to be painted earlier, the primer coat shall consist of cement primer.

3.2. *Painting Coat* —When the surface is dry, the spray painting with the wall paint in uniform and even layers will be done to the required number of coats. Each coat shall be allowed to dry over night and lightly rubbed with very fine grade of sand paper and loose particles brushed off before the next coat is sprayed.

If after the final coat of wall paints, the surface obtained is not upto the mark, further one or more coats as required shall be given afte rubbing down the surface and dusting off all the loose particles to obtain a smooth and even finish.

If the primer or wall paint gets thickened during the application, it shall be thinned suitably with the thinner recommended by the manufacturer.

Adequate ventilation shall be provided to disperse spray fumes. Fitments and floor shall be protected from the spray.

Other details.—The specifications for "painting (general)" shall hold good as far as applicable.

SPECIFICATION No. 66–D.

SPRAY PAINTING WITH FLAT WALL PAINT ON OLD WORK.

1. *Paint.*—The specification shall be same as in paragraph 13.28.1.

2. *General.*—Where the old paint is in sound condition, renewal shall be carried out as given in para 3 to 5. Otherwise the old paint shall be completely stripped and spray painting shall be carried out as over new work. Such removal shall be paid for separately.

3. *Preparation of surface* —The surface shall be washed to remove dust and dirt. A mild detergent solution like soap water shall be used for washing and the surface shall also be rubbed down lightly with abrasive paper when dry. Any patches appearing on the surface shall first be touched up with a coat of paint. These shall be allowed to dry and then rubbed down lightly.

4. *Painting.*—The paint shall then be applied with spraying machine in uniform and even layer. A second coat shall be applied if considered necessary by the Engineer-in-charge but only after the first coat is complete dry and hard.

5. *Other details.*—The specifications for "Painting (General)" shall hold good as far as they are applicable.

SPECIFICATION No. 66-E.

PAINTING WITH ACID PROOF PAINT.

1. *Paint.*—Acid proof paint of approved brand and manufacture and of the required shade shall be used.

2. *Preparation of surface and application.*—The specifications shall be same as for "Painting with ordinary or superior quality ready mixed paints on new work or old work".

3. *Other details.*—The specifications for "Painting (General)" shall hold good as for as they are applicable.

SPECIFICATION No. 66-F.

PAINTING CAST IRON RAIN WATER, SOIL WASTE AND VENT PIPES AND FITTINGS.

1. Painting cast iron rain water, soil, waste and vent pipes and fittings including priming coat, on new work.

1.1. *Paints.*—(*a*) *Primer.*—The Primer shall be prepared on site or shall be of approved brand and manufacture as specified in the item.

(b) *Paint.*—Paint shall be anti—corrosive, bitumastic paint, aluminium paint or other type of paint as specified in the description of the item.

1.2. *Preparation of surface.*—The surface shall be prepared for priming coat as described in sub-para 2.2. of specification No. 66-B.

1.3. *Application.*—The number of coats of painting over the priming coat shall be as stipulated in the description of the item.

The application of paint over priming coat shall be carried out as per specification for application of the relevant quality of paint in new work.

1.4. *Measurements.*—Measurement will be taken over the finished line of pipe including specials, etc., in running metres, correct to a cm.

Pipes of different diameters of bore shall be measured and paid for separately.

Specials and fitting such as holder-bat clamps, plugs etc. will not be measured separately.

1.5. *Rate.*—The rate shall include the cost of all materials and labour involved in all the operations described above, including painting of all specials and fittings.

1.6. *Other details.*—Specifications for "Painting (General)" shall hold good as far as they are applicable.

2. Painting cast iron rain water, soil, waste and vent pipes and fittings on old work.

2.1. *Paints.*—The specifications for paints shall be the same as in sub-paragraph 1.1. (b).

2.2. *Preparation of surface.*—The surface shall be prepared as for painting with ordinary or superior quality ready mixed paint, on old iron and steel work.

2.3. *Application.*—The specification for painting will be same as for painting with ordinary or superior quality ready mixed paint on old iron and steel work.

2.4. *Measuremets, rate and other details.*—These shall be the same as in corresponding sub-paragraphs 1.4. to 1.6. under new work.

SPECIFICATION No. 66-G.

LETTERING WITH PAINT.

1. *Lettering with paint on new work.*

1.1. *Paints.*—Black Japan paint or ordinary quality ready mixed paint as ordered by the Engineer-in-charge shall be used. The paints whether black Japan or ordinary ready mixed paint, shall be of approved brand and manufacture. Ordinary ready mixed paint shall be of the shade required by the Engineer-in-charge.

1.2. *Lettering.*—The letters and figures shall be to the heights and widths as ordered by the Engineer-in-charge. These shall be stencilled or drawn in pencil and got approved before painting. They shall be of uniform size and finished neatly. The edges shall be straight or in pleasant smooth curves. The thickness of the ettering shall be as approved by the Engineer-in-charge. Lettering shall be vertical or slanting as required.

Two or more coats of paint shall be applied till uniform colour and glossy finish are obtained.

1.3. *Measurements.*—Measurement shall be taken in terms of letters cm (the cm measurement relates to the vertical height of the lettering) The letter heights shall be measured correct to a cm.

Dots, dashes, punctuations and other similar marks or lines shall be measured for payment.

1.4. *Rate.*—Rate shall inlcude the cost of all labour and materials involved in the operations described above. The rate per cm. height of letter shall hold good irrespective of the width of the letters or figures or the thickness of the lettering.

The same rate will apply irrespective of whether black Japan or ordinary ready mixed paint of any shade as required is uesd.

2. *Relettering with paint (on old work)*—

2.1. *Paint.*—Specifications shall be the same as in paragraph 1.1.

2.2. Painting shall be done over the existing letters and shall accurately follow their lines and curves.

One or more coats of paints shall be applied till a uniform colour and glossy finish obtained.

2.3. *Measurements and rate.*—The specifications shall be the same as in the corresponding sub-paragraph 1.3. and 1.4. under new work.

SPECIFICATION No. 67

WOOD OILING.

1. The surface to be wood oiled shall be throughly cleaned as specified in the standard specification "Painting" and be perfectly dry and smooth, and free from dust. Before oiling is started, care shall be taken to see that all knots are killed and all cracks or holes plugged. The knots shall be cut out to a slight depth, and the holes cleaned free from dust and filled in with wood putty which is made as follows.—

On a piece of wood, say about 25 cm. by 15 cm. face, and on the side where cross-grains appear a small quantity of size of glue is gently poured and the surface is scraped with the edge of a fine carpenter's chisel. Very fine wood powder mixed with the glue and a stiff paste formed. After filling in the holes and cracks with this wood putty and when dry, it shall be rubbed down with a carpenter's file and smoothened with sand-paper, so that the knots or holes do not show and the whole surface present an uniform appearance.

2. The wood oil to be used shall be of the best quality and from an approved maker. If the oil is found to be too thick spirits or turpentine shall be added to give the required consistency. The wood oil shall be laid on evenly and properly with brushes of the best quality. Successive coats shall be applied after the previous coats are thoroughly dry and inspected by the officer in-charge. The work after completion shall not be patchy nor stickly to touch. No hair or other material shall be allowed to stick on the wood-oil.

3. Measurement and rate shall be as defined in the standard specification "Painting".

Note.—Wood oiling will only be done for interior wood-work, not exposed to the weather.

SPECIFICATION No. 67-A.

PAINTING WITH WOOD PRESERVATIVE.

1. *Painting 2 coats with wood preservative on new work.*

1.1. Oil type wood preservative of specified quality and approved make, conforming to IS : 218—1952 shall be used.

1.2. *Preparation of surface.*—Painting shall be done only when the surface is perfectly dry to permit of good absorption. All dirt, dust or other foreign matter shall be removed from the surface to be painted. All roughness shall be sand papered and cleaned.

1.3. *Application.*—The preservative shall be applied liberally with a stout brush and not daubed with rags or cotton waste. It shall be applied with a pencil brush at the joints of the wood work. The first coat shall be allowed at least 24 hours to soak in before the second (the final) coat is applied. The second coat shall be applied in the same manner as the first coat. The excess of preservative which does not soak into the wood shall be wiped off with a clean dry piece of cloth.

1.4. *Other details.*—The specifications for "Painting (General)" shall hold good in so far as they are applicable.

2. Painting one coat with wood preservative on old work–The work shall be done in the same manner as for new, except that only one coat shall be done.

SPECIFICATION No. 68.

TARRING WITH COAL-TAR.

Specifications for crude coal tar laid down in IS : 212/61 shall also apply.

1. For coal-tarring wood or iron work, the surface being well-cleaned, coal-tar shall be heated, not quite to the boiling point, thinned by the addition of 1 litre of common kerosene oil to 18 litres or 24 bottles of tar, and while still very hot, applied like paint with a brush. When possible to remove iron work for the purpose, it shall be heated to nearly a red heat and then painted with coal-tar. Iron - work, which cannot be heated shall be painted with hot tar and kerosene oil as specified above. The second coat shall be applied only after the first is dry.

No streaky patches of tar shall be visible on the surface after finish.

2. One kilogram of unslaked lime mixed with 4.5 litres coal-tar will prevent its running and shall be used unless otherwise specified.

3. Measurement and rate shall be as defined in IS : 1200 (Part XV)/ 1968. Scrapping and cleaning will be included in the tarring rate if so specified, or a separate schedule items will be provided as may be defined in the schedule items.

SPECIFICATION No. 69.

RECEIPT NO. 1. STANDARD TAR PAINTING.

1. Receipt No. 1 gives a thick elastic coating suitable for anicut shut ters, sluice shutters and inside of punts, and other work, where a slight stickiness is immaterial.

Materials.

36 Litres of coal tar.
4 kilograms of freshly slaked lime.
5 kilograms of pitch.
5 litres of kerosene lamp oil.

2. *Preparation and application* :—Thoroughly boil the first three ingredients together for not less than 15 minutes mere warming is not sufficient, the mixture must be actually boiled. Then add the kerosene oil (after removing the pot from the fire), and thoroughly mix all ingredients together, and apply as hot as possible with long handled brushes. Small brushes made of beaten out palmyra leaf stalks can be used for getting into awkward corners and crevices, and are cheap. The painting should be done late in the morning or after midday when the iron work has become heated up, in the sun and on no account should any paint be applied on a rainy or even cloudy day.

3. Coal-tar varies some what in its consistency, and if a thick quantity happens to have been supplied, the mixture may be made thinner by either slightly reducing the amount of pitch or by increasing the proportion of kerosene oil. The former alternative is preferable.

4. *Covering capacity* - About 2 kgs. and 3 kgs. of this mixture are required for single and double coats for 10 sq. metres respectively

5. Clause 3 of the standard specification for "Tarring with coal tar" applies also to this specification.

6. It is essential that the surface to be painted is quite clean and free from rust, blistered paint etc.

SPECIFICATION No. 70.

VARNISHING.

Specfications for varnish laid down in IS: 337/52, IS; 338/52, IS: 340/52, IS: 343/52, IS: 347/52 shall apply.

Specifications for varnishings laid down in IS: 2338 (Part I/1968) shall apply.

Method of measurement laid down in IS: 2200 Part XV/68 shall apply.

SPECIFICATION No. 70-A.

FRENCH SPIRIT POLISHING.

1. *French spirit polishiug on old work.*

1·1. *Polish.*—Pure shellac varying from pale orange to lemon yellow colour, free from resin or dirt shall be dissolved in methylated spirit at the rate of 150 gm. of shellac to 1 litre of spirit. Suitable pigment shall be added to get the required shade.

1·2. *Preparation of surface* .—If the old polished surface is not much soiled, it shall be cleaned of grease and dirt by rubbing with turpentine and then rubbed with fine sand paper.

If the old polished surface is much soiled then it will be necessary to remove the entire polish as described in para 13·42 of CPWD specification and such removal shall be paid for separately outside the rate of polishing. Further the polishing itself will have to be done like new work and will be paid for as such.

1·3. *Application* .—The number of coats of polish to be applied shall be as described in the item.

A pad of woollen cloth covered by a fine cloth shall be used to apply the polish. The pad shall be moistened with the polish and rubbed hard on the wood in a series of overlapping circles applying the mixture sparingly but uniformly over the entire area to give an even level surface. A trace of linseed oil on the face of the pad facilitates this operation. The surface shall be allowed to dry and the remaining coats applied in the same way. To finish off, the pad shall be covered with a fresh piece of clean fine cotton cloth slightly damped with methylated spirit and rubbed lightly and quickly with circular motions. The finished surface shall have a uniform texture and high gloss.

1·4. *Measurements, rate and other details* .—These will be as for "Painting (General)" as far as they are applicable.

SPECIFICATION No. 71.

WAXING.

1. The surface shall be prepared as described in the Standard Specification "Varnishing", except that glue size application is not necessary. Stopping of all cracks and hole shall be done with a mixture of fine saw dust formed of the wood being treated, beaten up with sufficient beewax to give it coherence.

2. Waxing is to be done as follows :—

Take of — Beewax — 1 kg.
Turpentine — 0·5 kg.

Melt the wax and when it is thoroughly melted, add it to the turpentine and mix well and allow it to cool. Smear the wood work with this and allow it to remain over-night so as to soak into the pores of the wood. Then in the morning wipe the superfluous wax off and rub up with a soft flannel to a fine polish.

3. Measurement and rate shall be defined as in the standard specification "Painting".

NOTE.—As a rule, French polishing is better than wax polishing which latter will ordinarily only be done for carved work. French polishing requires to be done by skilled labour to be satisfactory.

SPECIFICATION No. 71-A.

BEES WAXING OR POLISHING WITH READY-MADE WAX POLISH.

1. *Bees waxing or polishing with ready-made wax polish on new work* :

1·1. *Materials* : The polishing shall be done with bees waxing prepared locally or with ready-made wax polish of approved brand and manufacture, as stipulated in the description of item.

(*a*) Where bees waxing is to be prepared locally, the following specifications for the same shall apply :—

Pure bees wax free from paraffin or streaine adulterants shall be used. Its specific gravity shall be 0·965 to 0·969 and melting point shall be 63° C.

The polish shall be prepared from a mixture of bees wax linseed oil, turpentine and varnish in the ratio of 2:1½:1:½ by weight

The bees wax and boiled linseed oil shall be heated over a slow fire. When the wax is completely dissolved, the mixture shall be cooled till it is just warm and turpentine and varnish added to it in the required proportions and the entire mixture shall be well stirred.

1·2. *Preparation of surface* :—Preparation of surface will be as for "varnishing" with the exception that knots holes and cracks shall be topped with a mixture of fine saw dust formed of the wood being treated, beaten up with sufficient bees wax to give it cohesion.

1·3. *Application* .—The polish shall be applied evenly with a clean soft pad of cotton cloth in such a way that the surface is completely and fully recovered. The surface is then rubbed continuously for half an hour.

When the surface is quite dry, a second coat shall be applied in the same manner and rubbed continuously for one hour or until the surface is dry.

The final coat shall then be applied and rubbed for two hours (more if necessary) until the surface has assumed a uniform gloss and is dry, showing no sign of stickiness.

The final polish depends largely on the amount of rubbing which should be continuous and with uniform pressure, with frequent changes in the direction.

1·4. *Other details* :—The specifications for "Painting (General)" shall hold good as far as they are applicable.

2. *Bees waxing or polishing with ready-made wax polish on old work*.

2·1. *Materials* :—These will be as specified for new work in sub-paragraph 1·1.

2·2. *Preparation of surface*.—The wood work shall be cleaned of all smoke and grease by washing with lime water. The surface shall then be washed with soap and completely dried. Then it shall be prepared smooth with a carpenter's plane.

2·3. *Application*.--The polish shall be applied in the same manner as in paragraph 13·39. 1·3 for the final coat on new work. In this case one or two coats shall be applied as necessary to get uniform gloss, instead of three coats in the case of new work.

2·4. *Other details*.—The specification for "Painting (General)" shall hold good as far as they are applicable.

Notes and Recipes.

1. *Bases of paints*.—The base of all lead paints is either white or red lead. The former is a carbonate of lead, latter an oxide of lead. White lead paints are not suitable for delicate work as the lead becomes discoloured. White lead is, however, dense, of good body and permanent and is perhaps the base most largely used. It is obtainable in the market either dry or ground in oil. White lead is frequently adulterated with sulphate of baryta, whiting, etc. The presence of sulphate of baryta can be detected by the addition of nitric acid which will dissolve the lead but not the baryta.

Red lead is very largely used for painting ironwork, for the priming cost of wood work, and also as a drier. It is sometimes adulterated with brick-dust the presence of which may be detected by beating in a crucible, and treating with dilute nitric acid. The lead will be dissolved and the brick-dust will remain.

Oxide of zinc or zinc white is the base of most zinc paints. It has the advantage over leadpaints that it is not liable to discolouration by sulphur, but it has the disadvantage that it has less body than white lead, is difficult to work, and is less durable, Lead driers should not be used with zinc paint.

Oxide of iron forms the base of an important class of paints. The tints obtainable vary from yellowish brown to black.

2. *Linseed oil*.—Specifications for raw and boiled linseed oils covered by IS. 75/67 and 77/50 shall apply.

3. *Spirits of turpentine*.—Specifications for spirits of turpentine covered by IS. 533/1954 shall apply.

4. *Hard Stopping*.—Specifications for fillers covered by IS: 110/196 shall apply.

5. (*a*) *Priming coat for galvanized iron.* Specifications for painting of ferrous metals covered by IS: 1477/Part I and II/1971 shall apply.

(*b*) *Priming coat on portland cement.*—Specifications for painting plaster surfaces covered by IS: 2395 Part I/66 and IS: 2395 Part II /67shall apply.

6. *Recipes.* —The following make good varnishes.—

(*a*) Resin	2 Parts	By weight.
Linseed oil	2 Parts for common works.	
Copal	1 Part	
(*b*) Copal	3 Parts	By weight.
Oil of Turpentine	5 Parts	
Linseed oil	2 Parts	
(*c*) Amin resin	800 G	
Litharge	25 g.	
Sugar of lead	25g.	
Spirit of turpentine	5·5 litres or 4·75 kg.	
Linseed oil	2 litres or 1·86 kg.	
(*d*) Pale Shellac	7·5 Parts	By weight.
Mastic	6·5 Parts	
Spirits of wine	10 Parts.	

Varnish for iron-work and outdoor work. A ready mixed carriage varnish of approved make will usually be specified. *Another recipe is*: Dissolve in about 1 kg. of tar oil, 0·25 kg. of asphaltum and an equal quality of pounded resin mix hot in an iron kettle, taking care to prevent contact with flame when cold, use.

Varnish for common work. Take 1 kg. of lamp resin and powder it, place it in a can and add 1 litre of spirit of turpentine, shake well and let it stand, with occasional shaking, for a day or two. Then add 4 litres of boiled linseed oil, shake well together and allow it to stand in a warm room till clear. Decant clear portion and use, or reduce with spirit of turpentine until of the proper consistency. This varnish is intended for protecting surface exposed to the weather. It has been used with advantage for coating wood and iron work.

The preparation of varnishes is a difficult job and it is better to purchase varnishes ready prepared.

Recipe for French polish.—A good French Polish, suitable for the Indian climate, can be made with the following ingredients Dissolve in 8 litres methylated spirit the following;—

Shellac black	1·2 kg.
Olibanum	200 gm.
Gamboge	200 gm.
Copal	200 gm.
Gum benzoin	200 gm.

The gums are crushed small and added to the spirit and mixture is agitated until the gums are dissolved. Immersing the vessel containing the mixture in a warm bath aids the operation.

Recipe for oil coating for wood work.—The following mixture forms a good oil coating for wood work.—

1·2 kg. double-boiled linseed oil.
400 gm. Turpentine.
400 gm. bees-wax.

The oil and the wax are to be heated in a vessel over a slow fire till the wax is melted and after the mixture has cooled, turpentine is to be added and the mixture then applied in two coats.

Sweet oiling. —Mix equal parts of common vinegar, country sweet oil and turpentine. (This gives a darker effect than linseed oiling.)

466-3—55

Recipe for polishing teak.—To polish teak without destroying the natural colour of the wood, add one part of boiled linseed oil, followed by one part of turpentine, to two parts of bees-wax warmed to a thin liquid, and then apply while still warm with a clean cloth half an hour. When the surface is dry, apply a second coat in the same manner and rub for an hour, taking care to frequently change to the direction of the rubbing. Finally, apply a third coat which should be similarly rubbed for two hours until the surface has assumed an unifrm gloss and is quite dry, showing no signs of stickiness when touched. The final finish largely depends on the amount of rubbing but too much stress cannot be laid on the importance of having the surface to be polished, absolutely smooth and even, before applying the first coat, so that no roughness is apparent on rubbing with bare hand. Unless this precaution is taken the result will be an uneven gloss, altogether discounting the natural beauty of the teakwood, which no amount of subsequent polishing will remove.

A darker colour can be obtained by applying the same mixture and rubbing well into the surface of the wood for five minutes. Then having removed any of the mixture, remaining on the surface, apply French Polish with a pad consisting of cotton wool inside a clean white cloth, and rub in till the wood is quite dry. Care must be taken to renew the cloth should it show any sign of wearing, else the cotton wool will stick to the surface and give trouble, while occassionally moistening the pad with raw linseed oil will be found advantageous. The surface should then be carefully sand-papered to remove any small irregularities. If the sand-paper is moistened with linseed oil- and one piece is then rubbed on another for a few seconds, it will, prevent the wood being scratched. A final coat of French polish applied as before, and thoroughly rubbed until the wood feels perfectly dry when touched, should give a satisfactory finish.

7. *Schedule wording.*—The following typical schedule wording describes the operations to be done for the schedule contract rate per 10 sq. metres of the painting item.—

(2) ***For new wood work.***—Clean, knot, rub down, give priming coat, top and then apply.

One or two or three } coats.

Ready mixed paint pigment, ground, in oil.

Labour and materials complete*, executed in accordance with standard specification No. 66.

For old painted wood-work and iron work it should be defined in the schedule item wording if the rate is to* include removal of old paint.

* Note should be made of the place and price at which the print, oil and other ingredicts will be supplied in the cases described in the note to elause I (a) standard specification for printing".

EXTRACT FROM I. S. 75—1967.

Specification for linseed oil raw and refined

I. Scope.

1.1. This standard prescribes the requirements and the methods of sampling and test for linseed oil.

2.1.1. *Alkali—refined or semi-refined linseed oil.*—Linseed Oil which has been refined by neutralization with alkali and bleached with bleaching earth or activated carbon or both no other chemical agents being used. The oil may also be treated with mineral aci prior to alkali refindìng.

2.1.2. *Acid—refined linseed oil.*—Linseed oil which has been refined using mineral acid and bleached with bleaching earth or activated carbon or both.

3. *Types and grades.*—The material shall be of two types, expressed and solvent extracted with grades as given below :—

(*a*) *Expressed.*—

(i) Alkali refined;

(ii) Acid refined;

(iii) Raw grade 1; and

(iv) Raw grade 2.

(*b*) *Solvent—extracted.*—

(i) Semi-refined; and

(ii) Raw.

3.1.1. Of these, the Alkali refined grade and the Raw Grade 1 of the expressed type are suitable for edible use.

NOTE.—Although the Alkali-refined and the semi-refined grades are equivalent, the latter is not considered suitable for direct edible consumption.

4. *Requirements.*

4.1. *Description* :—The material shall be obtained from good quality linseed cake by solvent—extraction or from clean and sound linseed from linum usitatissimum linn, fam. Linaceae by a process of expression, or solvent extraction.

4.2. The material shall be clear and free from rancidity, adulterants, sediment, suspended and other foreign matter, separated water and added colouring and flavouring substances.

4.2.1. The clarity of the material shall be judged by the absence of turbidity after keeping the filtered sample at 30°C for 24 hours.

EXTRACT FROM I.S. 77—1950.

Specification for linseed oil, boiled for paints.

1. *Scope.*

2.2. This standard prescribes the requirements and the methods of test for the material commercially known as linseed oil, boiled, for paints. The material is used as a drying oil.

4. *Requirements.*

4.1. *Description* :—The material shall be prepared from genuine linseed oil and necessary driers. It shall be clear and free from sediment and other insoluble matter.

4.2. *Colour* :—The colour of the material, when examined through a 0.25 in (or 6.35 mm) all glass cell in a standard lovibond tintometer, shall be not deeper than a combination of 10 yellow units and 11 red units.

Alternatively, when tested in a suitable colorimeter, the materia shall be not darker than a freshly prepared soultion of 2.220 g. of chemically pure potassium dichromate dissolved in 100 ml. of concentrated sulphuric acid (sp. gr. 1.84).

4.3. *Freedom from rosin* :—The material shall show no positive reaction for rosin when tested as prescribed under 23 of IS : 74—1950.

4.5. When lead free material is required, it shall contain not more than 0.05 percent of lead or compounds of lead (calculated as metallic lead) when tested as prescribed under 22 of IS : 74—1950).

EXTRACT FROM I.S. 78—1950.

Specification for linseed oil, pale boiled, for paints.

1. *Scope.*

1.1. This standard prescribes the requirements and the methods of test for the material commercially known as Linseed Oil, pale boiled, for paints. The material is used as a drying oil.

4. *Requirements.*

4.1. *Description* :—The material shall be prepared from genuine linseed oil and necessary driers. It shall be clear and free from sediment and other insoluble matter.

4.2. *Colour*.—The colour of the material, when examined through a 0.25 in (or 6.35 mm.) all glass cell in a standard Lovibond Tintometer, shall be not deeper than a combination of 10 yellow units and 2 red units.

Alternatively, when tested by a suitable colorimeter, the material shall be not darker than a freshly prepared solution of 0.38 g. of chemically pure potassium dichromate dissolved in 100 ml. of con centrated sulphuric acid (sp. gr. 1.84).

4.3. *Drying time*.—The oil shall be surface dry in not more than 18 hours when tested as prescribed under 15 of IS : 74—1950.

4.4. *Freedom from rosin*.—The oil shall show no positive reaction for rosin when tested as prescribed under 23 of IS : 74—1950.

4.6. When lead-free material is required, it shall contain not more than 0.05 percent of lead or compounds of lead (calculated as metallic lead) when tested as prescribed under 22 of IS : 74—1950

EXTRACT FROM I.S. 86—1950.

Specification for oil paste for paints, to Indian standard colours.

1. *Scope.*

1.1. This standard prescribes the requirements and the methods of test for the material commercially known as Oil Paste for Paints with the distinctive colours as specified in the title. The material is normally used for making ready mixed paints.

4.3. *Form and condition* :

4.3.1. The material shall be supplied in the form of a smooth. homogeneous paste. When thoroughly mixed and taken on a spatula, it shall not flow in a continuous stream when the spatula is held in a vertical position.

4.3.2. The material shall be in such a condition that stirring with an appropriate quantity of a mixture of three parts by volume of linseed oil boiled (IS : 77—1950), or linseed oil, pale boiled (IS : 78—1950), and one part by volume of white spirit (IS : 84—1950)i easily produces a uniform paint suitable for application by brushes

4.4. The material shall also comply with the requirements in Table 1.

TABLE 1. REQUIREMENTS FOR OIL PAINTS WITH THE DISTINCTIVE COLOURS AS SPECIFIED IN THE TITLE.

(*Clause* 4.4.)

Serial number and characteristics.	*Requirement.*	*Reference to IS : 85—1950*
(1)	(2)	(3)
1. Finish	- Smooth with oil gloss ..	6
2. Colour	Close match to the specified IS colour.	8
3. Residue on sieve..	Not more than 0.5 percent ..	9
4. Water content ..	Note more than 0.5 percent	10
5. Keeping properties	Not less than one year from the date of manufacture.	13
6. Marking and delivery	As agreed with the purchaser, but each package to be marked "Lead Paint".	14

EXTRACT FROM I.S. 110—1968.

Specification for Ready mixed paint, brushing, grey filler, for enamels. for use over primers.

TABLE 1. REQUIREMENTS FOR READY MIXED PAINT BRUSHING GREY FILLER FOR ENAMELS FOR USE OVFR PRIMERS.

(*Clause* 3.4.)

	Serial number and characteristic.	*Requirements.*	*Method of test (ref. to CL No. in IS. 101-1964)*
	(1)	(2)	(3)
(i)	Drying time, hard dry	Not more than 12 hours	7.1. & 7.2
(ii)	Consistency	Smooth and uniform and suitable for brushing.	7.4
(iii)	Finish	Smooth and matt to semiglossy.	7.5
(iv)	Colour	Grey	11
(v)	Residue on sieve, percent by weight max.	2.0	13
(vi)	Flexibility, and adhesion (after 48 hours air-drying).	No visible damage or detachment of films.	16
(vii)	Flash point ..	Not below 30° C. ..	24
(viii)	Keeping properties.	Not less than six months.	31

4.2.1 The containers may also be marked with the ISI Certification mark.

466-3—55A

APPENDIX A.

(*Clause* 3.2.)

DETERMINATION OF FLATTENING PROPFRTIES.

A.1. *Procedure—*

A.1.1. Brush on a mild steel panel 150 ×150 ×0.800 mm., in size, a coat of the material over a coat of primer and allow it to air-dry for 12 hours under laboratory drying conditions treat the approved sample in the same manner and at the same time. Subject both surface to facing and rubbing and then compare the sample undertest with the approved sample tested in the same manner and at the same time.

A.1.2. The material when so compared shall not be inferior to the approved sample.

APPENDIX B.

(*Clause* 3.3.)

B.O. *General—*

B. 0.1. *Outline of the method.*-The grey filler is applied, over suitable primer, on one half of a metal panel. This after wet rubbing and allowing to dry is overcoated with a film of synthetic enamel. The gloss of the enamel film on the filler coated portion is compared with the gloss on the other half.

B.1. *Procedure—*

B.1. 1. A metal panel 0·C630 to 0.800 mm. thick and 300 X 150mm in size is cleaned, degreased and derusted as prescribed in 5.2.of I.S. : 101—1964.

B.1.2. Apply the coat of primer (conforming to IS: 3538—1966 or IS 2077—1962 @ and allow to dry over night. Then apply the material uniformly to one half of the panel. Allow this to dry for 16 hr. Apply one more coat of the meterial as above and allow to dry for another 16hr. The dry film thickness of the two coats of the materials shall be 40 to 50 microns.

Wet rub the film with emery paper No. 280 and wipe off. Allow this to dry for one hour. Overcoat this with synthetic enamel (conforming to IS: 2932—1964 on the entire panel coated with filler as well as uncoated.

B.1.3. *Reports.*—Examine the gloss of the enamel film on the filler coated portion visually with that of the other half. The gloss of the filler coated portion shall not be inferior to the other half when thus examined.

B.1.3.1. Alternatively, if agreed to between the purchaser and the supplier, the gloss of filler coated portion shall also be examined instrumentally and shall not be less than 80 per cent of the gloss, when compared to the other half. In case of dispute, the results of instrumental examination of gloss shall be accpeted.

EXTRACT FROM I.S. 212—1961

Specification for crude coaltar for general use.

3.0. *Requirements—*

3.1. *Composition.*—Crude coal tar shall be the genuine product of destructive distillation of coal, free from adulteratants. The composition of the material shall be the subject of agreement between the purchaser and the vendor.

3.2. *Water*. —Water contents of crude coal tar shall not be in excess of five per cent by weight and shall be determined as described in I. S. 1211—1958, Methods for testing Tar and Bitumen; Determination of water content (Dean and Stark method)

3.3. *Mineral matter* (*Ash*).—The mineral matter in crude coal tar shall not leave on incineration, ash in excess of one persent by weight of moisture free tar, on the weight of moisture—free tar, determined as described in IS: 1217—1958 Methods for testing tar and Bitumen : Determination of Mineral matter (ash).

EXTRACT FROM I.S. 337—1975.

Specification for varnish, finishing interior.

TABLE I.—REQUIREMENTS FOR VARNISH FINISHING INTERIOR.

(*Clause* 4.3.)

Serial number and characteristic.	Requirement.	Method of (Ref. to Cl. No in IS 197—1969) *
(1)	(2)	(3)
( ) Drying time max:		7.2
(*a*) Surface dry	6 hours.	
(?) Hard dry.	18 hours.	
(*c*) Task free ..	24 hours.	
(ii) Finish	Smooth and glossy ..	8
(iii) Colour	Not darker than a combination of 41 yellow units and 10 red units.	9
(iv) Scratch hardness. (on mechanical tester).	No such scratch as to show the bare metal.	10
(v) Flexibility and adhesion.	Not visible damage or detachment of film.	11 Method 1.
vi) Stripping test ..	Scratches free from jagged edges.	12
(vii) Flash point, min.	30°.	13
(viii) Volatile matter content percent by mass work.	50. 0	15
(ix) Viscosity in stokes	1.0 to 2.0	17
(x) Acid value, max.	15.0	18
(xi) Keeping properties.	Not less than one year from the date of manufacture.	20

*Method of sampling and test for varnishes and lacquers (first revision).

EXTRACT FROM I.S. 338—1952.

Specification for Varnish, under coating, exterior, natural resin.

4. *Requirements.*

4·1. *Description.*—The materials shall be clear and transparent and free from foreign matter, sediment and undissolved water.

4·2. *Composition.*—The material shall be based on natural resins drying oils, driers and thinners in suitable proportions to satisfy the requirements of this standard.

4·3. The material shall also comply with the requirements in Table I.

TABLE I: REQUIREMENTS FOR VARNISH UNDERCOATING EXTERIOR NATURAL RESIN.

(*Clause* 4·3.)

Serial number and characteristic	Requirements.	Reference to column number in IS: 197-1969.
(1)	(2)	(3)
(i) Drying time max:—		7·2
(a) Surface dry ..	8 hours	
(b) Hard dry ..	18 hours	
(ii) Finish	Smooth and glossy ..	8
(iii) Colour	Not darker than a combination of 41 yellow units and 10 red units.	9
(iv) Flexibility and adhesion	No visible damage or detachment of film	11 method 1
(v) Stripping test	Scratches free from Jagged edges.	12
(vi) Flash point min. ..	35·0°C(or 95·0°F) ..	13
(vii) Volatile matter content, percent by weight, max.	50·0	14
(viii) Viscosity at 30·0°C	Not less than 1·50stockes and not more than 2·50 stokes.	16
(ix) Acid value, max. ..	25·0	17
(x) Keeping properties ..	Not less than one year from the date of manufacture.	19
(xi) Marking and delivery	As agreed between the purchaser and the vendor.	20

EXTRACT FROM I.S. 340—1952.

Specification for varnish, mixing.

4 *Requirements.*

4·1. *Description*:—The material shall be clear and transparent and free from foreign matter, sediment and undissolved water.

4·2. *Composition* :—The material shall be based on resins, drying oils, driers and thinners in suitable proportions to satisfy the requirements of this standard.

4·3. The material shall become hard dry and attain a condition suitable for flatting with pumice powder and water in not less than 6 hours and not more than 10 hours, when tested according to the method prescribed in Appendix A.

4·4. The material shall mix satisfactorily in all proportions with linseed oil, raw (IS 75—1950) or linseed oil, boiled (IS: 77—1950) or stand oil (IS: 79—1950) or a mixture of any two or all of these oils.

4·5. The materials shall show no sign of fattening when tested as prescribed in Appendix B

4·6. The material shall also comply with the requirements in Table I.

TABLE I. REQUIRMENTS FOR VARNISH : MIXING.

(*Clause* 4·6)

Serial number and Characteristic.	*Requirements.*	*Reference to Column number in IS: 197—1969*
(1)	(2)	(3)
(i) Finish	Smooth and glossy ..	8
(ii) Colour	Not darker than a combination of 41 yellow units and 10 red units.	9
(iii) Flexibility and adhesion.	No visible damage or detachment of film obtained by dipping.	11 method I.
(iv) Stripping test ..	Scratches free from Jagged edges.	12
(v) Flash point min. ..	35·0°C (or 95·0°F) ..	13
(vi) Volatile matter content, percent by weight max,	40·0	14
(vii) Viscosity at 30°C	Not less than 1·50 stokes and not more than 2·50 stokes.	16
(viii) Acid value, max.	15·0	17
(ix) Keeping properties	Not less than one year from the date of manufacture	19
(x) Marking and delivery	As agreed between the purchaser and the vendor.	20

EXTRACT FROM I.S.: 347—1952.

Specification for Varnish, shellac, for general purposes.

4. *Requirements*.

4·1. *Description.* The material shall be free from foreign matter and visible impurities.

4·2. *Composition.*—The materials shall contain 40±2 percent by weight of shellac (IS: 16—1949) dissolved in denatured spirit (IS; 324—1952).

4·3. *Iodine value.*—The iodine value of the residue obtained from the material after evaportion at 40° C. under vacum shall be not more than 20° C.

4·3·1. The iodine value shall be determined as prescribed under appendix GII. of IS: 16—1949.

4·4. *Colour Index.*—The colour index of the material shall not exceed 18·0.

4·4·1. The colour index shall be determined as prescribed under appendix D of IS : 16—1949, with the following modification for 2·3 of that Appendix.

" 2·3. *Shellac solutions* .—Weight accurately a quantity of the material equivalent to 10·0 g of dry shellac and dilute to 100 ml. with cold 95 per cent (by volume) ethylalcohol (IS: 321—1952).Filter the solution in an ordinary funnel using a medium grade filter paper Discard the first 15 ml. of the filtrate and then collect 5 ml. or more of the clear filterate for the test ".

5. *Tests.*—

5·1. Unless specified otherwise, tests shall be conducted as prescribed in IS : 197—1969. References to the relevant clause of the standard are given in column (4) of Table I.

TABLE I. REQUIREMENTS FOR VARNISH, SHELLAC, FOR GENERAL PURPOSES.

(*Clause* 4.5.)

	Serial number and characteristic.	*Requirements.*	*Reference to column number in I.S. 197-1969*
	(1)	(2)	(3)
(i)	Drying item, max :		7·2
	(*a*) Hard dry .	2 hours.	
(ii)	Finish . . .	Smooth and glossy .	8
(iii)	Ash content, percent by weight, max.	0·50	15
(iv)	Freedom from resin	Shall show no positive reaction when subject to liebermann storch or Halphen Hicks test.	18
(v)	Keeping properties	Not less than one year from the date of manufacture in stoneware or glass containers.	19
(vi)	Marking and delivery.	As agreed between the purchaser and the vendor, but each container shall be marked " Highly inflamable."	20

EXTRACT FROM I.S. 533—1954.

Specification for gum sprit of turpentine. (*Oil of turpentine*).

3. *Grades*.

3.1. The material shall be classified into two grades, namely Grade 1 and Grade 2.

3.1.1. Grade 1 of gum spirit of turpentine is intended for use in all dispensing where the material is required for internal use, and in perfumery.

5. *Requirements*.

5.1. *Source.*—The material shall be genuine distillation product of the oleo-resin of pinus roxburghil sargent and allied pinus species.

5.2. *Description.*—The material shall be a clear, limpid, transparent liquid, with a pungent and somewhat bitter taste, and free from sediment, suspended matter, separated water and added adulterants.

5.2.1. The charteristic odour and taste of the material becomes stronger and less pleasant as the oil ages or is exposed to air.

5.3. *Grease spot test.*—Three drops of gum spirit of turpentine when successively evaporated from the same spot of an unsized paper shall leave no grease stain, thus showing the absence of fixed oils

EXTRACT FROM I.S. 1200 (PART XV.) 1968.

Method of measurement of building and civil engineering works.

PART XV—Painting.

3. *Measurement*,

3.1. Painting, except where otherwise stated, shall be measured in square metres.

3.1.1. No deduction shall be made for openings not exceeding $0{\cdot}5m^2$ each, and no addition shall be made for painting to beading moulding, edges, jambs, soffits, sills, etc., of such openings.

3.2. In case of shop fabricated structural steel and iron work, shop paint shall be included in fabrication. Site paint shall be measured separately on the basis of the weight of steel work and iron work or in square metres as need be.

NOTE.—No addition shall be made to the weight calculated for the purpose of measurement of steel and iron work for the paint applied either in shop or at site.

3.3. Painting up to 10 cm. width or in girth and not in conjuction with similar painted work shall be measured in running metres and shall include cutting to line where so required.

3.3.1. Cutting to line, where not included in the item, shall be measured separately in running metres.

3.4. Small articles upto $0{\cdot}1\ m^2$ of painted surfaces, where not in conjunction with similar painted work, shall be enumerated.

3.5. Painting on different types of work shall be kept separate and the surface to be painted shall be described. It shall be stated whether the measurements are flat or girthed. Alternatively, different surfaces may be gouped into one general item, areas of uneven surfaces being converted into equivalent plain areas in accordance with Table I·

3.6. Corrugated sheet surface and Nainital pattern roof surface shall be included with plain surfaces after increasing the areas by the following percentages :

	Per cent.
(*a*) Corrugated sheets	14
(*b*) Nainital pattern roof (plain sheets with rolls) ..	10
(*c*) Nainital pattern roof with corrugated sheets ..	25
(*d*) Asbestos cement sheets, corrugated	20
(*e*) Asbestos cement sheets, semi-corrugated	10

3.7. Painting on caves—gutters, rain water pipes, soil and ventilating pipes and steel poles shall be measured in running metres stating the size or girth,. Fittings, such as bends, shoes, branches, heads etc., shall be included in the length.

3.8. Painting on small articles, such as gate and turn straps metal ceiling roses, metal switch-blocks, heads and nuts of bolts, articles of builder's hardware and the like when picked out in a different tint or not in conjuction with similar painted work shall be enumerated.

3.9. Flag staffs, chimneys, aerial masts (not latticed), water tank flood light towers, over-head electric mast, spires and the like requiring special scaffolding shall be measured separately stating the size, height and average girth.

3.10. Painting in repair work upto one square metre shall be enumarated in the following categories :—

(*a*) Upto 0·1 sq.m.

(*b*) 0·1 to 0·5· sq. m. ; and

(*c*) 0·5 to 1 sq.m.

NOTE. Areas exceeding 1 square metre shall be measured as in 2·5.

TABLE 1. EQUIVALENT PLAIN AREAS OF UNEVEN SURFACES.

(*Clause* 3.5.)

Serial number and Description of work.		*How measued.*	*Multipying factor.*
	(1)	(2)	(3)
1.	Panelled or framed and braced or ledged and battened or ledged battened and braced joinery.	Measured flat (not girthed) including *CHOWKHAT* or frame. Edges, chocks, cleats, etc. shall be deemed to be included in the item.	1·30 (for each side).
2.	Flush joinery ..	Measured flat (not girthed) including *CHOWKHAT* or frame. Edges chocks, cleats, etc., shall be deemed to be included in the item.	1·20 (for each side).
3.	Fully glazed or gauzed joinery.	Measured flat (not girthed) including *CHOWKHAT* or frame. Edges, chocks, cleats, etc., shall be deemed to be included inthe item.	0·80 (for each side).
4.	Partly panelled and partly glazed or gauzed joinery.	Measured flat (not girthed) including *CHOWKHAT* or frame. Edges, chocks, cleates, etc., shall be deemed to be included in the item.	1 (for each side.)
5.	Fully venetioned or louvred joinery.	Measured flat (not girthed) including *CHOWKHAT* or frames. Edges, chocks, cleats, etc., shall be deemed to be included in the item.	1·80 (for each side.)
6.	Weather boarding ..	Measured flat (no girthed) supporting frame-work shall not be measured separately.	1·20 (for each side.)
7.	Wood shingle roofiing.	Measured flat (not girthed).	1·10 for each side.

Serial number and Description of work. (1)	How measured. (2)	Multiplying factor. (3)
8. Boarding with cover fillets and match boarding.	Measured flat (not girthed).	1.05 (for each side).
9. Tile and slate battening.	Measured flat overall; no deduction shall be made for open spaces.	0.80 (for painting all over.
10. Trellis (or Jaffri) work one-way or two-way.	Measured flat overall; no deduction shall be made for open spaces ; supporting members shall not be measured separately.	2 (for painting all over).
11. Guard bars, balustrades, gates, gratings, grills expanded metal and railngs.	Do.	1 (for painting all over.)
12. Gates and open palisade fencing including standards, braces, rails, stays, etc.	Measured flat overall; no deduction shall be made for open spaces; supporting members shall not be measured separately. (See Note)	1 (for painting all over).
13. Carved or enriched work	Measured flat..	2. (for each side.)
14. Steel roller shutters ..	Measured flat (size of opening) overall jamb guides bottom rails and locking arrangements, etc., shall be included in the item (top cover shall be measured separately).	1.10 (for each side).
15. Plain sheet, steel doors and windows.	Measured flat (not girthed) including frame edges, etc.	1.10 (for each side).
16. Fully glazed or gauzed steel doors and windows.	Do.	0.50 (for each side).
17. Partly panelled and partly glazed or gauzed steel doors.	Do.	0.80 (for each side).
18. Collapsible gate ..	Measured flat (Size of opening).	1.50 (for painting all over).

NOTE.—The height shall be taken from the bottom of the lowest rail, if the palisades do not go below it (or from the lower end of palisades, if they project below the lowest rail) up to the top of palisades, but not upto the top of standards, if they are higher than the palisades.

EXTRACT FROM *I. S.* 1477 (*Part* 1) 1971

Code of practice for painting of ferrous metals in buildings and allied finishes.

PART I – Pretreatment.

5. *Surface preparation and pre-treatment.*

5.1. Pre-treatment and priming of ferrous metals under-controlled conditions of the factory gives the best results and it is therefore advisable to adopt this method whenever possible. The object of such treatment is to preserve and maintain the metal surface during transport, storage and erection and to minimize the 'on sites preparation for final painting. Much will depend upon the time between the factory treatment and erection, the care with which the materaials have been stored and handled during that period, and the protective quality of the treatment applied.

5.1.1. Application of a suitable priming coat should follow pretreatment without delay. Subsequent coats of paint may be applied on the site after cleaning down any damaged parts and touching up with the primer paint.

6.2. *Removal of rust and scales.*—When steel leaves the rolling mill, it has a firmly adhering kin known as 'mill scale'. The continuous fresh layer of mill scale is in itself a good protection against corrosion of the underlying steel. However, on exposure to the atmosphere, mill scale absorbs moisture and commences to work itself loose allowing moisture to penetrate between the scale and the steel and resulting in rust formation, old steel, which has been kept for a long time in the open, has heavy layers of rust formed on its surface. If paint is applied on the layers of rust or loose mill scale, rusting continues almost to the same extent as if there was no paint, with the added disadvantage that over heavy layers of paint progressive corrosion is not easily detected. Derusting descaling are the essential preparations required prior to the application of any type of coating on iron and steel. There is considerable difference between the condition of a new steel which required painting and old steel which has been allowed to weather and rust, and the approach to each problem is different. Generally, derusting and descaling of steel may be carried out either mechanically or chemically.

6.2.1. *Mechanical cleaning.*—This may be done by scrapping, chipping wire-brushing, rubbing, with abrassive paper or steel wool, by flame cleaning and sand or shot blasting. New steel that is, to be painted has normally a surface partly rusted and partly comprising of firmly adhering mill scale. Once the firmly adhering mill scale has broken, it is extremely difficult to determine whether the remaining mill scale is adhering firmly enough to be left on the surface or should be removed. For ordinary working conditions it is practically impossible to remove firmly adhering mill scale by any hand operation. Any specification, which requires the cleaning or removing of mill scale or rust by scrapping sand-papering, chipping wire brushing etc. shall therefore be understood to mean that firmly adhering mill scale still not be removed and that the surface finally obtained will not give optimum protection against rust at a later date. While this refers to reasonably new steel which has been protected against excessive weathering in a yard or workshop, quite often very old steel is used on construction or in manufacturing processes where heavy rust or scale has formed. This type of scale consists of numerous layers of rust or chemically broken down steel and is not the same as the thin layer of mill scale. The difference is obvious in appearance, while mill scale is bluish black in colour rust scale is rustybrown in colour. Such rust and scale can usually be removed completely with a scraper or a chipping hammer or both. If complete removed of all types of mill scale is required (which is the best preparation) the old really efficient mechanical method of doing this is by sand-blasting or shot-blasting (see Appendix-A).

6.2.1.1. *Hand scrapping.*—The correct procedure shall be scrap thoroughly with a hand scraper followed by wire-brushing (first with coarse and then with fine wire, brushes) and finally sand-papering the surface with coarse sand paper (No. 3.) steel wood (No.2) or emery paper (No. 3.) or emery cloth. This will give a reasonable assurance that no lease mill scale or heavy rust is left on the surface. For purpose of examination the hand cleaned surface shall be wipe finally with mineral turpentine, which also removes grease and perspiration left by handmarks.

EXTRACT FROM I.S. 1477 (Part II)—1971.

Code of practice for painting of ferrous metals in buildings and allied finishes.

PART II—Painting.

3. *Procedure After preparation / pre-treatment—Function of Paint.*

3.1. With preparation and possible pretreatments as described in IS. 1477 (Part 1) 1971, the metal surface is ready for painting. It is essential that immediately after the completion of the pretreatment process, the first primer coat shall be applied within the shortest possible interval. This is particulary important in coastal areas with high humidity. The successful painting of iron and steel depends, to a great extent, on the preliminary work explained in detail in Part I of this standard and if it is not immediatly followed by ait least one protective paint coat, the results achieved might lose their desired value.

3.2. The application of the paint film has two main purposes. The first one is to protect the steel from corrosion and the second for decorative appearance. A painting which gives the steel adequate protection over a long period of time together with good appearance shall, therefore be adopted. Such a specification shall also make it possible to adopt a schedule of repainting which is comparatively inexpensive that is, as is possible to carryout without too high a preparation cost and at intervals as long as possible.

3.3. A paint film comprises of coats of primer, filler, undercoating and finishing paints. For satisafactory performance of a paint film, under the conditions in which they are required to perform selection of the right type of paints and their adjuncts is of utmost importance. Therefore, it shall be carefully considered whether the paint film has to withstand continuous exposure to exterior weather conditions or is required to withstand a corrosive atmosphere or is required to perform on indoor surfaces. There does not still exist an all purpose paint finish but satisfactory paint finishes are available for practically any particular condition of exposure. There are a number of published Indian Standard specification for interior and exterior, enamels and paints and their adjuncts, namley, primer, fillers, under coating and finishing enamels paints. For paints to perform under special conditions it is recommended that the paint manufacturer may be consulted.

4. *Primer coats* :

4.1. *Type of primers.*—Primers are applied on steel work to inhibit corrosion and hence called anti-corrosive primers. They should adhere to the surface firmly and offer a key to the subsequent coat, Anti-Corrosive primers may be leadbased or lead-free types. For spray application lead-free primers shall be used. The primer coat for ferrous surfaces shall be provided using one of the primers conforming to IS. 102 1962 or IS. 104 1962 or IS. 2074—1962 Other anti-corrosive primers such as zinc rich primer, also called 'Cold galvanizing' may be used in accordance with the manufacurers, recommendations.

4.2. It is strongly recommended that a primer is employed for which long-term experience under the specific climatic conditions is available and to insist that it shall conform to the relevant Indian Standard specifications.

4.3. The primer coat shall be applied soon after completion of pre-cleaning or pretreatment in order to prevent contamination of the surfaces in any way. Primer paints may be applied by the usual brushes and spray guns. Primers containing lead pigments shall not be applied by spray.

NOTE.—Opinion has been expressed by technologists that the primer coats on steel should in preference always be brushed, as only a brush is capable of "working in" the paint into the minute depressions on the non-absorbent steel surface thus ensuring a film, free from 'holidays'. Brush application is also stated to give better adhesion. With these points in view even where the finishing coats are applied by spray, the specifications in many instances require brush application of the two primer coats.

4.4. Two coats shall be applied allowing a drying time so that the first coat is quite hand dry before the second coat is applied or, according to the manufacturer's instructions. In the case of red lead after the second coat of primer, sufficient time shall be allowed for the red lead to dry thoroughly. Experience has shown that under conditions obtaining in hot and humid parts of India, a minimum of two or preferably three days' drying time for red lead gives good hardness to the film.

5. *Intermediate and finishing coats*.

5.1. *Filler coats.*—Filler coats are applied to fill deep dents and to obtain a smooth finish wherever necessary, the degree of filling depending upon the finish desired. Only factory prepared filler suitable for steel work shall be used. Fillers prepared by whiting and linseed oil by craftsman at site shall never be used as such filler may be unbalanced and incompatible with the primer, undercoating and finishing coats.

5·1·1. *Application.*—Correct application of filler requires a good 'Putty knife' and skill. It is an operation for skilled workman who obtain good results by experience . It is essential that filler applied shall be just sufficient to fill the depression or unevenness and it shall be restricted to the minimum. It shall be applied in thin layers. In filling deep depressions or unevenness, as many coats as are necessary may be applied allowing each layer to dry hard. The hardened filler surface shall be cut down by wet rubbin before the subsequent coat is applied. Where necessary, filler coats may be applied over the undercoats also.

5·1·2·. *Ready-mixed filler.*—To fill up surface scratches or similar fine dents all over the surface, application by brush or spray or coats of ready-mixed filler is recommended. Each coat shall be hard-dry and wet rubbed to a smooth finish before the next coat is applied.

5·2. *Undercoating*—After application of the primer, a coat of undercoating is recommended where a high class finish is required. The purpose is to provide a smooth and level foundation for the finishing coat, hide the primer/filler coats and give a full bodied colour in conjuction with the finishing coat. Undercoating paints shall conform to the relevant Indian Standard specifications. The undercoating may be applied by brush or spray. Application by spray gives a smoother finish than by brush. After the film of undercoating is hard dry, wet rub to a smooth finish before the first coat of finishing is applied.

5·3. *Finishing coats.*—The finishing coat gives the desired finish to the article. This is the coat which comes in direct contract with the weather and has to protect the underlying coats, which in turn protects the painted article. Choice of the finishing paint shall be made after carefully considering the conditions under which it has to perform. Finishing paints/enamels conforming to the relevant Indian Standard specifications shall be employed. The finishing coats may be applied by brush or spray. For Brush application good quality brushes shall be used. Formally two finishing coats are recommended. The second coat may be applied after the first coat is hard dry and its gloss is knocked off by scuffing with a very fine cutting device.

5·4. *Compatibility.*—Before considering the application of intermediate and finishing coats, it shall be made sure that those selected are compatible with each other. If a non-elastic finishing coat is applied over an elastic primer coat, it may lead to cracking or 'alligatoring' of the finishing coat and the primer coat may become visible through cracks in the finishing coat. Similarly if the finishing coats contains a strong solvent, it may attack the primer coat and lead to shrivelling (wrinkling) of the entire paint structure. As a general rule, it is safer to use primer, filler, undercoating and finishing paints made by the same manufacturer.

5·5. *Drying time.*—For the paint film comprising of the primer coats, the finishing coats with filler coats and undercoating where necessary to perform in unison, it is essential that each coat shall be thoroughly dry before the subsequent coat is applied. Otherwise defects in the film may appear soon after exposure due to the shrinking of anyone of the coats. An interval longer than the drying time specified in the relevant product specification may be necessary depending upon the material used, for example, red lead primer to I.S. 102—1962 requires a fairly long drying time.

5·6. *Flatting down.*—Cutting of primer coat, undercoat and first finish coat is essential to provide a key for subsequent coats in order to improve the intercoat adhesion. The primer coat with or without putty shall be dry cut and the undercoat with or without putty for spot work shall be wet cut with water proof emery paper No. 220/240. In the case of undercoatings without putty, prior to finishing coat shall be wet cut with waterproof emery paper No. 280/320. The first finish coat shall be wet cut with waterproof emery paper No. 320/400. The surface should be dry, clean and free from dust before subsequent coat is applied.

5·7. *Mixing before application.*—It is essential that a paint is applied only after the contents of the drum have been thoroughly mixed. Some paints, such as the red lead primer and zinc primer, after long stroage show setting of the pigment at the bottom of the drum and, therefore, more than ordinary stirring is required in order to suspend the pigment once again fully in the medium. As stirring of the settled pigment is time consuming, it will help considerably to adopt the following procedure.

A day or two before application, the drums shall be turned over to stand on their heads. When opening a drum, about half the contents shall be poured into another drum and then the sediment stirred into the remaining medium; when this is fully done and there are neither lumps nor sediment left, the two lots shall be mixed together and thoroughly stirred. The paint, while in use, shall be stirred from time to time to ensure that the pigment remains in suspension. The usual procedure of slightly stirring a 5 gallon drum and pouring the contents into the painter's bucket may result in most of the pigments remaining at the bottom of the drum and being eventually thrown away with the result that the paint actually applied will contain only a smaller percentage of the pigments which have so carefully been incorporated by the paint manufacturer.

5·7·1. *Addition to thinners.*—Thinners (such as mineral turpentine) shall not be added to paints on the feeling that the consistency of the paint supplied by the manufacturer is too thick. If the paint has been manufactured to conform to Inian Standard specifications, and has been subjected to control tests in a manufacturer's laboratory, the paint shall have the correct consistency and shall not require further dilution. If there is any doubt ,the viscosity of the paint may be checked (see8 5 1 1). If a slight adjustment of viscosity is necessary, use the thiner recommended by the manufacturer.

5·8. *Importance of environmental conditions and dryness of the surface.*—Painting operation should be carried out in well ventilated place, from dust. Draughts and direct sunlight should be avoided as it will result in poor flow and a patchy finish. It is essential that the surface to be painted shall be dry, free from moisture as otherwise corrosion and or other paint defects may result due to moisture getting trapped in the paint film. Correct timing for the application of the primer as well as other coats is important.

5·8.1. In coastal regions and areas with moderate or high humidity with appreciable difference in day and night temperatures, it is generally not safe to paint exterior steel work early in the morning due to the settlement of dew on the surface, In such places painting should be started later in the mornings after dew has evaporated. For the same reasons, painting during monsoon shall be avoided even indoors as the humidity is very high and drying will be affected resulting in paint defects.

6. *Painting schedules—*

6.1.2.1. While cleaning with power wirebrush, care shall be taken not to do it exessively, since a mill scale easily gets burnished to smooth even surface to which paint does not adhere, and this will be detrimental to the performance of paint. All accessible weld flux and splatter shall be removal by power tools.

6·2. *Painting—*

6·2·1. *Primer coats—*

6·2·1·1. Immediately after preparation of the surface, apply the first coat of primer by spray or brush, preferably the latter, working in the paint into the fine dents and ensuring a continuous film without 'holiday'.

6·2·1·2. After the first coat is hard dry, apply a second coat so that a film free from 'holidays' is obtained.

6·2·2. *Filler coats—*

6·2·2·1. After the second coat of primer is hard dry, rough sand the surface without scratching or in any way damaging the primer coats and clean free from dust.

6·2·2·2. Fill deep dents with paste filler using a good putty knife, pressing firmly into the dents and applying an optimum layer. Allow to hard dry and cut down by wet rubbing to a smooth finish. Allow the water to evaporate.

6·2·2·3. Apply as many coats of paste filler as are required to get a smooth surface, allowing each layer to hard-dry, then wet-rubbing to a smooth finish and allowing the water to dry off before the next layer is applied.

6·2·2·4. After the last coats of paste filler is hard dry and wet rubbed, where necessary, apply a coat of R/M filler by brush or spray to fill fine dents and scractches on the metal, allow to hard-dry and wet-rub to a smooth finish.

6·2·2·5. Apply the requisite number of coats, either in local patches or all over the surface as required, allowing each coat to dry-Hard wet rubbed and water allowed to dry off before the subsequent coat is applied.

6·2.3. *Undercoats*.

6·2·3·1. Wet rub the entire surface, cutting down to a smooth uniform surface. Allow the water to evaporate. Apply an optimum coat of undercoating by brush or spay with minimum bursh marks. Allow the film to hard-dry, Wet rub, cutting down to a smooth finish (ensuring that at no place the undercoat is completely removed). Allow the water to evaporate.

6·2·4. *Finishing coats*.

6·2·4·1. Apply the first finishing coat by brush or spray. Allow to dry.

6·2·4·2. Gently remove the gloss for the entire surface. Dust off and apply the second finishing coat.

7. *Maintenance painting*.

7·1. The breakdown of a paint film is a progressive one starting with the topmost coat, gradually going downwards to the primer coat. The object of maintenance painting is to renovate the paint film periodically, checking the progress of breakdown and main taining the protective and decoratvie value of the paint film, thus prolonging its effective life. The principles of maintenance painting are summarized in Table 2.

TABLE 2. RECOMMENDED PAINTING PRACTIC FOR MAINTENANCE WORK.

(*Clause* 7-1)

Serial number.	Condition of surface.				*Cleaning and painting procedure.*
	Rusting.	*Cracking.*	*Checking.*	*Chalking.*	
(1)	(2)	(3)	(4)	(5)	(6)
1.	Nil	Nil	Nil	Yes	Clean : rub with sand paper, apply one reviver coat.
2.	Nil	Nil	Yes Fine Checking.	Nil	Flat down to remove checked film ; clean ; apply one or two reviver coats.
3.	Nil	Yes Not reached the surface below.	....	Nil	Treat as in 7·5·1·2.
4.	Yes	Nil	Nil	Yes	Treat as in 7·5·1·5.
5.(a)	Localized ..	Nil	Nil	Yes	Treat as in 7·5·1·5·
(b)	Localized ..	Nil	Yes	Nil	Treat as in 7·5·1·5·
(c)	Localized ..	Yes	..	..	Completely remove paint to bare metal and paint with full schedule.
6.	Heavy rusting.	..	..	..	Completely remove paint to bare metal and paint with full schedule.

7.2. The symptoms of paint breakdown are chalking, hairline cracking deep checking, fine checking, peeling, blistering, and rusting. They may be present either alone or along with others depending upon the degree of breakdown. The breakdown normally starts from the top coat, generally when there is chalking, checking and cracking do not appear and the breakdown is a gradual process of erosion. This type of failure is most desirable as the protective value of the film is retained over a longer period and renovation is easier.

7·3. The symptoms given in 7·2 may appear all over the surface or it may appear in certain areas in patches. Blistering is another symptom of breakdown. Checking, cracking, blistering and peeling expose the primer coat and the surface underneath to the weather and corrosion is the result. Therefore ,such a breakdown is to be remedied quickly.

7.4. If the specification of the painting operation is known, maintenance painting may be easier and more effective as it is possible to renovate by using the same quality of paints as used earlier. If this is not known, maintenance painting has to be carried out on the overall strength of the existing film and renovated by using the best material required to perform under the conditions of exposure.

7·6. *Removal of old paint for repainting*.

7.6.1. Caution should be exercised while removing the old paint. Paint removers of the alkali based or solvent type are available and if proper care is not taken, they may do more harm than good. While washing down after using alkali type, other structures, such as wood may be adversely affected. For the solvent type, the fume and fire hazard is to be counted. They contain waxes and removal of last traces of wax is essential as otherwise adhesion of the paint coats may be adversely affected.

7.6.2. Burning off of cold paint carried out with caution is better than using paint removers.

7.6.3. Removal of the old paint by mechanical method of shipping and scraping is the best.

7.7. *Precautions against fungi*.—Exterior painted surfaces may develop fungi which shall be removed and ammoniacal copper solution (see note) shall be applied to the surface and allowed to dry tohroughly before repainting.

NOTE.—A recommended composition and concentration of the ammoniacal wash shall consist of 7 g. of copper carabonate dissolved in 80 ml. of liquor ammonia and diluted to one litre with water Alternatively, 2·5 percent of magnesium silicofluoride solution may be used.

8. *Inspection and testing.*

8.2. *General.*—The aim of inspection and testing is to ascertain whether the recommended practice is being employed during every stage of application and whether the final results fulfil the object of painting. Inspection, therefore, means a close supervision while the work is in progress. Any test carried out should be of non-destructive nature or, if of a destructive nature, should be either restricted to areas which can be restored without marring the general appearance, or be such that it is possible to restore easily without necessitating, a complete repetition of the work.

8.2. *Inspection of surfaces prior to painting.*—Inspection methods will depend on whether an article is to be painted for the first time or is to be repainted.

8.2.1. *New work* (Not previously painted).—The following shall be decided by inspection :

(*a*) The method of precleaning feasible or recommended.

(*b*) The intermediate protective treatments to be applied, if found necessary ;

(*c*) The painting schedule and the specifications for the paint for ensuring the particular performance required ; and

(*d*) The method of application, whether by brush, roller or spray.

8.2.2. *Old work* (Which requires repainting).—The following shall be decided by inspection ;

(*a*) Whether the entire existing paint requires removal ; and

(*b*) Whether repainting without paint removal would be adequate.

8.2.2.1. For ascertaining whether the old paint has deteriorated to such an extent that its complete removal is necessary, the following test for embrittlement should be employed.

As square coin such as a 5 Paise coin shall be pressed with the straight edge on an angle of 45° against the paint film. This will result in a chip of paint breaking loose from the surface if the paint has embrittled, lacks adhesion and requires removal. If the paint is not embrittled, it will curl or shrivel up under such pressure. The square coin test should be combined with an examiuation of the paint film through a magnifying glass to observe the extent of crazing. A suitable magnifying glass is the thread counter employed in the textile trade. It has a 10 magnification, and a paint film which does not show fine hair cracks under it may be considered as perfectly sound.

8.3. *Inspection during preperation of surfaces*.

8.3.1. *Cleaning and Degreasing*—At the work—site a visual and physical inspection is adequate. A degreased steel surface is duller in appearance than one which is even slightly oily. Wiping the surface with a piece of white cloth will show if minute traces of grease. and dust have been left on the surface. When steel is being degreased by wiping the surface, with mineral turpentine (or any other solvent), it is important to watch that the cleaning rags are washed or changed regularly.

8.3.2. *Derusting and descaling*.

(*a*) *Sandblasting*—The most satisfactory method of removing rust and scale is by sandblasting. The criterion of inspection should be that the steel after sandblasting has a greyish white metallic appearance. The surface should be uniform in colour and slightly rough. Only such a uniform appearance ensures that the surface has been thoroughly cleaned.

(*b*) *Hand scraping.*—No definite method of inspection may be laid down for hand scaping. It is unreasonable to expect handscraped surfaces to be perfectly clean, and for purposes of inspection, all loose rust or scale (and all loose paint in case of repainting) shall have been removed.

(*c*) *Chemical rust removal.*—In the case of chemical rust remova (pickling), inspection shall make sure that washing after pickling has removed all traces of acid. All work pieces shall be inspected particularly in inaccessible corners.

8.4. *Inspection before and during intermediate protective treatments.*—It is important to inspect the work to make sure that no time is allowed for fresh rust or other contamination to take place between: the precleaning and the intermediate protective treatment. Inspection of the various suggested intermediate protective treatments shall be carried out to ensure conformity with the recommended practice as laid down in this standard and in accordance with manufacturer's recommendations.

8.5. *General inspection before and during painting.*—when inspecting general painting work while in progress, it should be ensured.—

(*a*) that painting follows immediately after precleaning or pretreatments ; that any contamination which may occur in the interim period is removed, that special precautions are taken when painting after galvanizing ;

(*b*) that no painting is carried out when there is danger of dew ;

(*c*) that tools used are clean and not excessively worn ;

(*d*) that the paint in the drums is thoroughly mixed prior to application ; that drums are inspected to make sure that no sediment is left in them ;

(*e*) that if paint has thickened because of long storage or because of the evaporation of the solvents, its viscosity is adjusted as recommended by the paint manufacturer ;

(*f*) that each coat is allowed to dry sufficiently but not excessively before applying the following coat that manufacturer's instructions for drying time are adhered to properly ; and

(*g*) that every individual coat is properly applied, reasonably level and smooth, and free from runs and " Holidays " (minute uncovered areas).

8.6. *Inspection of general apperance of finished* work—Inspection of finished work, although not possible by definite standards, may best be judged by experience and commensonse.

8.6.1. *Time of inspection.*—Inspection of a finished work in the open shall not be carried out during mid-day or in bright sunligh as defects as more clearly visible in slightly diffused light. When inspecting interior painting, the sun should not shine directly on the surfaces to be inspected. The best time for inspection is in the early morning.

8.6.2. *Appearance.*—The finished job shall have a clean uniformly coloured appearance. If paint is applied by a spray gun, a smooth finish will be obtained. If paint is applied by a roller, the finish will have a light texture effect. If paint is applied by brush, light brush marks will be permisible to the naked eye at a distance of not more than 4 m. Brush marks depend on the type of paint, the quality of brushes used and above all, the skill of the workmen applying the paint. It would be unreasanable to expect perfection when applying paint by brush. If paint, applied by brush, has been stippled, no brush marks will be visible but there will be a slight texture effect instead ; stippling is not required except on large surfaces, or surfaces likely to be viewed from a short distance.

8.6.3. *Colour.*—Correct colour matching should be judged against a sample panel having the same type of surface as that to which the paint has been applied. The effect of colour is influenced by the texture or the method of application of the paint. Colour appears different during mid-day, in the evening or in the morning, and in artificial or natural light ; colour will change under a tungsten-flament lamp, a flourescent lamp or a mercury lamp (vapour). Application by brush gives a slightly different surface texture than application by spray or roller and the colour will, therefore, differ slightly. To avoid confusion at the time of inspection, the sample panel prepared from an identical material and painted by the same method should be placed as near as possible to the article to be inspected so that the incidence of light is the same.

8.6.4. *Gloss.*—The extent of gloss should be agreed upon prior to commencement of painting. As the extent of gloss is generally not of major importance, the gloss of the final job may best be judged by preparing test panels prior to the application of the paint on the bulk of the work and making a comparison with them ; such test panels may also be asked for from the paint supplier. It should be noted that gloss will vary with application by spray, brush or roller and will further very considerably with the type and nature of the surface, the smoother the surface the higher will be the gloss.

APPENDIX—A.

(*Clause* 6.3.)

BRUSHING OF PAINT.

A.1. *General*:—

A.1.1. Clean brushes shall be used, and it shall be ensured that the paint does not show objectionable pulling under the brush. The brush shall be such that the paint does not show lapping streaks and works satisfactorily under it.

A.1.2. The paint brush shall not be dipped deep into the paint as the bristles get overloaded, and the heel gets filled with paint thereby the brush loses its flexibility and shape. As a general rule, the brush shall be dipped to three fourths of the total length of the bristles. After the brush is initially dipped, the end is wiped against the walls of the container to ensure that paints does not dribble off the ends of the bristles when painting is started. The paints shall be mixed periodically during brushing.

A.1.3. For keeping paint in small quantities during application by brush, use of a paint container may be found advantageous. These containers are filled about three foruths during application. Cleaning of these containers is done only with paint thinners which are compatible with the paint to be filled.

A. 2. *Brush application.*

A.2.1. While applying paint with a brush, the brush shall be held at an angle of approximately 45 degrees to the vertical surface ; and several light strokes applied in the area to be painted, so as to first transfer the paint to the surface. During painting, the brush shall also be turned around through 180 degrees in order to ensure that the paint on both the faces of bristles is utilised completely. The paint is then spread with gentle pressure so as to hide the surface and produce a uniform coating. Ensure that the ends and not the sides of the bristle come into contact with the surface during painting.

A.2.2. The paint shall be applied, first using vertical strokes until the surfaces are covered, and then brushed cross-wise for complete coverage with light strokes, so as to smooth out laps and brush marks, and finally laid of with vertical strokes.

A.2.3. During painting, every time after the paint has been worked out of the brush bristles or after the brush has been unloaded, the bristles of the brush (which are drawn together due to the high surface tension of the small quantities of paint left in between the the bristles) shall be opend up by striking the brush against a portion of the unpainted surface with the end of the bristles held at right angles to the surface so that bristles thereafter will collect the correct amount of paint when dipped again in to the paint container.

A.3.1. A new bristle bursh is properly conditioned by suspending it in raw linseed oil for a period of 24 hours. The oil soaks into the bristles which makes it further impervious to paint pigments.

A.3.1.1. Before use, the linseed oil is removed from the bursh by washing it in a thinner compatible with the paint subsequently used.

A.3.2. After each day's work, the bursh shall be cleaned in mineral turpentine or any other suitable thinner, ensuring that the paint and pigment are completely removed from the heel of the brush.

A.3.2.1. Warm water and soap shall be used to clean the brushes used in water bound paints or emulsions.

A.3.3. After cleaning, the brushes are wrapped in heavy paper of water-proof paper for storage. If it is to be used the next day, it shall be hung in a thinner or linseed oil in a container. On no account, shall brushes be made to stand on the bristles.

APPENDIX—B.

(*Clause* 6.6).

SPRAY OF PAINT.

B.1. *Preparation of paint for spraying.*—

B.1.1. Generally, paints are availabe ready for use for spraying. If thinning is absolutely necessary, it should be kept down to a minimum.

NOTE.—Nitrocellulose lacquers (enamels) are not usually supplied in spraying consistency. They have to be thinned with special thinner to proper consistency before application.

B.2. *Spraying procedure* :—

B.2.1. During sparying the spary-gun shall be held perpendicular to the surface to be coated and shall be passed over the surface in a uniform sweeping motion. Different air pressures and fan adjustment shall be tried so as to obtain the best application with the minimum wastage of paint. The air pressures shall not be kept too high as otherwise the paint will fog up and will be wasted.

B.2.1.1. Spots that are inaccessible to the spray pattern shall be touched up by brush after spraying.

B.2.2. The possible causes of defects in spray painting work are detailed in appendix C and the suggested remedies shall be followed for satisfactory workmanship.

B.3. *Maintenance of spraying equipment.*

B.3.1. At the end of the job, the spray-gun shall be cleaned thoroughly so as to be free from dirt. In correct adjustments shall be set right, as otherwise they will result in variable spray patterns, runs, sags and uneven coats. Caustic solutions shall not be used for ciearing purposes as it will deteriorate the spray-gun.

APPENDIX—C.

(Clause B.2.2.)

SPRAY PAINTING DEFECTS : CAUSES AND REMEDIES

C.1. *Defects in finish.—*

C.1.1. *Sags.*

Possible causes. (1)	*Suggested remedies.* (2)
1. Dirty air cap and fluid tip (distorted spray pattern).	Remove air cap, and clean tip and air cap carefully.
2. Gun stroked too close to the surface.	Stroke the gun 150 to 250 mm. from surface.
3. Trigger not released at end of stroke (when stroke does not go beyond object).	Operator should release the trigger after every stroke.
4. Gun stroked at wrong angle to surface.	Gun should be stroked at right angles to surface.
5. Paint applied too heavily ..	Regulate flow of paint.
6. Paint thinned too much ..	*Add* the correct amount of solvent by measure.

C.1.2. *Streaks.—*

1. Dirty air cap and fluid tip (distorted spray pattern).	Remove air cap and clean tip and air cap carefully.
2. Insufficient or incorrect overlapping of storkes.	Follow the previous stroke accurately to deposit a wet coat.
3. Gun stroked too rapidly (dusting of the paint.)	Avoid "Whipping" and use deliberate slow strokes.
4. Gun stroked at wrong angle to surface.	Gun should be stroked at right angles to surface.
5. Stroking too far from surface	Stroke 150 to 250 mm. from surface.
6. Too much air pressure ..	Use least air pressure as necessary.

C.1.3. *Orange feel.—*

1. Paint not thinned out sufficiently.	*Add* the correct amount and the right type of solvent by measure.
2. Not depositing a wet coat ..	Check solvent, use correct speed overlap and stroke.
3. Gun stroked too rapidly (dusting of the paint).	Avoid "Whipping" Use deliberate slow strokes.
4. Insufficient air pressure ..	Increase air pressure or reduce fluid pressure.
5. Using wrong air cap or fluid nozzle.	Select correct air cap and nozzle for the material and feed.
6. Gun stroked too far from the surface.	Stroke the gun 150 to 250 mm. from surface.
7. Overspray striking a previously sprayed surface.	Spray detail parts first. End with a wet coat.

C. 2. *Defects in workmanship.—*

C. 2·1. *Excessive paint loss.—*

1. Not 'Triggering' the gun at each stroke.	It should be a habit to release trigger after every stroke.
2. Stroking at wrong angle to surface.	Gun should be stroked at right angles to surface.
3. Stroking gun too far from the surface.	Stroke the gun 150 to 250 mm. from the surface.
4. Wrong air cap or fluid tip ..	Ascertain and use correct set up.
5. Air pressure too high ..	Use the least amount of air as necessary.

C. 2. *Defects in workmenship*—cont.

C. 2·2. *Excessive spray fog, surface haze or bloom.—*

Possible causes. (1)	*Suggested remedies.* (2)
1. Too high air pressure ..	Use least amount of compressed air as necessary.
2. Spraying past surface of the product.	Release trigger when gun passes target.
3 Wrong air cap or fluid tip ..	Ascertain and use correct set up.
4 Gun stroked too far from the surface.	Stroke the gun 150 to 250 mm. from surface.
5 Material thinned out too much.	Add the correct amount.
6 Too humid an atmosphere ..	Spray during dry periods ; if not, use retarders or slow evaporating solvents as advised by the manufacturers.

C. 2·3. *Paint will not come from Spray gun :—*

1. Out of paint (gun begins to sputter).	*Add* paint, correctly thinned out, and strained.
2. Settled, caked pigment blocking gun tip.	Remove obstruction, strip paint thoroughly.
3. Grit, dirt, paint skins, etc., blocking gun tip, fluid valve or strainer.	Clean spray gun thoroughly and strain the paint, always strain paint before using it.

C. 2·4. *Paint will not come due to defects arising from pressure tank—*

1. Lack of air pressure in the pressure tank.	Check for leaks or lack of air entry.
2. Air intake opening, inside of pressure tank lid, clogged by dried up paint.	This is a common trouble. Clean the opening periodically.
3. Leaking gaskets on tank over.	Replace with a new gasket.

C. 2·5. *Gund sputters Constantly—*

1. Fluid nozzle not tightened to spray gun.	Tighten securely, using a good gasket.
2. Leaky connection on fluid tube or needle packing (sanction gun).	Tighten connections ; lubricate packing.
3. Fluid pipe not tightened to the pressure tank lid.	Tighten ; check for defective threads.

C. 2·6. *Paint leaks from spray gun—*

1. Fluid needle packing nut too tight.	Loosen nut ; lubricate packing.
2. Packing for fluid needle dry..	Lubricate this part daily.
3. Foreign particle blocks fluid tip.	Remove tip and clean.
4. Damaged fluid tip or needle .	Replace both tip and needle.
5. Wrong size needle	Use correct combination.

EXTRACT FROM I. S. 2338 (part I) 1967

Part I—operations and workmanship.

Code of practice for finishing of wood and Wood based materials.

4. *General Characteristics of wood and wood-based materials.*—The decorative and protective value of a finish may be influenced by the nature of the surface on which it is applied. There are several species of wood and an increasingly large number of woodbased panel products often differing from each other in surface characteristics. They may be hard, soft, resinous or porous in varying degrees.

4·1·1. Wood is a hygroscopic material and tries to reach a state of equilibrium with the atmosphere in so far as its moisture content is concerned, changes in moisture content are accompanied by swelling and shrinkage, which is most pronounced across the grain of the wood. Due to moisture movement the summerwoods swell to a greater extent than spring woods and this sets up stress—concentration at the sharply defined junctions between one year's summer growth and the next year's spring and the failure commences about this region. The resulting stresses on the film of finishing materials are such as to cause fissures to develop along the grain under adverse circumstances.

4·1·2. Before painting, wood shall be properly seasoned and the moisture content shall be brought as near as possible to the equilibrium moisture content as given in I.S. : 287—1969 so as to prevent uneven shrinkage during drying which may result in distoration or even in cracks in the paint finish. It is also advisable not to finish excessively dry wood.

4·1·3. The cellular structure of wood has a strong influence on the absorption of liquid components of finishes. Non-uniform absorption of vehicles by the wood upsets pigment-binder ratio impairing the appearance and life of the coating.

4·1·4. Plywood, block board, hard board and particle board have greater dimensional stability than solid wood and provide more uniform surface for finishing.

Design considerations.—

5·2·1. *Prime coat.*—

5·2·1·1· A suitable wood primer shall adhere firmly to the surface form a sound foundation for further coating and fulfil special functions, such as acting as a sealer on porous wood and hardboard.

5·2·1·2. Whenever the timber has large pores a preliminary priming with a quick drying varnish of the gold size type conforming to I.S. 198—1952 is desirable. The varnish shall be forced with a brush well into the pores so that the pores are completely filled. This filling of the pores shall not be regarded as a substitute for normal priming and shall be followed by a coat of primer.

5·2·1·3. Pink wood primer (*see* I.S. 3536-E-1966) or the mixture of white and red lead primer may be used in painting structures, containing a slight excess of moisture as they allow minute quantities of moisture to pass through without disrupting it.

5·2·1·4. Aluminium primer may be used for priming wood having knots and resinous matter. The primer prevents the resin of the wood from bleading.

5·2·2. *Stoppers and fillers.*—For deep holes, plastic wood conforming to I.S. 423—1961 shall be used. Stopping may be generally confined to large holes or cavities. Shallow indentations shall be made up with the paste filler conforming to I.S. 426—1961. For high class work filling operation shall be done over the whole surface by using the filler conforming to I.S. 110—1950. For clear finishes, filler conforming to I.S. 345—1952 shall be used.

5.2.3. *Undercoat and finishing coat materials.*—Before considering the application of under coat and finishing coat it shall be made sure that those selected are compatible with each other. If a non-elastic finishing coat is applied over an elastic primer coat it may lead to cracking or alligatoring of the finishing and the primer coat may become visible through cracks in the finishing coat may become visible through cracks in the finishing coat. Similarly if the finishing coat contains a strong solvent, it may attack the primer coat and lead to shrivelling (wrinkling) of the entire paint structure. It is therefore essential to specify and ensure that the various types of paints to be used are compatible with each other, and as Indian standard specifications on paints allow enough latitude for the manufacturer to adjust his guarantee that the paints purchased not only satisfy the specified requirements but are also compatible with each other. As a general rule, it is safer to use primer and finishing paints made by the same manufacturer.

6.1. *Surface preparation* :

6.1.1. Wood that is to be painted should be well seasoned and free from discoloured sapwood and from parge resinous or loose knots. If the wood is not properly seasoned, the surface may become uneven on drying and cracks may also develop. Paint applied over discoloured sapwood is liable to become discoloured ; resin from knot tends to exude through the paint. Any such unsound portions should, therefore, be cut out and replaced with sound wood.

6.1.2. Nails should be punched well below the surface to provide a firm key for stopping.

6.1.3. Mouldings should be carefully smoothed with abrasive paper and projecting fibres left after machining should be removed. Quirks need particular attention since paint collects on any rough projections and the finished appearance is then marred ;

6.1.4. Flat portions should be smoothed off with abrasive paper used across the grain prior to painting and with the grain prior to staining or if the wood is to be left in its natural colour. Wood work which is to be stained is sometimes smoothed by scraping instead of by glass papering.

6.1.5. Any knots, resinous streaks or bluish sapwood that are large enough to justify cutting out should be treated with two coat of pure shellac knotting, applied thinly and extended about 25 mm beyond the actual area requiring treatment. Aluminium primer may be used in the place of shellac knotting. If the area is small and the wood is not highly resinous, it is permissible instead of applying two coats of knotting, to apply one coat slightly pigmented with aluminium powder.

6.2. *Priming* :

6.2.1. If there is dirt or any other extraneous material this shall be removed. If the wood work is not already primed, a priming coat shall be applied. In case there is already a primer coat but an unsatisfactory one, it shall be rubbed down to bare wood and the surface reprimed. Primer shall be applied by brushing.

6.2.2. Care shall be taken to prime not only the surface of the wood that will be visible after fixing but also any surface which will be in contact with materials, such as brickwork or concrete from which the wood may absorb moisture. It would be an advantage to give surfaces a further coat of primer, before fixing.

6.2.3. Unless specified otherwise all joinery work, which is intended to be painted shall receive at least two priming coats. It is particularly important that end grains be so treated and, if it is necessary to cut the joinery before fittings, all cut ends shall be painted with two priming coats.

6.3. *Stopping and filling.*—Stopping and filling should be done after priming. If the surface is not first primed, the filler or stopping may shrink and fall away, owing to absorption of some of the binder.

6.3.1 Stopping is made to the consistency of stiff paste and is used to fill holes and cracks, while the function of the filler is to level up slight irregularities of surface. Filler is usually applied with a putty knife and is subsequently rubbed down to a level surface with abrasive paper, pumice stone or other suitable abrasive. For certain work, fillers are mixed to the consistency of thick paint and applied with a brush.

6.3.2. The filler coat should be of an optimum thickness and should be allowed to fully harden and flatten before subsequent coat is applied. Apply as many layers as necessary allowing the coats to harden and flatten between coats.

6.4. *Application of under coat.*—Under coat shall be applied after the surface has been primed, stopped, filled and rubbed down to a smooth surface. Undercoat may be brushed or sprayed. After drying the coat shall be carefully rubbed down and wiped clean before the next coat is applied.

6.5. *Finishing.*–The application of finishing paint varies according to the type of paint employed. Cleanliness is essential and as far as possible the application should be carried out in normal dry conditions. The finishing coat may be applied either with the brush or sprayed.

7. *Application of clear finishes* :

7.0 *General.*—Clear finishes for wood are generally used for interior surfaces as their durability when used on external surfaces is less than that of pigmented coating. This is mainly because of the destructive action on the clear finishes by the ultraviolet rays present in the sunlight. The ultraviolet radiation is to a great extent absorbed by the pigments present in the coatings while it may cause considerable damage to clear finishes.

7.1. For the application of clear finishes the following procedure shall generally be adopted :—

(*a*) Filling ;

(*b*) Staining ;

(*c*) Sealing ; and

(*d*) Finishing.

7.2. *Filling* :

7.2.1. The primary function of fillers is to fill the opened cells of the wood in the surface layer. This is necessary to prevent the excessive penetration of the finish, that is, subsequently applied and to level off the surface of a porous wood to make a smooth top finish possible.

7.2.2. On hard wood with large open vessels a suitable filler conforming to IS : 345–1959 may be used.

7.2.3. For special stain effects coloured fillers shall be used.

7.2.4. A combination of filler and stain may be used for reasons of cost, that is, to elimniate a separate staining operation. However, the result lacks the grain and colour contrast characteristic of wood stains.

7.2.5. On fine–textured woods having minute pores that do not require filling, unfilled drying oils, thin varnishes, lacquer or shellac may be used.

7.2.6. Filler or stain filler shall be heavily applied to the wood surface by hand, using hessian or jute rag across the grain. It may be rubbed when still wet to get better penetration. After 5 to 10 minutes it shall be wiped off by hand across the grain followed by a light wipe with the grain. Picking out of corners and carvings may be done with a rag wrapped around the end of a sharpened wood dowel. The filled surface shall be dried preferably overnight, and smoothened with abrasive paper. Wipe with a clean soft rag to remove dust and nibs.

7.3. *Staining* :

7.3.1. Staining of wood may be resorted for indoor fittings and even then only for subsequent clear finishes. The object of staining wood is to darken it as part of a decorative scheme. If skilfully carried out, staining may be used with good effect to enhance the natural grain or figuring of the wood.

7.3.2. The depth of colour produced by staining will depend not only on the concentration of the stain but also on the extent to which it is absorbed by the surface. Stain is readily absorbed by soft porous spring-wood but comparatively little by the harde rand tenser summerwood. Hardwoods, being less absorbent, will present less difficulty ; stain may be applied liberally and allowed to remain until sufficient quantity is absorbed, the excess being then wiped off if necessary. The effects produced by knots, resinous portions and other markings may be similarly accentuated. The different types of stains as water, spirit and oil stains have different penetrating properties and, therefore, shall be selected to suit the performance required.

7.3.2.1. *Water stains.*—Water stains are made with water soluble dyes. They emphasize the grain, especially that of soft-woods, since they are readily absorbed by the porous portions but less readily by the denser, more resinous portions. They will raise the grain of the wood thus spoiling the smoothness of the finish if a highly polished effect is required ; this difficulty can be overcome by first wetting the surface with water to raise the grain and then, after drying, smoothing it with abrasive paper before staining. Where it is, necessary to provide a temporary staining treatment on wood, that is damp or unseasoned, water stain is preferable to othert ypes of stain.

7.3.2.2. *Spirit stains.*—Spirit stains are solutions of spirit soluble dyes in industrial methylated spirit. Like water stains, spirit stains penetrate more into the softer portions of the wood and so accentuate the grain but they do not cause the fibres to swell nor raise the grain. They will dry very quickly and shall be applied quickly and skilfully to avoid patchy effects. If applied to damp wood the dyes in the stains are liable to be thrown out of solution. The surface after staining with spirit stains may be finished in the same way as after treating with water stains.

7.3.2.3. *Oil stains.*—Oil stains may be solutions of oil soluble dyes in linseed oil but usually, to give a wider range of colours, they consist of insoluble, semi-transparent pigments ground in linseed oil and thinned with turpentine or other solvent. Sometimes wax is added to make the stainless penetrating. Oil stains will give a softer effect than water stains or spirit stains. Generally they may be finished with glass or flat oil varnish. If wax polished the stain shall first be given time to dry hard. If applied to damp wood they are likely to develop a milky effect or bloom. The application of soil stains and varnish will retard the drying of the wood. Oil stains will not take well on certain resinous or oily woods, such as teak. Sometimes these woods are pretreated with solvents to remove the greasy matter from the surface prior to oil staining or varnishing.

7.3.3. *Wash coating.*—If grain raising stains have been employed or if it is desired to reduce to a minimum the risk of stain bleeding into top coats and to prevent discolouration of wood by absorption of oil and stains from the filler, a thin coat of shellac or lacquer shall be applied on the stained surfaces before sanding.

7·3·4. The stain may also be mixed with varnish to produce the combined effect in one operation; the result will, however, not be as satisfactory as when the " fininshing " follows as a separate operation after staining. Alternatively, the stain may also be mixed with wax so that after application in one operation the wax may be polished. Here again the results will not be as satisfactory as in a two stage system.

7·3·5. *Preparation of wood for staining* :

7·3·5·1. Sarface intended for staining shall be kept scrupulously clean and free from greasy finger marks. It shall be prepared by careful smoothing with fine abrasive paper, used in the direction of the grain; scratches across the grain are likely to become stained darker than the rest of the surface and so spoil the finished appearance. If water stain is to be used, the surface of the wood shall be wetted with water to raise the grain and then be allowed to dry before finally smoothing.

7·3·5·2. Small cracks or nail holes may be stopped with plastic wood, fine plaster of paris or other suitable stopping, if water stain or spirit stain is to be used. The stopping shall be rubbed down with fine abrasive paper when hard and touched with a little thinned knotting before staining. Where oil stain is to be used, stopping shall preferably be done after staining, using tinted putty or wood filler.

7·3·5·3. If necessary, softwood may be treated with hot weak size before staining to prevent undue absorption of stain, but in excess of size should be avoided. To a certain extent the degree of penetration of a stain may be controlled by pre-treatment of the absorbent surface with a hot weak size of thinned shellac varnish. Size shall preferably be not used where the stained surfaces are likely to come into contact with water, which may smear it. To control the depth of colour, however, diluted stain may be made to soak well into the wood. Where size is used, the surface shall be allowed to dry thoroughly before staining. In general, flat surfaces shall be treated first and mouldings and edges last, that is, reversing the order recommended when applying paint, the object being to avoid double staining along the edges.

7.3.6. *Application of stains.*

7·3·6·1. Stains may be applied by brushing, and wiping or by spraying. The stain shall be so thinned that it can be applied fairly liberally without over-staining. Care shall be taken, especially on absorbent softwoods, to apply the stain evenly and without overlapping. Spirit stains, in particular require careful and quick application as they dry very quickly.

7·3·6·2 The stained surface shall be varnished, wax polished or french polished as required after it has dried. For reasons of economy, the surface shall be sized before varnishing, in which case it is important to allow the size to dry thoroughly. Where a more durable finish is required two or three coats of finishing clear varnish is recommended.

7·4. *Sealing.*—A suitable sealer shall be applied on the filled and sanded surface to prevent absorption by the wood of the succeeding coats of finish and to seal stain and filler and thus preclude their bleeding into the finish coat.

7·4·1. Sealer may be sprayed on taking care not to flood the surface. It is allowed to dry hard.

7·4·2. A stain (toner) may be incorporated with the sealer for special colour effects.

7·4·3· When fully dry the surface shall be sanded taking care not to cut through at corners and edges. Dust shall be blown off and surface wiped with a clean rag.

7·5. *Varnishing.*—

7·5·1. Surfaces to be varnished should be prepared to produce a smooth, dry, matt surface. Previous coats of paint or stain, if any, should be allowed to dry and be rubbed down lightly, wiped off and allowed to dry.

7·5·1·1. The operation of varnishing calls for careful attention to cleanliness. All dust and dirt should be removed from the surface to be varnished and also from the neighbourhood. If the surfaces are dampened to avoid raising of the dust, they should be allowed to dry thoroughly before varnishing is commenced, Damp atmosphere and draughts should be avoided. For exterior work, a normal dry day should be chosen. Exposure to extremes of heat or cold or to a damp atmosphere will spoil the work.

7·5·1·2. In handling and applying varnish care should be taken to avoid forming froth or air bubbles. Brushes and containers should be kept scrupulously clean.

7·5·2. *Application.*—The varnish should be applied liberally with a brush and spread evenly over a portion of the surface with short light strokes to avoid frothing. It should be allowed to flow out while the next section is being laid-in. Excess varnish should then be scraped out of the brush and the first section be crossed, re-crossed and then laid off lightly. Too much or too little varnish left on the surface will mar the appearance of the finish. The varnish, once it has begun to set, should not be retouched. If a mistake is made, the varnish should be removed and the work started afresh.

7·5·2·1. Where two coats of varnish are specified, the first should be a hard-drying undercoating or flatting varnish; this should be allowed to dry hard and then be flatted down before applying the finishing coat. If two coats are applied, sufficient time should be allowed between coats.

7.5.2.2. When flat varnish is used for finishing, a preparatory coat of hard drying undercoating or flatting varnish should first be applied and should be allowed to harden thoroughly. It should then be lightly rubbed down before the flat varnish is applied. Sections of the work, such as panels, should be cut in clearly, so as to avoid any overlapping during application, as this is likely to impart some measure of gloss to partially dried areas, worked up in lapping. On large areas, the flat varnish should be applied rapidly, and the edges of each patch applied should not be allowed to set, but should be followed up whilst in free working condition.

8. *French polish* :

8·1. Pure shellac varying from pale orange to lemon yellow colour, free from resin or dirt should be dissolved in methylated spirit at the rate of 0·15 kg. of shellac per litre of spirit (see IS 348 1952). Suitable pigment should be added to get the required colour.

8·2. *Preparation of surface* :—All unevenness should be rubbed down to smoothness with sand paper and the surface should be well dusted. Fill up the pores in the wood with a filler made of a paste of whiting in water or methylated spirit (with a suitable pigment like burnt seinna or umber, if required) otherwise the french polish will get absorbed and a good gloss will be difficult to obtain.

8·3. *Application of polish* —A pad of woolen cloth covered by a fine cloth should be used to apply the polish. The pad should be moistened with polish and rubbed hard on the surface in a series of overlapping circles applying the polish sparingly but uniformly over the entire area to give an even surface. A trace of linseed oil on the face of the pad faciliates this operation. The surface should be allowed to dry and the remaining coats applied in the same way. To finish off, the pad should be covered with a fresh piece of clean fine cloth slightly damped with methylated spirit and rubbed lightly and quickly with circular motions. The finished surface should have a uniform texture and high gloss.

EXTRACT FROM I.S. 2338 (PART II) 1967.

Code of practice for finishing of wood and wood-based materials.

Part II—Schedules.

4. *Schedules for finishing wood work*:

4·1. *New wood work* :

4·1·1. *Preparation.*—The surface shall be prepared as specified in I.S. 2338. (Part I) 1967 However, the following points shall be noted :

(*a*) The surface shall be cleaned and smoothened with abrasive paper,

(*b*) The surface shall be primed,

(*c*) Knots shall be treated with two coats of shellac knotting, and

(*d*) Deep holes shall be filled with plastic wood conforming to I.S. 423-1961.

4·1·2. *Finish.*—The different coats as specified in Tables 1 and 2 shall be applied along with stopping and filling where necessary for the corresponding type of finish.

4.2. *Maintenance work.*—In the case of painting or finishing relating to maintenance work, the principles given in Table 3 should generally be adopted.

TABLE 3.—RECOMMENDED PRACTICE FOR MAINTENANCE PAINTING.

(*Clause* 4.2).

Serial number.	*Condition of Surface.*				*Cleaning and painting practice.*
	Blistering	*Cracking.*	*Checking.*	*Chalking.*	
(1)	(2)	(3)	(4)	(5)	(6)
1.	Nil.	Nil.	Nil.	Yes	Clean; rub with sand paper, apply one reviver coat.
2.	Nil.	Nil.	Yes.	Nil.	Flat down to remove checked film; clean; apply one or two reviver Coats.
3.	Nil.	Yes. Localised.	Nil.	Nil.	Rub down with steel wool/sand paper to remove cracked/crazed film; touch up with primer where damaged; apply two coats of finishing.
4.	Yes. Localised.	Nil.	Nil.	Nil.	Scrape and rub down (with sand paper) the spot to bare wood, feather out the edges of paint, allow the surface to breathe out; touch up with primer; apply two coats of finishing (with a coat of under coat, if necessary).
5.	Do.	Nil.	Nil.	Yes.	Treatments in (1) and (4) combined.
6.	Do.	Nil.	Yes.	Nil.	Treatments in ( ) and (4) combined.
7.	Do.	Yes. Deep	Nil.	Nil.	Completely remove paint to bare wood and follow the full schedule.
8.	Nil.	Yes. Deep.	Nil.	Nil.	Do.
9.	Yes. Heavy.	Nil.	Nil.	Nil.	Do.

NOTE.—Quality of paints for interior and exterior as in Tables 1 and 2.

466-3—57

EXTRACT FROM I.S. 2395 (Part I.) /1966.

Code of practice for painting concrete, masonry and plaster surfaces.

Part I—Operations and workmanship.

4. *Characteristic of the substrata and treatment* :

4.1. *General.*—In painting calcareous surfaces, careful considera-tion shall be given to the physical and chemical properties of the substrata and the backing materials which are strongly alkaline. Concrete, lime and cement plasters are likely to cause alkali attack on paint. This will have to be clearly distinguished from materials which are neutral or nearly so, as in case of calcium sulphate plasters. The characteristics of different calcareous surfaces are described in Appendix A.

4.2. *Planning of all painting operations in Relation to Dampsness in the background.*—When painting new walls, any type of paint system which will seal in the moisture shall be avoided.

4.2.1. The material for initial decoration shall, therefore, be chosen in due relation to the ultimate scheme for redecoration. If, for example, it is intended eventually to paint the surface with an oil paint, the initial decoration shall be done either with a material which can be removed easily and completely, or with one which is suitable to receive oil paint.

4.2.2. When the surface has properly set and cured and when all excess moisture has dried out from it and from the backing and further movements of moisture will be negligible, painting may be done as specified, it being merely necessary to select an alkali resistant priming paint when oil based paints are used to suit the porosity of the surface.

4.2.3. However, where it will not be possible to allow the required time. for the surface to dry out fully, the decoration in such cases shall be with a porous finish, such as lime wash, colour wash, cement paint (see Appendix B.), oil-free distemper or suitable emulsion paint which will allow drying to continue at a reasonable rate through their films. Gloss paint shall not be used until drying is complete.

If a surface remains persistently damp, the cause shall be examined and the surface suitably treated before attempting to decorate. If remedy is impractical, isolation of the affected surfaces by battening out and plastering or boarding may be necessary. Local areas affected by efflorescence (see Appendix C.) shall be cut out and re-plastered, or treated with metal foil to prevent the absorption of water from the exterior or the penetration of water into the interior (See Appendix D.)

4.3. *Painting and other finishes on both sides of the wall.*—Painting new walls or partitions on both sides may result in an increased risk of paint failure, because the means of escape of water introduced during construction operations are restricted. A difference in the porosity of the paint films applied to either side of a wall may result in one side being more affected than the other. The risk is similar and greater when only one side is painted and other side is sealed by some impermeable form of treatment, for example, wall tiling. Particularly, severe conditions may be met when walls, partitions and ceilings are built of materials that need large quantities of water for curing and setting. For all solid walls, partitions and ceilings, therefore, the precautions outlined in 4.2. shall be carefully observed.

4.4. *Variation in suction.*—The variation in suction characteristics of the surfaces to be painted require corresponding variation of the priming coat or, in some cases, the use of glue size, petrifying liquid or sealers according to the type of paint to be used. Surfaces which show local variations in suction, as for example, between individual bricks or on patches produced on plastered surfaces by local over trowelling or by efflorescence, shall be treated by the application of a suitable primer. Lime plaster finishes have a moderate suction, which can easily be counteracted by use of sealers.

4.4.1. If the suction is so high or variable that a normal painting procedure is unlikely to give a good finish, one of the following pretreatments shall be applied over the whole surface as a primer, according to the type of paint to be used ;

Type of Paint.	*Pre-treatment.*
(*a*) Size-bound distemper.	
(1) One-coat application.	A coat of clearcole.
(2) Two-coat application.	A coat of size alone will be sufficient.
(*b*) Dry distemper	A coat of the same distemper thinned with water or petrifying liquid supplied by the manufacturer. or A cost of "sharp colour" or primer-sealer with addition of finely ground pumice.
(*c*) Oil paint	A coat of thin primer or primer-sealer, preferably in consultation with the manufacturer of the paint.
(*d*) Emulsion paint	A coat of the same paint thinned with water or sealers recommended by the manufacturer.
(*e*) Cement paint and lime wash.	Wet the surface before applying paints.

4.5. *Surface imperfections.*—Imperfections on surfaces either plastered or otherwise mar the apprearence of the paint finish, and are especially conspicuous if the finish is a glossy. Where smooth finishes are required, particular attention shall be paid to the preparation of the surface, including any necessary rubbing down, sealing, stopping or filling.

Plaster, if improperly gauged and worked, is liable to develop surface crazing (map crazing). This defect, if present, shall be treated according to the method given in 6.1.2. before painting to prevent the cracks or their positions from showing in the finished work.

5. *Selection of paints* :

5.1. The selction of paints shall generally be as given in the schedules covered in IS 2395 (Part II).)

6. *Preparation of back ground.*

6.1. *For lime plaster surfaces* :

6.1.1. In the case of new lime plaster, precautions with regard to the drying of background shall be observed carefully as these will considerably affect the performance of the finish. In the case of new lime plaster, the essential principles with respect to drying of background will be the following:—

(*a*) If possible, lime plaster shall be left unpainted for the first few months so as to allow the plaster to carbonate, harden and dry thoroughly, if the plaster has any tendency to craze or crack owing to shrinkage on drying, the movements shall be allowed to occur before the surface is painted; so as to enable provisions of suitable preparatory treatment. Heating the rooms, if accompanied by good ventilation, will assist drying, but shall be cautiously adopted. Too rapid drying may damage the plaster by causing undue shrink age and separation of the plaster coats.

(*b*) If there is any objections to leaving the plaster bare, a temporary decoration of soft distemper (non-washable distemper) may be applied. This may be removed easily at a later date and replaced by a more permanent decoration. Other types of paint suitable for early application are cement paints, silicate paints, and washable distemper depending upon the final decoration in view.

(*c*) If the background of the plaster is one likely to contain large amounts of water, for example, new brickwork, concrete or building blocks, no attempt shall be made to apply oil paint (especially gloss finishes) until there is every reason to believe that the walls are thoroughly dry. Some indication of the progress in drying can be obtained by means of the tests described in Appendix E.

(*d*) If the background is of a dry type, for example, wood or metal lath, oil paints may be applied with safety after a few weeks drying, and oil-bound distempers even earlier.

6.1.2. In case of old-unpainted plaster surfaces any source of dampness in walls and ceilings shall be removed and painting shall be deferred until the plaster has dried.

Any major cracks or defects in the plaster shall be cut out and made good. Cracks may be wetted thoroughly prior to filling, or priming paint may be applied to the sides of cracks to avoid undue absorption of water and subsequent shrinkage of the filling. For filling, a retarded hemi-hydrate calcium sulphate plaster gauged with about one-third of its volume of hydrated lime may be used.

Prior to painting, fine cracks may be filled with a mixture of linseed oil, putty and white lead or a distemper type of filling composition depending on the finish which is to follow.

6.1.3. In the case of previously painted lime plaster surfaces the following precautions given in 6.1.3.1. to 6.1.3.6. shall be observed

6.1.3.1. Any existing fungus or mould growth shall be completely removed. The surface shall be thoroughly scraped and rubbed down with bristle brush and sand paper and then washed down with clean water and allowed to dry. A coat of fungicidal wash shall then be applied and allowed to dry after which a further coat shall be applied and left for sometimes to dry thoroughly. The surface shall be kept under observation during the drying out period and if the mould recurs, the treatment and drying shall be repeated before painting. The surface shall be brushed with a soft bristle brush to remove any dust particles 24 hours after the wash. Painting shall be carried out over the top of the fungicidal wash without removing it with water.

6.1.3.2. Any existing paint showing extensive flaking, bleaching, or saponification (as shown by stickiness or the presence of yellow soapy runs) shall be removed by scraping and washing and the sur face allowed to dry completely. It may then be repainted as prescribed for new surfaces.

6.1.3.3. Local defective patches shall be treated individually by removing all loose or softened paint and bringing forward the treated patches with primer and undercoating before applying a fresh coating over the whole area.

6.1.3.4. Dry distempers and lime wash shall be totally removed prior to repainting. It may sometimes be necessary to wet the surface before scraping. This shall not be overdone and all surfaces shall be perfectly dry prior to the application of any priming coats.

6.1.3.5. Certain wall and ceiling surfaces may reveal hairline cracks. After complete removal of the existing paint systems and if the lime plaster has cured and dried completely, use atleast two coats of any of the primers for the paint system to be adopted. When oil paint is to be used, the primer atleast shall be of the alkali resistant type. Lime fast pigments shall be used.

6.1.3.6. Water based paint or washable distemper, if in a clean, sound conditions need not be removed if similar coatings are to be applied in the new paint system. By using a mild detergent, the surface may be washed and then after a light sanding, will be ready to receive a fresh coat (with spot priming if required).

6.2. *For cement and cement concrete surfaces.*—For new surface it is preferable the surface is left unpainted for as long as possible to allow drying. Before painting, the surface shall be thoroughly brushed to remove all dirt and remains of loose or powdered materials.

Treatment of the surface with solution of acids or salts such as zinc sulphate is not advisable and the risk of alkali attack is not reduced appreciably and efflorescence may be increased. But on old unpainted surfaces, if there is an extensive growth of vegetable material which cannot be removed by brushing, the growth shall be destroyed by applying a wash of ammoniacal copper solution in accordance with 4.6.2. The dead and dry remains of the growth shall be brushed off prior to painting. Any loose or uneven areas or any major cracks in the cement concrete or plaster background shall be cut out and made good and the repairs allowed to dry thoroughly before painting is commenced. Minor repairs may be made with cement mortar. Cement plaster or concrete which is previously painted shall be prepared in the same manner as in 6.1.3.

6.3. *For Gypsum plaster surfaces.*—Before application of the paint it shall be ensured whether the surface is alkaline or neutral and the alkalinity may be tested in accordance with E-1.

If the surface of the plaster has a patchy appearance and shows wide varitaions in suction due to efflorescence or other causes, a paint primer shall be applied before the application of a regular paint system.

For old surfaces, unpainted or previously painted, the preparation of background will be the same as in the case of lime plasters. If it is a neutral surface, the application of a priming paint may not be necessary.

6.4. *For masonry surfaces.*—All mortar joints shall be brought to a sound condition before painting operations are started. In the case of new brickwork, painting shall be deferred for atleast three months after completion of the masonry work and longer if the weather during this period has become unfavourable for drying. Dirt may be removed by washing with water. In the case of old masonry, whenever there is extensive growth of vegetable matter, it shall be treated suitably according to 4.6. Previously painted brick work shall be prepared in the manner given at 6.1.3.

8. *Maintenance.*

8.1. *General.*

8.1.1. Existing paint work shall be cleaned or rubbed down according to its type, and damage to the plaster shall be made good.

8.1.2. Defective paint on surfaces (as shown by stickiness or the presence of soapy runs) shall be removed and the surface allowed to dry completely. Repainting on such exposed plaster shall be carried out as described for new plaster surfaces.

8.1.3. Where small patches of defective paint are removed, the area may be filled with a water filler using a broad-knife to bring it level with the surrounding surface. Water fillers shall be applied to the plaster and primed when dry. Where oil paint is to be used all patches and repairs shall be primed and brought forward with under coating. Where oil-bound water paint or emulsion paint is to be used a thin coat shall be applied prior to the general application.

8.1.4. The choice of paint system to be applied to the surface will vary according to the nature of the existing paint and that of the new finish to be applied (See IS : 2395 (Part II).

EXTRACT FROM I.S. 2395 (Part II)/1967.

Code of practice for painting concrete, masonry and plaster surfaces.

PART II—SCHEDULES.

4. *Schedules for painting calcareous surfaces.*

4.1. *New Work.*—The surfaces of concrete, masonry and palster shall be prepared as specified in 6 of IS : 2395 (Part I)/1966† and the surface of asbestos cement building products shall be prepared as given in 5 of IS : 3140–1965‡. However the following points shall be noted : -

(*a*) The surfaces are alkaline and are likely to hold large quantity of water and so the painting should be carried out when the surface is dry. However, cement paints, lime wash and colour wash tolerate a certain amount of dampness.

(*b*) The paint for initial decoration shall be chosen in due relation to the ultimate scheme of painting.

(*c*) The variation in suction characteristics requires corresponding variation of the priming coat and if necessary, treat ment recom mended in 4.4.1. of IS : 2395 (Part I) 1966 may be applied.

(*d*) The surface should be treated as recommended in 4.6.2. and 4.6.3. of IS : 2395 (Part I)/1966, if infected with algae and mould.

(*e*) If efflorescence appears, painting should be deferred until it ceases or suitable remedial measures are taken as laid down in C-3 of IS : 2395 (Part I)/1966.

4.2. *Finishing.*—

4.2.1. The different coats as specified in Tables 1 and 2 shall be applied along with pretreatments where necessary for corresponding types of paints.

4.2.2. Normally stopping or filling as required should be carried out before any painting is done and care should be taken to see that any cracks between plaster and wood work (for example skirtings) are securely filled. If such cracks are wide, caulkings with hemp or similar material may be necessary to support the filling and prevent it falling away through the gaps. Minor defects are frequently more apparent once the priming of first coat has been applied and if further stopping or filling is done over this first coat the area must be brought forward with appropriate paint to restore even porosity over the surface.

4.3. *Maintenance work.*—In the case of painting relating to maintenance work, the principles given in Table 3 should generally b adopted.

TABLE I—SCHEDULES FOR PAINTING NEW CALCAREOUS SURFACES—INTERIOR.

(*Clause* 4.2.1.)

Serial number and final finish required. (1)	*Primer coat.* (2)	*Under coat.* (3)	*Finishing coats.* (4)
1 White wash	A thinned coat of white wash.	....	White wash (two coats).
2 Colour wash	A thinned coat of colour wash.	....	Colour wash (two coats).
3 Distemper			
(*a*) Dry distemper (non- washable)	Clear coat or size etc.	Filler to be used, if required	Dry distemper (two coats). (I.S. 427–1965)
(*b*) Oil bound distemper	Alkali resistant primer	Do.	Oil bound distemper (two coats). (I.S. 428–1953).
4 Emulsion paint	A thinned *coat of emulsion paint.	Do.	Emulsion paint (two coats).
5 Flat/semigloss paint	Alkali resistant primer	Under coat as required Filler to be used, if required.	Flat/semigloss paint (two coats).
6 Gloss paint	Alkali resistant primer	Do.	Gloss Paint (two coats) (I.S. 133–1965).
7 Chemical resistant paint	A thinned coat of the paint	Filler to be used if required	Chemical resistant paint (two coats).
8 Cement paint	A thinned coat of cement paint	....	Cement paint (two coats).
9 Bituminous paint	A thinned coat of the paint	....	Bituminous paint (two coats).

* Emulsion paint may be thinned according to the manufacturer's recommendation.

TABLE 2—SCHEDULES FOR PAINTING NEW CALCAREOUS SURFACES—EXTERIOR.

(*Clause* 4.2.1.)

Serial number and final finish required.	*Primer coat.*	*Under coat.*	*Finishing coats.*
(1)	(2)	(3)	(4)
1 White wash	A thinned coat of white-wash.	Nil	White wash (two coats).
2 Colour wash	A thinned coat of colour wash.	Nil	Colour wash (two coats).
3 Emulsion P..int.	A thinned* coat of emulsion Paint.	Filler to be used, if required.	Emulsion paint† (two coats)
4 Flat/Semigloss paint	Alkali resistant primer ..	Under coat as required ..	Flat/semigloss paint (two coat.)
5 Gloss paint	Do ..	Do.	Gloss Paint (two coats) (I. S.: 2932–1964) (I. S.: 2933–1964).
6 Chemical resistant paint ..	A thinned coat of the paint	Filler to be used, if required.	Chemical resistant paint (two coats).
7 Cement paint	A thinned coat of cement paint	Nil.	Cement paint-(two coats).
8 Bituminous paint	A thinned coat of the paint ..	Nil.	Bituminous paint (two coats).

* Emulsion paint may be thinned according to the manufacturer's recommendation.

TABLE 3—RECCMMENDED PRACTICE FOR MAINTENANCE PAINTING.

(*Clause* 4.3.)

Serial number.	*Conditon of surface.*					*Cleaning and painting practice.*
	Blistering andr softening.	*Efflorescence.*	*Chalking.*	*Cracking.*	*Flaking.*	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	NIL	NIL	Yes.	NIL	NIL	Clean, rub down with abrasive paper, apply one finishing coat.
2	NIL	Yes.	Yes.	NIL	NIL	Rub down the affected surface to bare plaster, allow to dry, touch up with primer coat and then apply the required number of finishing coats and follow by a reviver coats on the entire surface, if required.
3	Yes.	NIL	NIL	NIL	NIL	Scrape off the soft film, allow the surface to dry completely, touch up with primer coat and then apply the required number of finishing coats and follow by a reviver coat on the entire surface, if required.
1	NIL	NIL	NIL	Yes. (Localised.)	NIL	Rub down and even up the surface with sand paper to remove cracked film. Touch up with primer, and apply the required number of finishing coats and follow by a reviver coat on the entire surface, if required.
:	NIL	NIL	NIL	NIL	Yes.	Remove the paint from the affected portion completely and follow part or full schedule of painting as the case may be.

NOTE.—1. In case of any serious characteristics failure mentioned above (except chalking), the paint should be completely removed and the full schedule of painting be followed.

NOTE.—2. There is no effective remedy for efflorescence.

EXTRACT FROM C. P. W. D. SPECIFICATION.

Painting.

13.33. *Painting (General).*

13.33.1. *Materials.*—Paints, Oils, Varnishes, etc., of approved brand and manufacture shall be used. Ready mixed paint as received from the manufacturer without any admixture shall be used.

If for any reason, thinning is necessary in case of ready mixed paint, the brand of thinner recommended by the manufacturer or as instructed by the Engineer-in-charge shall be used.

Approved paints, Oils or Varnishes shall be brought to the site of work by the contractor in their original containers in sealed condition. The material shall be brought in at a time in a l quate quantities to suffice for the whole work or atleast a fortnight's work. The materials shall be kept in the joint custody of the contractor and the Engineer-in-charge. The empties shall not be removed from the site of work, till the relevant item of work has been completed and permission obtained from the Engineer-in-charge.

13.33.2. *Commencing work.*—Painting shall not be started until the Engineer-in-charge has inspected the items of work to be painted, satisfied himself about their proper quality and given his approval to commence the painting work.

Painting except the priming coat, shall generally be taken in hand after all other builders work is practically finished.

The rooms should be thoroughly swept out and the entire building cleaned up, at least one day in advance of the paint work being started.

13.33.3. *Preparation of surface.*—The surface shall be thoroughly cleaned and dusted. All rust, dirt, scales, smoke and grease shall be thoroughly removed before painting is started. The prepared surface shall have received the approval of the Engineer-in-charge after inspection, before painting is commenced.

13.33.4. *Application.*—Before pouring into smaller containers for use, the paint shall be stirred thoroughly in its containers, when applying also, the painting shall be continuously stirred in the smaller containers so that its consistency is kept uniform.

The painting shall be laid on evenly and smoothly by means of crossing and laying off, the later in the direction of the grain of wood. The crossing and laying off consists of covering the area over with paint, brushing the surface hard for the first time over and then brushing alternately in opposite direction, two or three times and then finally brushing lightly in a direction at right angles to the same. In this process, no brush marks shall be left after laying off is finished. The full process of crossing and laying off will constitute one coat.

Where so stipulated, the painting shall be done by spraying. Spray machine, used may be (*a*) high pressure (small air pressure) type or (*b*) a low pressure (large air gap) type, depending on the nature and location of work to be carried out. Skilled and experienced workmen shall be employed for this class of work. Paints used shall be brought to the requisite consistency by adding a suitable thinner.

Spraying should be done only when dry condition prevails.

Each coat shall be allowed to dry out thoroughly and rubbed smooth before the next coat is applied. This should be facilitated by thorough ventilation.

Each coat except the last coat, shall be lightly rubbed down with sand paper or fine pumice stone and cleaned off dust before the next coat is laid.

No left over paint shall be put back into the stock tins. When not in use, the containers shall be kept properly closed.

No hair marks from the brush or clogging of paint puddles in the corners of panels angles of mouldings etc., shall be left on the work.

In painting doors and windows, the putty round the glass panes must also be painted ; but care must be taken to see that no paint stains, etc., are left on the glass. Tops of shutters and surfaces in similar hidden locations shall not be left out in painting.

In painting steel work, special care shall be taken while painting over bolts, nuts, rivets, overlaps, etc.

The additional specifications for primer and other coats of paints shall be as according to the detailed specifications under the respective headings.

13.33.5. *Brushes and containers.*—After work, the brushes shall be completely cleaned of paint and linseed oil by rinsing with turpentine. A brush in which paint has dried up is ruined and shall on no account be used for painting work. The containers, when not in use, shall be kept closed and free from air so that paint does not thicken and also shall be kept safe from dust. When the paint has been used, the containers shall be washed with turpentine and wiped dry with soft clean cloth, so that they are clean, and can be used again.

13.33.6. *Measurements*—

13.33.6.1. The units of measurement for painting except where otherwise shaded shall be given in " sq. metres ".

13.33.6.2. Small articles not exceeding 10 sq. decimetres (0·1 sq. m.) of painted surfaces where not in conjunction with similar painted work shall be enumerated.

13.33.6.3. Painting up 15 cm. in width or in girth and not in conjuction with similar painted work shall be given in running metres.

NOTE—Compress of trusses compound girders, stanchions, lattices and similar work shall, however, be given in sq. metres irrespective of the size of girth of members.

13.33.6.4. In measuring, painting, varnishing, oiling, etc., of joinery and steel work, etc., the co-efficient as in the following table shall be used to obtain the area payable.

The ceofficients shall be applied to the areas measured flat and not girthed, in all cases :—

Table of co-efficients to be applied over areas of different surfaces to get equivalent plain areas :—

Serial number and description of work. (1)	*Multiplying co-efficient.* (2)
WOODWORK—DOORS—WINDOWS, ETC.	
1. Panalled or framed and braced doors, windows etc.	1·30 (for each side).
2. Ledged and battened or ledged, battened and braced, doors, windows, etc.	Do.
3. Flush doors, etc.	1·20 (for each side).
4. Part panalled and part glassed or gauged doors, windows, etc.	1·0 (Do.)
5. Fully glazed or gauged doors, windows, etc.	0·80 (for each side).
6. Fully venetioned or louvered doors, windows etc.	1·80 (for each side).
7. Trellis (or Jaffri) work one way or two way.	2 (for painting all over).

Serial number and description of work. (1)	*Multiplying Co-efficient.* (2)
8. Carved or enriched work ..	2 (for each side).
9. Whether boarding	1.20 (for each side).
10. Wood shingle roofing ..	1.10 (for each side).
11. Boarding with cover fillets and match boarding.	1.05 (for each side).
12. Tile and slate battening ..	0.80 (for painting all over).
13. Plain sheeted steel doors or windows.	1.10 (for each-side).
14. Fully glazed or gauged steel doors and windows.	0.50 (for each-side).
15. Partly panalled and partly glazed or gauged doors and windows.	0.80 (for each side).
16. Corrugated sheeted steel doors or windows.	1.25 (for each side).
17. Collapsible gates	1.50 (for painting all over).
18. Rolling shutters of inter-locked laths.	1.10 (for each side).
General work :	
19. Expanded metal, hard drawn steel wire fabric of approved quality, grill work and gratings in guard bars, balustrades, railings and partitions.	1 (for painting all over).
20. Open Palisade fencing and gates including standards, braces, rails stays, etc., in timber or steel.	1 (for painting all over).
NOTE : The height shall be taken from the bottom of the lowest rail, if the palisades do not go below it (or from the lower end of palisades, if they project below the lowest rail) up to the top of palisades but not upto the top of standards, if they are higher than the palisades.	
21. Corrugated iron sheeting in roofs, side cladding etc.	1.14 (for each side).
22. A.C. Corrugated sheeting in roofs side cladding etc.	1.20 (for each side).
23. A.C. Semi-corrugated sheeting in roofs side cladding etc. (or Nainital pattern using plain sheets).	1.10 (for each side).
24. Wire gauge shutters including painting of wire gauge.	1 (for each side).

Explanatory notes on the table of co-efficients in para 13.33.6.4.

(1) Where doors, windows, etc., are of composite types other than those included in para 13-33—6 —4 the different portion shall be measured separately with their appropriate co-efficients the centre line of the common rail being taken as the dividing line between the two portions.

(2) Measurements for doors, woindows, etc., shall be taken flat (and not girthed) over all including chowkhats or frames, where provided. Where chowkhats or frames are not provided, the shutter measurements shall be taken.

(3) Collapsible gates shall be measured for width from outside to outside of gate in its expanded position and for height from bottom to top of channel verticals. No separate measurements shall be taken for the top and bottom guide rails rollers, fittings, etc.

(4) Rolling shutters of interlocked laths shall be measured or the actual shutter width and the height from bottom of opening to the centre of the shaft. No separate measurements shall be taken for painting guides and other exposed features within or outside the shutter area. The painting of top cover or hood shall however be measured separately.

(5) Co-efficients for sliding doors shall be the same as for normal types of doors in the table. Measurements shall be taken outside to outside of sheltters, and no separate measurements shall be taken or painting guides, rollers, fittings, etc.

(6) Measurements of painting of doors, windows, collapsible gates, rolling shutters, etc., as above shall be deemed to include painting all iron fittings in the same or different shade for which no extra will be paid.

(7) The measurements as above shall be deemed to include also the painting of edges, blocks, cleats, etc., for which no extra will be paid.

(8) The co-efficients for doors and windows shall apply irrespective of the size of frames and shutter members.

(9) When the two faces of a door, window, etc., are to be treated with different specified finishes, measureable under separate items, the edges of frames and shutters shall be treated with the one or the other type of finish as ordered by the Engineer-in-charge, and the measurement of this will be deemed to be included in the measurement of the face treated with that finish.

(10) In the case where shutters are fixed on both faces of the frames, the measurement for the door frame and shutter on one face shall be taken in the manner already described, while the additional shutter on the other face will be measured for the shutter area only excluding the frame.

(11) Where the shutters are provided with clearance at top or/ and bottom such openings shall be deducted from the overall measurements and relevant co-efficients shall be applied to obtain the area payable.

(12) In case of trellis (or jaffri) work, the measurements shall include the painting of the frame member for which no separate measurements shall be taken. Trellis door or window shutters shall also be measured under trellis work.

(13) Measurements of guard bars expanded metal, hard drawn steel wire fabric of approved quality grill work and gratings, when fixed in frame work, painting of which is once measured elsewhere shall be taken exclusive of the frames. In other cases the measurements sjhall be taken inclusive of the frames.

(14) For painting open palisade fencing and gates etc., the height shall be measured from the bottom of the lowest rail, if the palisades do not go below it. (or from the lower end of the palisades, if they projects below the lowest rail), upto the top of the rails or palisades whichever are higher, but not upto the top of the standards when the latter are higher than the top rails or the palisades.

(15) In the case of asbestos cement corrugated or semi-corrugated sheeting and iron corrugated sheeting in roofs, side cladding etc., the work shall be measured flat (not girthed) as fixed.

13.33.6.5. Width of moulded work of all other kinds, as in hand rails, cornices, architraves shall be measured by girth.

13.33.6.6. For trusses compound girders, stanchions, lattice girders, and similar work, actual areas will be measured in sq.metres and no extra shall be paid for painting on bolt heads, nuts, washers etc., even when they are picked out in a different tint to the adjacent work.

13.33.6.7. Painting of rain water, soil, waste, vent and water pipes, etc., shall be measured in running metres of the particular diameter of the pipe concerned. Painting of specials such as bends heads, branches, junctions, shoes etc., shall be included in the length and no separate measurements shall be taken for these or for painting brackets, clamps, etc.

13.33.6.8. Measurements of wall surfaces and wood and other work not referred to already shall be recorded as per actuals.

13.33.6.9. Flag staffs, steel chimneys, aerial masts, spires and other such objects requiring special scaffolding shall be measured separately.

13.33.6.10. Length and breadth shall be measured correct to a cm. When one or more coates are required to be applied to metal work before fixing, this shall be started and measured separately from painting applied after fixing.

13.33.7. *Precautions.*—All furnitures, fixtures, glazing, floors etc., shall be protected by covering and stains, smears, splashings, if any, shall be removed and any damage done shall be made good by the contractor at his cost.

13.33.8. *Rate.*—Rates shall include cost of all labour and materials involved in all the operations described above and in the particlular specifications given under the several items.

13'34 *Painting priming coat on wood, iron or plastered surfaces.*

13.34.2. *Preparation of surface* :

13.34.2.1. *Wood work.*—The wood work to be painted shall be dry and free from moisture. The surface shall be thoroughly cleaned. All unevenness shall be rubbed down smooth with sand paper and shall be well dusted. Knots, if any shall be covered with preparation of red lead made by grinding red lead in water and mixing with stong glue sized and used hot.

The surface treated for knotting shall be dry before painting is applied. After the priming coat is applied, the holes and indentation of the surface shall be stopped with glazier's putty or wood putty. Stopping shall not be done before the priming coat is applied as the wood will absorb the oil in the stopping and the latter is therefore liable to crack.

13.34.2.2. *Iron and steel work.*— All rust and scales shall be removed by scrapping or by brushing with steel wire brushes. Hard skin of oxide formed on the surface of wrought iron during rolling which becomes loose by rusting, shall be removed.

All dust and dirt shall be thoroughly wiped away from the surface.

If the surface is wet, it shall be dried before priming coat is undertaken.

13.34.2.3. *Plastered surface* .—The surface shall ordinarily not be painted until it has dried completely. Trial patches of primer shall be laid at intervals and where drying is satisfactory, painting shall be taken in hand. Before primer is applied, holes and undulations, shall be filled up with plaster of paris and rubbed smooth.

13·54 *Removing old paint* :

13·54·1. Removing old paint with patent paint remover and preparing surface.

13·54·1·1. *Paint remover*— Patent paint remover shall consist of volatile organic liquids thickened with waxes and other ingredients to retard the evaporation of the liquid and to enable a substantial layer of remover to be applied to the surface.

The paint remover shall be of a brand and manufacture approved by the Engineer-in-charge.

It shall be free from alkaline matter and non-caustic so that it can be handled by workmen without injury. It shall be non-inflammable quality as far as possible.

13·54·1·2. *Application.*— Paint remover shall be used where burning off with blow lamp is not suitable. The paint remover shall be applied liberally with a brush and allowed to remain on the surface for a period depending on the particular brand of remover used and on the thickness of the paint coating to be removed. When the paint film lifts and wrinkles under the action of the remover it shall be stripped with a sharp instrument. If the film is not thoroughly removed, a second coat of remover may be applied if necessary over such patches and then the film thoroughly scrapped off.

After the surface has been stripped, it shall be washed down with mineral turpentine to remove all traces of paraffin wax, which forms one of the ingredients of patent paint remover and which if left in place will prevent the paint from drying.

The cleaned surface shall be suitably prepared for application of paint or other finish.

13·54·1·3· *Precautions.*— Where the paint remover used is of the inflammable type, suitable precaution against risk of fire shall be taken.

Neighbouring painted surfaces which are not to be treated should be properly protected from contact with paint remover.

13·54·1·4· *Preparation of surface.*— The surface shall then be prepared as described in para 13·34·2 for *"Painting with priming Coat"*

13·54·1·5· *Measurements.*— Specification in para 13·33·6 will hold good.

13·54·1·6. *Rate.* – Rate shall include the cost of all labour and materials involved in all operations described above.

13·54·1·7. *Other details.*— Specification for " Painting (General) " in paragraph 13·33 shall hold good as far as possible.

13·54·2. *Removing old paint with caustic soda solution and preparation of surface* :

12·54·2·1. *Application.*— Caustic soda dissolved with 48 times its volume of water shall be applied to the old paint with a brush and when the paint film lifts and wrinkless it shall be thoroughly scrapped off in the same way as in sub-paragraph 13·54·1·2. After the surface has been stripped thoroughly, it shall be rinsed with several changes of clean water to remove all traces of alkali, which if allowed to remain are liable to spoil the new paint applied over it. A little acetic acid or vinegar added to the final change of rinsing water helps to neutralize any remaining alkali.

13 54·2·2. *Precaution.*— Caustic soda as its name implies is a corrosive liquid and care should be taken to see that no liquid spills over the skin or clothing.

13·54·2·3. *Preparation of surface, measurements, rate and other details* : – The specification for these shall be the same as in corresponding sub paragraph of 13·54·1.

13·54·3. *Removing old paint with blow lamp and preparing surface.*

13·54·3·1. The paint shall be removed either with a blow lamp or with an areacetylene equipment. The flame shall be allowed to play upon the paint just enough to soften it without charring either the paint or the background. The softened paint shall then be removed with a stripping knife following the flame as it is moved up the surface.

Burning off shall begin at the bottom of a vertical surface and shall proceed upwards.

13·54·3·2. *Precautions.*— Removal with blow lamp shall not be done on narrow or carved under cut surfaces or where there is risk of damage to neighbouring materials such as panes in glazed windows.

13·54·3·3. *Preparation of surface, measurements, rate and other details.* – The specifications for these shall be the same as in the corresponding sub-paragraphs of 13·54·1.