

Chapter 4

Reinforced Cement Concrete

4.0 GENERAL

Reinforced cement concrete work may be cast-in-situ or pre-cast as may be directed by the Engineer according to the nature of work. Reinforced cement concrete work shall comprise of the following which may be paid separately or collectively as per the description of the item of work.

- b) Form work (Centring and Shuttering) Reinforcement
- c) Concreting : (1) Cast-in-situ (2) Pre-cast

4.1 MATERIALS

4.1.1 General

Water, cement, fine and coarse aggregate shall be as specified under respective paras of Chapter 26 - Mortars and Chapter 3 - Concrete Work as applicable. Portland Pozzolana Cement described in Chapter 26 cannot be used for PSC works and can be used for RCC works with certain precautions. The cement used shall be any of the following and the type selected should be appropriate for the intended use.

- (a) 33 grade ordinary Portland cement conforming to IS:269
- (b) 43 grade ordinary Portland cement conforming to IS: 8112
- (c) 53 grade ordinary Portland cement conforming to IS:12269
- (d) Rapid hardening Portland cement conforming to IS:8041
- (e) Portland Slag cement conforming to IS:455
- (f) Portland pozzolona cement (flyash based) conforming to IS:1489 (part 1)
- (g) Portland Pozzolana cement (calcined clay based) conforming to IS:1489 (part 2)
- (h) Hydrophobic cement conforming to IS:8043.
- (i) Low heat Portland cement conforming to IS:12600
- (j) Sulphate resisting Portland cement conforming to IS:12330.

Different types of cement shall not be mixed together. In case more than one type of

cement is used in any work, a record shall be kept showing the location and the types of cement used.

4.1.2 Steel for Reinforcement

The Steel reinforcement for RCC Works shall be any of the following types:-

- a) Mild steel and medium tensile bars conforming to IS: 432 (Part.I) (some important provisions are included in Para 4.1.3 below)
- b) High strength deformed steel bars conforming to IS:1786 (some important provisions are included in Para 4.1.4 below)
- c) Hard drawn steel wire fabric conforming to IS:1566
- d) Rolled Steel Structural steel conforming to IS: 2062 Grade A & Grade B. Thermo-mechanically treated bars TMT Bars (Refer Annexure 4.1)

4.1.3 Mild Steel & Medium Tensile Steel

4.1.3.1 Types and Grades

Reinforcement supplied in accordance with Para 4.1.2 shall be classified into the following types :

- a) Mild steel bars: It shall be supplied in the following two grades.
 - i) Mild steel bars grade I designated as Fe 410--S
 - ii) Mild steel bars grade II designated as Fe 410-O
- b) Medium tensile steel bars, grade II designated as Fe-540-W-HT.

Independent test check on quality of steel drawn from each lot shall be conducted. The Modulus of elasticity of steel shall be taken as 200 KN/ mm². The characteristic yield strength of different steel shall be assumed as the minimum yield stress / 0.2 percent of proof stress specified in the relevant Indian Standard.

4.1.3.2 Nominal Mass/Weight

The tolerance on mass/weight for round and square bars shall be the percentage given in Table 4.1 of the mass/weight calculated on the basis that steel weighs 0.785 kg/cm², cross sectional area per metre run.

TABLE 4.1
TOLERANCE ON NOMINAL MASS

Nominal size in mm	Tolerance* on the nominal mass Percent		
	Batch	Individual sample **	Individual sample for coil ***
(a) Up to and including 10	± 7	± 8	± 8
(b) Over 10 up to and including 16	+5	-6	+6
(c) Over 16	± 3	-4	+4

* tolerance shall be determined in accordance with method given in IS:1786.

** for individual sample, plus tolerance is not specified for (b) and (c).

*** for coil batch tolerance is not applicable.

4.1.3.3 Physical Requirement

Physical requirements are given in Table 4.2.

TABLE 4.2

SL	Type and nominal size of bar	Ultimate tensile Stress N/mm ² minimum	Yield stress N/mm ²	Elongation percent minimum
1.	Mild steel grade I For bars upto and including 20 mm	410	250	23
	For bars over 20 mm upto and including 50 mm	410	240	23
2.	Mild steel grade II For bars upto and including 20 mm	370	225	23
	For bars over 20 mm upto and including 50 mm	370	215	23
3.	Medium tensile steel For bars upto and including 16 mm	540	350	20
	For bars over 16 mm, upto and including 32 mm	540	340	20
	For bars over 32mm, upto and including 50mm	510	330	20

Elongation Percent is on gauge length of $5.65 \sqrt{S_0}$ where S_0 is the cross sectional area of the test piece.

Note : 1. Grade (II) Mild steel bars are not recommended for use in structures located in earthquake zone subjected to severe damage and for structures subjected to dynamic loading (other than wind loading) such as bridges. Grade II Mild Steel Bars shall not be used in Railway Bridges. (Refer Correction Slip No.2 dated 17.05.2000 to Concrete Bridge Code).

2. Welding of reinforcement bars covered in this specification shall be done in accordance with requirements of IS:2751.

4.1.3.4 Selection and Preparation of Test Sample :

This shall be done in accordance with provisions of IS :1786. All test pieces shall be selected by the Engineer or his authorized representative either –

a. From cutting of bars

or

b. If he so desires, from any bar after it has been cut to the required or specified size and the test piece taken from any part of it.

In neither case, the test pieces shall be detached from the bar or coil except in the presence of the Engineer or his authorized representative.

The test pieces obtained in accordance with above shall be full sections of the bars as rolled and shall be subjected to physical tests without any further modifications. No reduction in size by machining or otherwise shall be permissible except in case of bars of size 28mm and above. No test piece shall be annealed or otherwise subject to heat treatment. Any straightening which a test piece may require shall be done cold.

4.1.3.5 Testing

Following lab tests shall be carried out

- a) Tensile Tests : This shall be done as per IS:1608.
- b) Bend Test : This shall be done as per IS:1599.

4.1.3.6 Retest

Should any one of the test pieces first selected fail to pass any of the tests specified above, two further samples shall be selected for testing in respect of each failure. Should the test pieces from both these additional samples pass, the materials represented by the test samples shall be deemed to comply with the requirement of the 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 standard.

4.1.4.1.4 High strength Deformed Bars and Wires.

4.1.4.1 Physical Requirements

For all sizes of steel bars, requirements are mentioned below in Table 4.3.

TABLE 4.3

SL	Property	Grade		
		Fe 415	Fe 500	Fe 550
1.	0.2% proof Stress/yield stress, min. N/mm ²	415	500	550
2.	Elongation, percent min. on gauge length $5.65\sqrt{S_o}$, where S_o is the X-Sectional Area of the test piece.	14.5	12	8
3.	Tensile strength	10% more than actual 0.2% proof stress but not less than 465 N/mm ²	8% more than actual 0.2% proof stress but not less than 545 N/mm ²	6% more than actual 0.2% proof stress but not less than 585 N/mm ²

4.1.4.2 Selection and Preparation of Test Sample

Please refer Para 4.1.3.4 above.

4.1.4.3 Testing

Following lab tests shall be carried out

1. Tensile Test. This shall be done as per IS:1608.
2. Bend Test: This shall be done as per IS:1599
3. Rebend Test: This shall be done as per IS:1786

4.1.4.4 Rebend test (As per IS-1786)

Please refer Para 4.1.3.6 above.

4.1.5 Thermo-Mechanically Treated Bars

Note on these bars is at Annexure 4.1.

4.1.6 Stacking and Storage

Steel for reinforcement shall be stored in such a way as to prevent distortion and

corrosion. Care shall be taken to protect the reinforcement from exposure to saline atmosphere during storage, fabrication and use. It may be achieved by treating the surface of reinforcement with cement wash or by other suitable methods. Bars of different classifications, sizes and lengths shall be stored separately to facilitate issue in such sizes and lengths to cause minimum wastage in cutting from standard length.

In case of long storage reinforcement bars shall be stacked above ground level by at least 150 mm upon platforms, skids, or other suitable supports to avoid distortion of sections. A coat of cement wash shall be given for such long storage to prevent scaling and rusting.

4.1.7 FUSION BONDED EPOXY COATED REINFORCING BARS – As per IS 13620 : 1993 (Some important para of the above IS

code are reproduced below for information and guidance.

1 SCOPE

This standard covers deformed steel reinforcing bars with protective epoxy coating applied by electrostatic spray method.

2 REFERENCES

The Indian Standards mentioned below are a necessary adjunct to this standard:

IS No.	Title
1786 : 1985	High strength deformed steel bars and wires for concrete reinforcement (third revision)
6885 : 1973	Method for knoop hardness testing of metals

3. COATING MATERIALS

3.1 The coating material shall meet the requirements specified in Annex A.

3.2 The patching or repairing material or both, shall be compatible with the coating, inert in concrete and feasible for repairs at the coating plant or in the field. This material shall be approved by the purchaser prior to use. The patching or repair shall be performed in accordance with the recommendation of the material manufacturer.

4. REINFORCING STEEL

4.1 Steel reinforcing bars to be coated shall conform to IS 1786 : 1985.

5. SURFACE PREPARATION

5.1 The surface of the steel reinforcing bars to be coated shall be cleaned by abrasive blast cleaning to near white metal. The surface profile shall be free from mill scale, rust and foreign matter when viewed under well-lit conditions.

5.2 The coating shall be applied to the cleaned surface as soon as possible after cleaning. Any formation of rust blooms on the cleaned bars is to be removed by blast cleaning before application of the coating. However, in no case shall the coating be delayed more than eight hours after cleaning unless otherwise permitted by the purchaser.

6 APPLICATION OF COATING

The coating shall be applied as an electrostatically charged dry powder sprayed onto the grounded steel bar using an electrostatic spray gun. The powder may be applied to either a hot or cold bar. The

coated bar shall be given a thermal treatment specified by the manufacturer of the epoxy resin which will provide a fully cured finish coating. Temperature shall be controlled as recommended by the manufacturer of the coating to ensure a workman like job without blistering or other defects.

7. REQUIREMENTS OF COATED BARS

5.1.1 Coating Thickness

7.1.1 For acceptance purpose at least 90 percent of all coating thickness measurements shall be 0.1 mm to 0.3 mm after curing. The coating thickness limits do not apply to patched areas. A minimum of 15 measurements shall be taken approximately evenly spaced along each side of the test bar. At least 90 percent of these measurements shall be within the specified limits.

NOTE - By mutual agreement between the purchaser and the manufacturer, thicker coating may be accepted where the bars are not to be bent or worked after the coating has been applied.

7.2 Continuity of Coating

The coating shall be visually inspected after curing for continuity of the coating and shall be free from holes, voids, contamination, cracks and damaged areas discernible to the unaided eye. In addition, there shall be not more than an average of two holidays per 300mm when tested in accordance with **8.2**.

7.3 Adhesion

The adhesion of coating shall be evaluated on a representative number of bars selected in accordance with **9.4** from each production lot. No visible cracks of disbanding in the coating on the outside radius shall be allowed when tested in accordance with **8.3**.

8. TEST METHODS

8.1 The thickness of the coating shall be measured on the body of reinforcing bar between deformations and ribs or both, on a straight length. Non-destructive coating thickness measurements using magnetic gauges shall be used.

8.1.1 'Pencil' type pull-off gauges which require the operator to observe the reading at the instant the magnet is pulled from the surface and do not hold shims tightly against the steel plate during calibration are not recommended for use.

8.1.2 Gauge calibrating with shims shall be performed on a smooth, clean, low-carbon

steel plate (at least 75x75x13 mm), rather than on a clean reinforcing bar.

8.1.3 A correction factor defining the effect of the bar preparation process shall be obtained as the difference between (a) the average of the 10 gauge readings on a cleaned but uncoated reinforcing bar of the size and lot being coated and (b) the average of 5 gauge readings on a smooth mild steel plate. This correction factor shall then be subtracted from all subsequent gauge readings on coated bars.

8.1.4 Fixed probe gauges shall be checked to ensure that the force generated by the spring loaded probe housing is sufficient to ensure intimate contact between the probe tip and the coating on the curved bar surface. If intimate contact does not result, it will be necessary to remove the probe housing and utilize hand-pressure to obtain valid indicated thicknesses.

8.2 Holidays

Table 1 Mandrel diameter for Bend Test Requirement (Clause 8.3)

Bar diameter (mm)	Mandrel Diameter (mm)
(1)	(2)
6	60
7	80
10	100
12	100
16	125
18	150
20	150
22	200
25	200
28	225
32	280
36	280
40	400
45	450
50	500

9. FREQUENCY OF TEST

9.1 Coating thickness shall be tested at a frequency of not less than one full length bar every twenty bars for each size.

9.2 Continuity of coating shall be determined by testing one full length bars for each size.

9.3 Coating thickness over the whole of the coated bar section shall be determined

A 67.5 volts holiday detector shall be used in accordance with detector manufacturer's instructions. Detector may be an in line DC detector or a hand held DC detector.

8.3 Adhesion of Coating

The adhesion of the coating shall be evaluated by bending production coated bars 120 degrees (after rebound) around a mandrel of size as prescribed in Table 1. The bend test shall be made at a uniform rate and shall take up to 90 seconds to complete. The two longitudinal deformations shall be placed in a plane perpendicular to the mandrel radius and the test specimen shall be at thermal equilibrium between 25 C and 35 C.

NOTE – the fracture or partial failure of steel reinforcing bar in the bend test for adhesion of coating shall not be considered as an adhesion failure of the coating.

by sectioning and examining one bar in every twenty bars for each size.

9.4 For testing adhesion of coating, samples shall be selected from each size according to the frequency given below:

Nominal Bar Size/mm	No. of Samples
Up to 16	1 for every 1 T
Above 16 and upto 25	1 for every 2 T
Above 25	1 for every 4 T

10. RETEST

10.1 If the specimen for coating thickness or for adhesion of coating fails to meet the specified requirements, twice the number of samples originally selected shall be tested for each failure test. If the results of these retests meet the specified requirements, the coated bar represented by the samples shall be accepted.

11. HANDLING AND IDENTIFICATION

11.1 All systems for handling coated bars shall have padded contact areas. All bundling shall be used to prevent damage to the coating. All bundles of coated bars shall be lifted with a strong back, spreader bar, multiple supports, or a platform bridge to prevent bar-to-bar abrasion from sags in the bundles of coated bars. The bars or bundles shall not be dropped or dragged.

11.2 The identification of all reinforcing bars shall be maintained throughout the fabrication and coating processes to the pint of shipment.

12. INSPECTION

All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified.

13. PERMISSIBLE COATING DAMAGE AND REPAIR AFTER COATING APPLICATION

13.1 Coating damage due to fabrication and handling need not be repaired in case where the damaged area is 40 mm² or smaller.

13.2 All damaged areas larger than 40 mm² shall be repaired with patching material.

13.3 Maximum amount of damage shall not exceed 2 percent of the surface area of each bar (total of damage in **13.1** and **13.2**)

13.4 Patching shall be done in accordance with the patching material manufacturer's recommendations.

14. REJECTION

Coated bars represented by the samples that do not meet the requirements of this specification shall be rejected. By mutual agreement between the purchaser and the manufacturer, such bar may be stripped of coating, recleaned, re-coated, and resubmitted for acceptance test in accordance with the requirements of the specification.

15. MANUFACTURER'S CERTIFICATE

If requested by the purchaser, the manufacturer shall furnish, at the time of shipment, a written certificate that the

coated reinforcing bars meet the requirements of this specification.

16. IDENTIFICATION AND MARKING

16.1 The manufacturer or supplier shall mark the bars in such a way that all finished bars can be traced to the cast from which they are made or the original identification mark of the bars.

16.2 Each bundle containing the bars may also be suitably marked with the Standard Mark in which case the concerned test certificate shall also bear the Standard Mark.

For each bundle of bars a tag shall be attached indicating the Cast No./Lot No., grade and size of bars

4.2 FORM WORK (CENTRING AND SHUTTERING)**4.2.1 Form Work**

Form work, also termed as false work in IS: 14687, shall include all temporary or permanent forms or moulds required for forming the concrete which is cast-in-situ, together with all temporary construction required for their support. For detailed Guidelines on Form work for Concrete structures, IS: 14687 may be referred to.

4.2.2 Design & Tolerance in Construction

Form work shall be designed and constructed to the shapes, lines and dimensions shown on the drawings with the tolerances given below. (Clause 9.6 of IS:14687)

- a) Deviation from specified dimension of cross section of Columns and beams :
+ 12 mm to - 6 mm
- b) Deviation from dimensions of footings
 - i) Dimension in Plan : + 50 mm to - 12 mm
 - ii) Eccentricity in plan : 0.02 times the width of footings in the direction of deviation but not more than 50mm.
 - iii) Thickness : ± 0.05 times the specified thickness.

(Note : Tolerances apply to concrete dimensions only and not to positioning of vertical steel or dowels).

4.2.3 General Requirement

- a) Forms shall be designed to ensure safety of permanent constructions and of workmen.
- b) The design of form work shall conform to sound Engineering practices and relevant IS codes. It shall be strong enough to withstand the dead and live loads and forces caused by ramming and vibrations of

concrete and other incidental loads, imposed upon it during and after casting of concrete. It shall be made sufficiently rigid by using adequate number of ties and braces. Screw jacks or hard board wedges where required shall be provided to make up any settlement in the form work either before or during the placing of concrete.

c) Forms shall be so constructed as to be removable in sections in the desired sequence, without damaging the surface of concrete or disturbing other sections. Care shall be taken to see that no piece is keyed into the concrete.

d) The scheme of Form work should facilitate adequate and safe access to all areas for inspection.

e) The Form work shall be erected such that the shape and dimensions of the Concrete Structures conform to the drawings, the specifications and tolerances. Cambers, bevelled edges and mouldings if specified should be provided in the Form.

f) Commercially available Form work may be used provided they satisfy the requirements mentioned in IS: 14687-1999.

4.2.3.1 Material for Form Work

a) Propping and Centring: All propping and centring should be either of steel tubes with extension pieces or built up sections of rolled steel. Use of wooden ballies should be discouraged.

b) Centring / Staging: Staging should be as designed with required extension pieces as approved by Engineer to ensure proper slopes, as per design for slabs/beams etc. and as per levels as shown in drawings. All stagings should be either of Tubular steel structure with adequate bracings as approved or made of built up structural sections made from rolled structural steel sections.

c) In case of structures with two or more floors, the weight of concrete, centering and shuttering of any upper floor being cast shall be suitably supported on one floor below the top most floor already cast.

d) Form work and concreting of upper floor shall not be done until concrete of lower floor has set at least for 14 days.

4.2.3.2 Shuttering

Shuttering used shall be of sufficient stiffness to avoid excessive deflection and joints shall be tightly butted to avoid leakage of slurry. If required, rubberized lining of

material as approved by the Engineer shall be provided in the joints.

Steel shuttering used for concreting should be sufficiently stiffened. The steel shuttering should also be properly repaired before use and properly cleaned to avoid stains, honey combing, seepage of slurry through joints etc. Timber Shuttering should be discouraged and should be permitted only with the specific approval of the Engineer. This is in consideration of conservation of timber and the fact that the finish of concrete surface with timber shuttering cannot be as good as with steel shuttering. If wood forms are allowed to be used, the boards must be uniform in thickness, tongued and grooved, smoothly finished on the surface next to the concreting evenly matched and tightly placed, except where the desired surface or appearance requires special treatment use of forms of Plywood / similar product which can absorb water is recommended.

4.2.3.3 Design of Form Work

Form work shall be properly designed for self weight, weight of reinforcement, weight of fresh concrete, and in addition, the various live loads likely to be imposed during the construction process (such as workmen, materials and equipment). In case the height of centering exceeds 3.50 metres, the prop may be provided in multi-stages.

4.2.3.4 Camber

Suitable camber shall be provided in horizontal members of structure, especially in cantilever spans to counteract the effect of deflection. The form work shall be so assembled as to provide for camber. The camber for beams and slabs shall be 4 mm per metre (1 to 250) or as directed by the Engineer, so as to offset the subsequent deflection. For cantilevers the camber at free end shall be $1/50^{\text{th}}$ of the projected length or as directed by the Engineer.

4.2.3.5 Walls

The form faces have to be kept at fixed distance apart and an arrangement of wall ties with spacer tubes or bolts is considered best. The two shutters of the wall are to be kept in place by appropriate ties, braces and studs.

4.2.3.6 Removal of Form work (Stripping time)

In normal circumstances and where ordinary Portland cement is used, forms may generally be removed after the expiry of the following periods. (Based on Clause 9.5.1 of IS: 14687-1999)

Type of Formwork	Minimum Period before striking Form work
(a) Vertical formwork to columns, walls, beams	16 – 24 hours
(b) Soffit formwork to slabs (Props to be refixed immediately after removal of formwork)	3 days
(c) Soffit formwork to - beams (Props to be refixed immediately after removal of formwork)	7 days
(d) Props to slabs (1) Spanning up to 4.5m (2) Spanning over 4.5 m (3) Spann	7 days 14 days
(e) Props to beams and arches: (1) Spanning up to 6m (4)(2) Spanning over 6m	14 days 21 days

Note 1 For other types of cement, the stripping time recommended for ordinary Portland cement may be suitably modified. If Portland Pozzolana or low heat cement has been used for concrete, the stripping time will be 10/7 of the period stated above.

Note 2 The number of props left under, their sizes and disposition shall be such as to be able to safely carry the full dead load of the slab, beam or arch as the case may be together with any live load likely to occur during curing or further construction.

Note 3 For rapid hardening cement, 3/7 of above periods will be sufficient in all cases except for vertical side of slabs, beams and columns which should be retained for atleast 24 hours.

Note 4 In case of cantilever slabs and beams, the centering shall remain till structures for counteracting or bearing down have been erected and have attained sufficient strength.

Note 5 Proper precautions should be taken to allow for the decrease in the rate of hardening that occurs with all types of cement in cold weather and accordingly stripping time shall be increased.

Note 6 All Form work shall be removed without any shock or vibration as would damage the reinforced concrete. Before the soffits and struts are removed, the concrete surface shall be exposed, where necessary to ascertain that the concrete has sufficiently hardened.

Note 7 Work damaged through premature or careless removal of forms shall be reconstructed.

Note 8 In terms of Para 4.2.3.1 (c) above in multistoreyed buildings, the centering and shuttering of any upper floor being cast should be supported on one floor below the top most floor already cast. The props supporting such an upper floor being concreted should continue to remain in position till the form work of the freshly laid concrete can be removed.

4.2.4 Surface Treatment

4.2.4.1 Oiling the Surface

Shuttering gives much longer service life if the surfaces are coated with suitable coating or releasing agent which acts both as a parting agent and also gives surface protections. Provision of Clause 6.3 of IS: 14687 "Guidelines on False work for Concrete Structures" may be referred in this regard.

After 3-4 uses and also in cases when shuttering has been stored for a long time, it should be recoated before the next use. In no case the used black oil is to be used for oiling.

4.2.5 Inspection of Form work

The completed form work shall be inspected and approved by the Engineer before the reinforcement bars are placed in position.

Proper form work should be adopted for concreting so as to avoid honey combing, blow holes, grout loss, stains or discoloration of concrete etc., Proper and accurate alignment and profile of finished concrete surface will be ensured by proper designing and erection of form work which will be approved by Engineer.

Shuttering surface before concreting should be free from any defect/deposits and fully

cleaned so as to give perfectly straight smooth concrete surface. Shuttering surface should be therefore checked for any damage to its surface and excessive roughness before use.

4.2.5.1 Erection of Form Work (centering and shuttering)

Following points shall be borne in mind while checking during erection.

- a) Any member which is to remain in position after the general dismantling is done, should be clearly marked.
- b) Material used should be checked to ensure that, wrong items/rejects are not used.
- c) If there are any excavations nearby which may influence the safety of form works, corrective and strengthening action must be taken.
- d)
 - i) The bearing soil must be sound and well prepared and the sole plates shall bear well on the ground.
 - ii) Sole plates shall be properly seated on their bearing pads or sleepers.
 - iii) The bearing plates of steel props shall not be distorted.
 - iv) The steel parts on the bearing members shall have adequate bearing areas.
- e) Safety measures to prevent impact of traffic, scour due to water etc., should be taken. Adequate precautionary measures shall be taken to prevent accidental impacts etc.,
- f) Bracing, struts and ties shall be installed along with the progress of form work to ensure strength and stability of form work at intermediate stage. Steel sections (especially deep sections) shall be adequately restrained against tilting, overturning and form work should be restrained against horizontal loads. All the securing devices and bracing shall be tightened.
- g) The stacked materials shall be placed as catered for in the design.
- h) When adjustable steel props are used, they should:
 - i) be undamaged and not visibly bent.
 - ii) have the steel pins provided by the manufacturers for use.
 - iii) be restrained laterally near each end.

iv) have means for centralizing beams placed in the forkheads.

- k)i) Screw adjustment of adjustable props shall not be over extended.
- k)j) Double wedges shall be provided for adjustment of the form to the required position wherever any settlement/elastic shortening of props occurs. Wedges should be used only at the bottom end of single prop. Wedges should not be too steep and one of the pair should be tightened/clamped down after adjustment to prevent their shifting.
- k) No member shall be eccentric upon vertical member.
- m)l) The number of nuts and bolts shall be adequate.
- m) All provisions of the design and/or drawings shall be complied with. Cantilever supports shall be adequate.
- o)n) Props shall be directly under one another in multistage constructions as far as possible.
- p)o) Guy ropes or stays shall be tensioned properly.
- q)p) There shall be adequate provision for the movement and operation of vibrators and other construction plant and equipment.
- r)q) Required camber shall be provided over long spans.
- r) Supports shall be adequate, and in plumb within the specified tolerances.

4.2.6 Measurements

4.2.6.14.2.6.1 General

The form work shall include the following:

- a) Splayed edges, notching, allowance for overlaps and passing at angles, sheathing battens, strutting, bolting, nailing, wedging, easing, striking and removal.
- b) All supports, struts, braces, wedges as well as mud sills, piles or other suitable arrangements to support the form work.
- c) Bolts, wire ties, clamps, spreaders, nails or any other items to hold the sheathing together.
- d) Working scaffolds, ladders, gangways and similar items.
- e) Filleting to form stop chamfered edges of splayed external angles not exceeding 20 mm wide to beams, columns and the like.
- f) Where required, the temporary openings provided in the forms for pouring concrete, inserting vibrators, and cleaning

holes for removing rubbish from the interior of the sheathing before pouring concrete.

- g) Dressing with oil to prevent adhesion and
- h) Raking or circular cutting.

4.2.6.2 Area to be measured

Where it is stipulated that the form work shall be paid for separately, measurements shall be taken of the area of shuttering in contact with the concrete surface. Dimensions of the form work shall be measured correct to a cm.

4.2.6.3 Classification of Measurements

The measurements shall be taken separately for the following:-

- a) Foundations, footings, bases of columns etc. and for mass concrete and pre cast shelves.
- b) Walls (any thickness) including attached pilasters, buttresses, plinth and string courses etc.,
- c) Suspended floors, roofs, landings, shelves and their supports and balconies.
- d) Lintels beams, girders bressummers and cantilevers.
- e) Columns, pillars, posts and struts.
- f) Spiral (excluding landings) except Spiral Staircase.
- g) Spiral staircases (including landings).
- h) Arches.
- i) Domes, vaults, shell roofs, arch ribs and folded plates.
- j) Chimneys and shafts.
- k) Well steining.
- l) Vertical and horizontal fins individually or forming box, louvers and bands.
- m) Waffle or ribbed slabs.
- n) Edges of slabs and breaks in floors and walls (to be measured in running metres where below 200 mm in width or thickness).
- o) Cornices and mouldings
- p) Small surfaces, such as cantilevers ends, brackets and ends of steps, caps and boxes to pilaster and columns and the like.
- q) Chullah hoods, weather shades, chhajjas, corbels etc., including edges and

4.2.6.4 Centring, and shuttering where exceeding 3.5 metre height in one floor shall be measured and paid for separately.

4.2.6.5. Where it is not specifically stated in the description of the item that form work shall be paid for separately, the rate of the RCC item shall be deemed to include the cost of form work.

4.2.6.6 No deductions from the shuttering due to the openings/ obstructions shall be made if the area of such openings/obstructions does not exceed 0.1 square metre. Nothing extra shall be paid for forming such openings.

4.2.7 Rate

The rate of the form work includes the cost of labour and materials required for all the operations described above.

4.3 REINFORCEMENT

4.3.1 General requirements

Steel conforming to para 4.1.2 for reinforcement shall be clear and free from loose mill scales, dust, loose rust, coats of paints, oil or other coatings, which may destroy or reduce bond. It shall be stored in such a way as to avoid distortion and to prevent deterioration and corrosion. Prior to assembly of reinforcement on no account any oily substance shall be used for removing the rust.

4.3.1.1 Assembly of Reinforcement

Bars shall be bent correctly and accurately to the size and shape as shown in the detailed drawing or as directed by the Engineer. Preferably bars of full length shall be used. Necessary cutting and straightening is also included in the Rates and no extra payment will be made for the same. Over lapping of bars, where necessary, shall be done as directed by the Engineer. The overlapping bars shall not touch each other and these shall be kept apart with concrete between them by 25 mm or $1 \frac{1}{4}$ times the maximum size of the coarse aggregate whichever is greater. But where this is not possible, the overlapping bars shall be bound together at intervals not exceeding twice the dia. of such bars with two strands annealed steel wire of 0.90 mm to 1.6 mm twisted tight. The overlaps/splices shall be staggered as per directions of the Engineer. But in no case the over lapping shall be provided in more than 50% of cross sectional area at one section.

4.3.1.2 Bonds and Hooks Forming End Anchorages

Reinforcement shall be bent and fixed in accordance with procedure specified in IS: 2502, Code of practice for bending and fixing of bars for concrete reinforcement. The details of bends and hooks are shown below for guidance. In case of high strength deformed bars hooks are not required.

a) U – Type Hook : In case of mild steel plain bars, standard U type hook shall be provided by bending ends of rod into semicircular hooks having clear diameter equal to four times the diameter of the bar as shown in **Figure 4.1A**.

Note : In case of work in seismic zone, the size of hooks at the end of the rod shall be eight times the diameter of bar or as given in the structural drawing.

b) Bends : Bend forming anchorage to a M.S. plain bar shall be bent with an internal radius equal to two times the diameter of the bar with a minimum length beyond the bend equal to four times the diameter of the bar as shown in **Figure 4.1B**.

4.3.1.3 Anchoring Bars in Tension

Deformed bars may be used without end anchorages provided, development length requirement is satisfied. Hooks should normally be provided for plain bars in tension. Development length of bars will be determined as per IS: 456 – 2000.

4.3.1.4 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 IS: 456-2000. The projected length of hooks, bends and straight lengths beyond bend, if provided for a bar in compression, shall be considered for development length.

4.3.1.5 Binders, stirrups, links etc.,

In case of binders, stirrups, links etc., the straight portion beyond the curve at the end shall be not less than eight times nominal size of bar.

4.3.1.6 Welding of Bars

Wherever facility for electric arc welding is available, welding of bars shall be done in lieu of overlap. The location and type of welding shall be got approved by the Engineer. Welding shall be as per IS: 2751 and IS: 9417.

4.3.2 Placing in Position

4.3.2.1 Fabricated reinforcement bars shall be placed in position as shown in the drawings or as directed by the Engineer. The bars crossing one another shall be tied together at every intersection with two strands of annealed steel wire 0.9 to 1.6 mm thickness twisted tight to make the skeleton of the steel work rigid so that the reinforcement does not get displaced during deposition of concrete.

Tack welding in crossing bars shall also be permitted in lieu of binding with steel wire if approved by the Engineer.

4.3.2.2 The bars shall be kept in correct position by the following methods:-

a) In case of beam and slab construction precast cover blocks in cement mortar 1:2 (1 cement : 2 coarse sand) about 4 x 4 cm section and of thickness equal to the specified cover shall be placed between the bars and shuttering, so as to secure and maintain the requisite cover of concrete over reinforcement.

b) In case of cantilevered and doubly reinforced beams or slabs, the vertical distance between the horizontal bars shall be maintained by introducing chairs, spacers or support bars of steel at 1.0 metre or at shorter spacing to avoid sagging.

c) In case of columns and walls, the vertical bars shall be kept in position by means of timber templates with slots accurately cut in them; or with block of cement mortar 1:2 (1 Cement:2 coarse sand) of required size suitably tied to the reinforcement to ensure that they are in correct position during concreting.

d) In case of other RC.C. structures such as arches, domes, shells, storage tanks etc., a combination of cover blocks, spacers and templates shall be used as directed by the Engineer.

4.3.2.3 Tolerance on Placing of Reinforcement

Unless otherwise specified by the Engineer, reinforcement shall be placed within the following tolerances:- (National Building Code, 2005; Para 11.3.1; Part 6 Section 5.5A)

	Tolerance in spacing
(a) For effective depth, 200 mm or less	+/- 10 mm
(b) For effective depth, more than 200 mm	+/- 15 mm

4.3.2.4 Cover

Minimum cover in structural members shall be maintained as for moderate exposure. However, in slabs (excluding roof slab, chhajjas, fins) mild exposure would be permitted. The minimum nominal cover to meet durability requirements shall be as under :

Exposure	Nominal Concrete Cover in mm not less than
Mild	20
Moderate	30
Severe	45
Very severe	50
Extreme	75

Notes : 1. For main reinforcement up to 12 mm diameter bar for mild exposure the nominal cover may be reduced by 5 mm.

2. Unless specified otherwise, actual concrete cover should not deviate from the required nominal cover by + 10 mm/ -0mm.

3. For exposure condition 'severe' and 'very severe' reduction of 5 mm may be made, where concrete grade is M35 and above.

4. In terms of Para 12.3.2 Part 6 Section 5 & 5A of National Building Code, 2006, spacers, chairs and other supports detailed on drawings, together with such other supports as may be necessary, should be used to maintain the specified nominal cover to the steel reinforcement. Spacers, chairs or steel support bars should be placed at a maximum spacing of 1m. Closer spacing may sometimes be necessary. Spacers and cover blocks should be of concrete of same strength or PVC or of steel.

4.3.2.5 Bending at Construction Joints

Where reinforcement bars are bent aside at construction joints and afterwards bent back

into their original position care should be taken to ensure that at no time the radius of the bend is less than 4 bar diameters for plain mild steel or 6 bar diameters for deformed bars. Care shall be taken when bending back bars to ensure that the concrete around the bar is not damaged.

4.3.3 Measurement

Reinforcement including authorized spacer bars and laps shall be measured in length of different diameters, as actually (not more than as specified in the drgs.) used in the work nearest to a centimeter and their weight calculated on the basis of standard weight given in **Table 4.4** below. Wastage and unauthorized overlaps shall not be paid for. Annealed steel wire required for binding or tack welding shall not be measured, its cost being included in the rate of reinforcement.

Wherever tack welding is used in lieu of binding, such welds shall not be measured. Chairs, separators etc., shall be provided as directed by the Engineer and measured separately and paid for.

TABLE 4.4
CROSS SECTIONAL AREA AND MASS OF STEEL BAR

(As per IS: 1786-Clause 5.2)

Nominal Size mm	Cross Sectional Area Sq.mm.	Mass per metre Run Kg.
6	28.3	0.222
8	50.3	0.395
10	78.6	0.617
12	113.1	0.888
16	201.2	1.58
18	254.6	2.00

20	314.3	2.47
22	380.3	2.98
25	491.1	3.85
28	616.0	4.83
32	804.6	6.31
36	1018.3	7.99
40	1257.2	9.85
45	1591.1	12.50
50	1964.3	15.42

4.3.4 Rate

The rate for reinforcement shall include the cost of labour and materials required for all operations described above such as cleaning of reinforcement bars, straightening, cutting, hooking, bending, binding, placing in position etc., as required or directed including tack welding on crossing of bars in lieu of binding with wires, as well as welding of bars in lieu of overlap.

4.4 CONCRETING

4.4.1 General

The concrete shall be as specified under **Chapter 3 Concrete work**. The proportion by volume or by the weight of ingredients shall be as specified.

4.4.2 Consistency

The concrete which will flow sluggishly into the forms and around the reinforcement without any segregation of coarse aggregate from the mortar, shall be used. The consistency shall depend on whether the concrete is vibrated or hand tamped. It shall be determined by slump test as prescribed in **Chapter 3 on 'Concrete'**.

4.4.3 Placing of Concrete

4.4.3.1 Concreting shall be commenced only after the Engineer has inspected the centering, shuttering and reinforcement as placed and passed the same. Shuttering shall be clean and free from all shavings, saw dust, pieces of wood, or other foreign material and surfaces shall be treated as prescribed in para 4.2.4.

4.4.3.2 In case of concreting of slabs and beams, wooden plank or cat walks of Chequered MS plates or bamboo chalties or any other suitable material supported directly on the centering by means of wooden blocks or lugs shall be provided to convey the concrete to the place of deposition without disturbing the

reinforcement in any way. Labour shall not be allowed to walk over the reinforcement.

4.4.3.3 In case of columns and walls, it is desirable to place concrete without construction joints. The progress of concreting in the vertical direction, shall be restricted to one metre per hour.

4.4.3.4 The concrete shall be deposited in its final position in a manner to preclude segregation of ingredients. In deep trenches and footings concrete shall be placed through chutes or as directed by the Engineer. In case of columns and walls, the shuttering shall be so adjusted that the vertical drop of concrete is not more than 1.5 metres at a time.

4.4.3.5 During cold weather, concreting shall be done as stipulated in Para 3.2.11.2

4.4.3.6 During hot weather Concreting shall be done as stipulated in Para 3.2.11.3.

4.4.3.7 It is necessary that the time between mixing and placing of concrete shall not exceed 30 minutes so that the initial setting process is not interfered with unless some retarders or quick setting cement are added as per design.

4.4.4. Compaction

It shall be as specified in Para 3.2.9 of Chapter 3 'Concrete Work' of the Specification.

4.4.4.1 Concrete shall be compacted into dense mass immediately after placing by means of mechanical vibrators designed for continuous operations. The Engineer may however relax this conditions at his discretion for certain items, depending on the thickness of the members and feasibility of vibrating the same and permit hand compaction instead. Hand compaction shall be done with the help of tamping rods so that concrete is thoroughly compacted and completely worked around the reinforcement, embedded fixtures, and into

corners of the form. The layers of concrete shall be so placed that the bottom layer does not finally set before the top layer is placed. The vibrators shall maintain the whole of concrete under treatment in an adequate state of agitation, such that deaeration and effective compaction is attained at a rate commensurate with the supply of concrete from the mixers. The vibration shall continue during the whole period occupied by placing of concrete, the vibrators being adjusted so that the center of vibrations approximates to the center of the mass being compacted at the time of placing.

4.4.4.2 Concrete shall be judged to be properly compacted, when the mortar fills the spaces between the coarse aggregate and begins to cream up to form an even surface. When this condition has been attained, the vibrator shall be stopped in case of vibrating tables and external vibrators. Needle vibrators shall be withdrawn slowly so as to prevent formation of loose pockets in case of internal vibrators. In case both internal and external vibrators are being used, the internal vibrators shall be first withdrawn slowly after which the external vibrators shall be stopped so that no loose pocket is left in the body of the concrete. The specific instructions of the makers of the particular type of vibrator used shall be strictly complied with. Shaking of reinforcement for the purpose of compaction should be avoided. Compaction shall be completed before the initial setting starts, i.e. within 30 minutes of addition of water to the dry mixture or within the initial setting time if retarders have been added in the concrete.

4.4.5 Construction Joints

4.4.5.1 Concreting shall be carried out continuously up to the construction joints, the position and details of which shall be as shown in structural drawing or as indicated in **Fig.4.2** or as directed by the Engineer. Number of such joints shall be kept to minimum. The joints shall be kept at places where the shear force is the minimum. These shall be straight and shall be at right angles to the direction of main reinforcement. Construction joints should comply with IS:11817.

4.4.5.2 In case of columns the joints shall be horizontal and 10 to 15 cm below the bottom of the beam running into the column head. The portion of the column between the stepping off level and the top of the slab shall be concreted with the beam.

4.4.5.3 When stopping the concrete on a vertical plane in slabs and beams an approved stop-board (see **Fig.4.2**) shall be placed with necessary slots for reinforcement bars or any other obstruction to pass the bars freely without bending. The construction joints shall be keyed by providing triangular or trapezoidal filler nailed on the stop-board. Inclined or feather joints shall not be permitted. Any concrete flowing through the joints of stop-board shall be removed soon after the initial set. When concrete is stopped on a horizontal plane, the surface shall be roughened and cleaned after the initial set.

4.4.5.4 When the work has to be resumed, the joint shall be thoroughly cleaned with wire brush and loose particles removed. A coat of neat cement slurry at the rate of 2.75 kg. of cement per square meter shall then be applied on the roughened surface before fresh concrete is laid.

4.4.5.5 In case of bridge construction "Specification for Construction Joints" including the position of Construction Joints, preparing the surface of the Joint and concreting at Construction Joints, Appendix A (Para 8.5.3) of Concrete Bridge Code, 1997 may be referred to.

4.4.6 Expansion Joints

Expansion joints shall be provided as shown in the structural drawings or as indicated in **Figures 4.3A to 4.3P** for the purpose of general guidance or as directed by the Engineer. However it is recommended that structures exceeding 45 m in length shall be divided by one or more expansion joints. The filling of these joints with bitumen filler, bitumen felt or any such material and provision of copper plate, etc., shall be paid for separately in running metre. The measurement shall be taken up to two places of decimal stating the depth and width of joint.

4.4.7 Curing

After the concrete has begun to harden i.e. about 1 to 2 hours after its laying, it shall be protected from quick drying by covering with moist gunny bags, sand, canvas hessian or any other material approved by the Engineer. After 24 hours of laying of concrete, the surface shall be cured by ponding with water for a minimum period of 7 days from the date of placing of concrete in case of OPC and at least 10 days where mineral admixtures or blended cements are used. The period of curing shall not be less than 10 days for concrete exposed to dry

and hot weather condition. Para 3.2.12 under **Chapter 3** may also be referred.

4.4.8 Finishing

4.4.8.1 In case of roof slabs the top surface shall be finished even and smooth with wooden trowel, before the concrete begins to set.

4.4.8.2 Immediately on removal of forms, the R.C.C. work shall be examined by the Engineer, before any defects are made good.

.1 The work that has sagged or contains honey combing to an extent detrimental to structural safety or architectural concept shall be rejected as given in Para 4.4.10.5 based on visual inspection test.

.2 Surface defects of a minor nature may be accepted. On acceptance of such a work by the Engineer, the same shall be rectified as follows:-

a) Surface defects which require repair when forms are removed, usually consist of bulges due to movement of forms, ridges at form joints, honey-combed areas, damage resulting from the stripping of forms, and bolt holes.

b) Bulges and ridges are removed by careful chipping or tooling and the surface is then rubbed with a grinding stone.

c) Honey-combed and other defective areas must be chipped out, the edges being cut as straight as possible and perpendicularly to the surface, or preferably slightly undercut to provide a key at the edge of the patch.

i) i) Shallow patches are first treated with a coat of thin grout composed of one part of cement and one part of fine sand and then filled with mortar similar to that used in the concrete. The mortar is placed in layers not more than 10 mm thick and each layer is given a scratch finish to secure bond with the succeeding layer. The last layer is finished to match the surrounding concrete by floating, rubbing or tooling on formed surfaces by pressing the form material against the patch while the mortar is still plastic.

ii) ii) Large and deep patches require filling up with concrete held in place by forms. Such patches are reinforced and carefully dowelled to the hardened concrete.

d) Holes left by bolts are filled with mortar carefully packed into places in small amounts. The mortar is mixed as dry as possible, with just enough water so that it

will be tightly compacted when forced into place.

e) Tiered holes extending right through the concrete may be filled with mortar with a pressure gun similar to the gun used for greasing motor cars.

f) Normally, patches appear darker than the surrounding concrete, possibly owing to the presence on their surface of less cement laitance. Where uniform surface colour is important this defect shall be remedied by adding 10 to 20 percent of white Portland cement to the patching mortar, the exact quantity determined by trial.

g) The same amount of care to cure the material in the patches should be taken as with the whole structure. Curing must be started as soon as possible, after the patch is finished to prevent early drying. Damp hessian may be used but in some locations it may be difficult to hold it in place. A membrane curing compound in these cases will be most convenient.

.3 The exposed surface of R.C.C. work shall be plastered with cement mortar 1:3 (1 cement and 3 fine sand) of thickness not exceeding 6 mm to give smooth and even surface true to line and form. Any 'RCC surface which remains permanently exposed to view in the completed structure shall be considered exposed surface for the purpose of this specification. Where such exposed surface exceeding 0.5 sqm. in each location is not plastered with cement mortar 1:3 (1 cement : 3 fine sand) 6 mm thick, necessary deduction shall be made for plastering not done.

.4 The surface which is to receive plaster or where it is to be joined with brick masonry wall, shall be properly roughened immediately after the shuttering is removed, taking care to remove the laitance completely without disturbing the concrete. The roughening shall be done by hacking. Before the surface is plastered, it shall be cleaned and wetted so as to give bond between concrete and plaster.

RCC work shall be done carefully so that the thickness of plaster required for finishing the surface is not more than 6 mm.

.5 The surface of RCC slab on which the cement concrete or mosaic floor is to be laid shall be roughened with brushes while the concrete is green. This shall be done without disturbing the concrete.

4.4.9. Testing of Concrete – Grade Concrete:

4.4.9.1 For concrete designated by Grade, Sampling and Testing shall be carried out in accordance with Clause 15 of IS:456.

4.4.9.2 The Acceptance Criteria shall be as indicated in Clause 16 of IS: 456.

4.4.9.3 In case 'established values of standard deviation' are not available for the purpose of Col. 2 of Table 11 referred in Clause 16, following values as indicated in Table 8 of IRC Bridge Code may be assumed.

TABLE 4.5
ASSUMED STANDARD DEVIATION
(Table 8 of IRC Bridge Code)

GRADE OF CONCRETE	ASSUMED STANDARD DEVIATION N/mm^2
M 20	4.6
M 25	5.3
M 30	6.0
M 35	6.3
M 40	6.6
M 45	7.0
M 50	7.4
M 55	7.6
M 60	7.8

4.4.9.4 In order to get a relatively quick idea of the quality of concrete, optional tests on beams for modulus of rupture at 72 + 2 hours or at 7 days, or compressive strength tests at 7 days may be carried out in addition to 28 days compressive strength tests. For this purpose, the values given in Table 4.6 below may be taken for general guidance in case of concrete made with

ordinary Portland cement. In all cases, the 28 days compressive strength specified in Table 3.6 on "Grades of Concrete" in Chapter 3 'Concrete Work' shall alone be the criterion for acceptance or rejection of the concrete. In terms of which the specified characteristic compressive strength at 28 days in N/mm^2 is 20 in case of M-20, 25 in case of M-25 and so on.

TABLE 4.6
OPTIONAL TESTS REQUIREMENTS OF CONCRETE
(Table 7 of IRC Bridge Code)

GRADE OF CONCRETE	COMPRESSIVE STRENGTH ON 15 cm CUBES (N/mm^2)	MODULUS OF RUPTURE BY BEAM TEST Min. (N/mm^2)	
	Min. at 7 days	At 72 + 2 h	At 7 days
(1)	(2)	(3)	(4)
M 20	13.5	1.7	2.4
M 25	17.0	1.9	2.7
M 30	20.0	2.1	3.0
M 35	23.5	2.3	3.2
M 40	27.0	2.5	3.4
M 45	30.0	2.7	3.6
M 50	33.5	2.9	3.8
M 55	37.0	3.1	4.0
M 60	40.0	3.3	4.2

4.4.9.5 Clauses 15 & 16 of IS: 456-2000 are extracted as Annexure 4.2 for ready reference.

4.4.10 Testing of Concrete - Ordinary Concrete

4.4.10.1 Regular mandatory tests on the workability of the fresh concrete shall be done to achieve the specified compressive strength of concrete as detailed in Chapter 3 'Concrete Work'. These will be of two types.

a) Mandatory Test - Lab. Test – Cube Test for Compressive Strength of Concrete

b) Additional Field Test - Cube Test for Compressive Strength of Concrete

Results of Field Test will prevail over Lab. Test

4.4.10.2 Mandatory Lab Test

It shall be carried out as prescribed in Annexure 4.3.

4.4.10.3 Additional Field Test

Additional test if required, shall be carried out as prescribed in **Annexure 4.4.**

4.4.10.4 Slump Test

This test shall be carried out as prescribed in Annexure 3.4 of Chapter 3 'Concrete Work'.

4.4.10.5 Visual Inspection Test

The concrete will be inspected after removal of the form work as described in Para 4.4.8.2. The question of carrying out tests described in Annexures 4.3 and 4.4 (Paras 4.4.10.2 and 4.4.10.3.) will arise only after satisfactory report of visual inspection.

The concrete is liable to be rejected if:

- (i) it is porous or honeycombed .
- (ii) its placing has been interrupted without providing a proper construction joint.
- (iii) the reinforcement has been displaced beyond tolerance specified; or construction tolerances have not been met.

However, the hardened concrete may be accepted after carrying out suitable remedial measures to the satisfaction of the Engineer at the risk and cost of the contractor.

4.4.11 Standard of Acceptance – Ordinary Concrete

Concrete shall be accepted if it satisfies the criteria laid down in para 16 of IS-456 which is reproduced in Annex 4.2.

4.4.12 Measurement

4.4.12.1 Dimensions shall be measured nearest to a cm except for the thickness of slab which shall be measured correct to 0.5 cm. The areas shall be worked out nearest

to 0.01 sqm. The cubical contents shall be worked out to nearest 0.01 cubic metre. However additional length, breadth and thickness over and above as shown in the drawings will not be paid.

4.4.12.2 Reinforced cement concrete whether cast-in-situ or precast shall be classified and measured separately as follows :

- a) Raft, footing, bases of columns etc., and mass concrete.
- b) Walls (any thickness) including attached pilasters, buttresses, plinth and string course, fillets etc.,
- c) Suspended floors, roofs, landings and balconies.
- d) Shelves
- e) Chajjas
- f) Lintels, beams and bressummers
- g) Columns, pillars, piers, abutments, posts and struts.
- h) Stair-cases including waist or waist-less slab but excluding landing except in (i) below.
- i) Spiral stair-case (including landing)
- j) Arches, arch ribs, domes and vaults.
- k) Chimneys and shafts.
- l) Well steining.
- m) Vertical and horizontal fins individually or forming box, louvers and facias.
- n) Kerbs, steps and the like.
- o) String courses, bands, coping, bed plates, anchor blocks, plain window sills and the like.
- p) Mouldings as in cornices window sills etc.,
- q) Shell, dome and folded plates.
- r) Extra for shuttering in circular work in plan.

4.4.12.3 Work under the following categories shall be measured separately.

- a) Rafts, footings, basis of columns etc., and mass concrete.
- b) All other items up to 2 floor level above Plinth
- c) Every additional floor above floor level 2
- d) R.C.C. above roof level shall be measured along with R.C.C. work in floor just below.

4.4.12.4 No deduction shall be made for the following:-

- a) Ends of dis-similar materials (e.g. Joists, beams, post girders, rafters, purlins

trusses, corbels steps etc.,) up to 500 sq cm in cross-section.

- b) Opening up to 0.10 sqm.

Note : In calculating area of openings up to 0.1 sqm the size of opening shall include the thickness of any separate lintels or sills. No extra labour for forming such openings or voids shall be paid for.

- c) The volume occupied by reinforcement.
d) The volume occupied by water pipes, conduits etc. not exceeding 25 sqcm each in cross sectional area. Nothing extra shall be paid for leaving and finishing such cavities and holes.

4.4.12.5 Measurement shall be taken before any rendering is done in concrete members. Measurement will not include rendering. The measurement of R.C.C. work between various units shall be regulated as below:-

- a) Slabs shall be taken as running continuously through except when slab is monolithic with the beam. In that case it will be from the face to face of the beam.
- b) Beams shall be measured from face to face of columns and shall include haunches, if any, between columns and beam. The depth of the beam shall be from the bottom of slab to the bottom of beam if beam and slab are not monolithic. In case of monolithic construction where slabs are integrally connected with beam, the depth of beam shall be from the top of the slab to the bottom of beam.
- c) The columns measurement shall be taken through.
- d) Chajjas along with its bearing on wall shall be measured in cubic metre nearest to two places of decimal. When chajja is combined with lintel, slab or beam, the projecting portion shall be measured as chajjas; built in bearing shall be measured as per item of lintel, slab or beam in which chajja bears.
- e) Where the band and lintel are of the same height and the band serves as lintel, the portion of the band to be measured as lintel shall be for clear length of opening plus twice the over all depth of band.

4.4.13 Tolerances

Subject to the condition that structural safety is not impaired and architectural concept is not hampered, the tolerances in dimensions

of R.C.C. members shall be as specified in the drawings by the designer. Whenever these are not specified, the permissible tolerance shall be decided by the Engineer on lines of Para 4.2.2 above or after consultations with the Designer, if necessary.

When tolerances in dimensions are permitted, following procedure for measurements shall apply.

- a) If the actual dimensions of R.C.C. members do not exceed or are less than the design dimensions of the members plus or minus tolerance limit specified above, the design dimensions shall be taken for the purpose of measurement.
- b) If the actual dimensions exceed the design dimensions by more than the tolerance limit, the design dimensions only shall be measured for the purpose of payment.
- c) If the actual dimensions are less beyond the tolerance limit specified, the actual dimensions of the RCC members shall be taken for the purpose of measurement and payment.
- d) For acceptance of RCC members whose dimensions are not exactly as per design dimensions, the decision of the Engineer shall be final. For the purpose of payment, however, the clarification as given in Paras a, b & c above shall apply.

4.4.14 Rate

4.4.14.1 The rate includes the cost of materials and labour involved in all the operations described above.

4.4.14.2 No extra payment for richer mix which projects into any member from another member during concreting of junctions of beams and columns etc. will be made except to the extent structurally considered necessary and when so indicated in the structural drawings. The payments for work done under items of different mixes shall be limited strictly to what is indicated in the structural drawings.

4.5 ENCASING STEEL ROLLED SECTIONS

4.5.1 General

Before concrete work is started, the Engineer shall check that all rolled steel sections to be encased, have been erected truly in position. The sections shall be unpainted and shall be wire brushed to remove the loose rust/scales etc., Where so specified, ungalvanised metal, having mesh

or perforations large enough to permit the free passage of 12.5 mm nominal size aggregate through them, shall be wrapped round the section to be encased in concrete and paid for separately.

4.5.2 Wrapping

4.5.2.1 In case of columns, the wrapping shall be arranged as illustrated in **Figure 4.4A** to pass through the center of the concrete covering. The wrapping of the entire length of the columns should be carried out in stages and no stage shall cover more than 1.5 metre of height of columns. Successive wrappings shall be carried out only after the immediate adjacent wrapping has been encased in concrete. The surface and edges of the flanges of the steel columns shall have a concrete cover of not less than 50 mm. The wrappings of successive stages shall be tied together.

4.5.2.2 In the case of beams and grillages, the wire mesh or expanded metal shall be wrapped round the lower flange of the beam as illustrated in **Figure 4.4B** and wrapping shall be suspended by wire hangers 5 mm diameter placed at about 1.2 metres centers. The surfaces and edges of the steel sections shall have a concrete cover of not less than 50 mm. The wrapping shall pass through the center of the concrete covering at the edges and soffits of the flanges.

4.5.3 Form work

This shall be as prescribed in Para 4.2

4.5.4 Concreting

Concrete shall consist of an Ordinary mix of 1:2:4 (1 cement: 2 coarse and 4 graded stone aggregate of 12.5 mm nominal size) unless a richer mix is specified. The mix shall be poured solidly around the steel sections and around the wrapping by vibrating the concrete in to position. Consistency of concrete, placing of concrete and its compaction, curing, finishing and strength of concrete shall be as described in Para 4.4.

4.5.5 Measurements

The length shall be measured correct to one cm and other dimensions correct to 0.5 cm. The cement concrete shall be measured as per gross dimensions of the encasing exclusive of the thickness of plaster. No deduction shall be made for the volume of steel sections, expanded metal, mesh or any other reinforcement used therein. However, in case of boxed stanchions or girders, the boxed portion only shall be deducted.

Fabric reinforcement such as expanded metal shall be measured separately in square metres stating the mesh and size of strands.

4.5.6 Rate

The rate shall include the cost of materials and labour required for all the operations described above except the cost of fabric reinforcement. It shall also include the cost of bending of the fabric as necessary circular cutting or wastage. The cost of providing and erecting steel section and wire hangers shall be paid for separately.

4.6 PRE CAST REINFORCED CONCRETE

4.6.1 General Requirements

4.6.1.1 Precast reinforced concrete units such as columns, fencing, posts, door and window frames, lintels, chhajjas, copings, sills, shelves, slabs, louvers etc., shall be of grade or mix as specified and cast in forms or moulds. The forms/moulds shall be of steel sections for better finish. Provision shall be made in the forms and moulds to accommodate fixing devices such as nibs, clips, hooks, bolts and forming of notches and holes. The contractor may pre cast the units on a cement or steel platform which shall be adequately oiled provided the surface finish is of the same standard as obtained in the forms. Each unit shall be cast in one operation.

4.6.1.2 Concrete used for precasting the units should be well proportioned, mixed, placed and thoroughly compacted by vibrators or tamping to give a dense concrete free from voids and honey combing.

4.6.1.3 Precast articles shall have a dense surface finish showing no coarse aggregate and shall have no cracks or crevices likely to assist in disintegration of concrete or rusting of steel or other defects that would interfere with the proper placing of the units. All angles of the pre cast units with the exception of the angles resulting from the splayed or chamfered faces shall be true right angles. The arises shall be clean and sharp except those specified or shown to be rounded. The wearing surface shall be true to the lines. On being fractured, the interior of the units should present a clean homogeneous appearance.

4.6.1.4 The longitudinal reinforcement shall have a minimum cover of 12 mm or twice the diameter of the main bar, whichever is more, unless otherwise directed in respect of all items except

fencing posts or electric posts where the minimum cover shall be 25 mm.

4.6.2 Curing

4.6.2.1 After having been cast in the mould or form the concrete shall be adequately protected during setting in the first stages of hardening from shocks and from harmful effects of frost, sunshine, drying winds and cold. The concrete shall be cured at least for 7 days from the date of casting.

4.6.2.2 The precast articles shall be matured for 28 days before erection or being built so that the concrete shall have sufficient strength to prevent damage to units when first handled.

4.6.3 Marking

Precast units shall be clearly engraved / to indicate the top of member and its location and orientation in the structure.

4.6.4 Storing and Transporting

Precast units shall be stored, transported and placed in position in such a manner that they will not be over-stressed or damaged.

4.7 PRECAST CEMENT CONCRETE JALI

4.7.1 General

The Jali shall be of cement concrete 1:2:4 (1 cement:2 coarse sand : 4 stone aggregate 6 mm nominal size) reinforced with 1.6 mm thick mild steel wire, unless otherwise specified.

4.7.2 Fixing

The Jali shall be set in position true to plumb and level before the jambs, sills and soffits of the openings are plastered. It shall then be properly grouted with cement mortar 1:3 (1 cement:3 coarse sand) and rechecked for levels. Finally the jambs, sills and soffits shall be plastered embedding the Jali uniformly on all sides.

4.7.3 Measurements

The Jali shall be measured for its gross superficial area. The length and breadth shall be measured correct to a cm. The thickness shall not be less than that specified.

4.7.4 Rate

The rate shall be inclusive of materials and labour involved in all the operations described above except plastering of jambs, sills and soffits, which will be paid for under relevant items of plastering.

4.8 MIX DESIGN

4.8.1 Mix design and proportioning

4.8.1.1 Recommended Guidelines for Concrete Mix Design are given in IS: 10262-1982 which may be referred to for details. As mentioned therein in order that not more than the specified proportion of test results are likely to fall below the characteristic strength, the concrete mix has to be designed for a somewhat higher target average compressive strength. In terms of Clause 9.2.2 of IS: 456-2000 the Target Mean Strength of Concrete mix should be equal to the characteristic strength plus 1.65 times the Standard Deviation. Mix proportions shall be designed to ensure that the workability of fresh concrete is suitable for conditions of handling and placing, so that after compaction it surrounds all reinforcements and completely fills the form work. When concrete is hardened, it shall have the stipulated strength, durability and impermeability.

4.8.1.2 Standard deviation calculations of test results based on tests conducted on the same mix design for a particular grade designation shall be done in accordance with Clause 9.2.4 of IS: 456-2000. Table 8 of IS: 456-2000 gives the standard deviation that can be assumed for design of mix in the first instance. The final standard deviation figures may be determined based on test results for the particular grade of concrete when available.

4.8.1.3 Determination of the proportions by weight of cement, aggregate and water shall be based on design of the mix.

4.8.1.4 As a trial the manufacturer of concrete may prepare a preliminary mix according to provisions of SP:23-1982. (Special Publication 23-1982 of Bureau of Indian Standards).

4.8.1.5 Mix design shall be tried and the mix proportions checked on the basis of tests conducted at a recognized laboratory approved by the Engineer.

4.8.1.6 All concrete proportions for various grades of concrete shall be designed separately and the mix proportions established keeping in view the workability for various structural elements, methods of placing and compacting.

4.8.2 Approval of Design Mix

4.8.2.1 The producer/manufacturer/contractor of concrete shall submit details of each trial mix of each grade of concrete designed for various workability conditions to the Engineer for his comments and approval. Concrete of any particular design mix and

grade shall be produced/manufactured for works only on obtaining written approval of the Engineer.

4.8.2.2 For any change in quality/quantity in the ingredients of a particular concrete, for which mix has been designed earlier and approved by the Engineer the mix has to be redesigned and approval obtained again.

4.9 TRANSPORTATION OF CONCRETE & PUMPING OF CONCRETE

4.9.1 General

Fresh concrete can be transported to the placement area by a variety of methods. Common among them are:

- Mixer trucks
- Stationary truck bodies with or without agitators.
- Buckets hauled by trucks.
- Conveyor belts.
- Hose or pipe line by pumping.

Each type of transportation has specific advantages and limitations depending on the condition of use, mix, accessibility and location of placing.

4.9.2 Transportation by Mixer Trucks

4.9.2.1 These are essentially revolving drums mounted on truck chassis. Truck mixers used in the job shall be labelled permanently to indicate the manufacturers specifications for mixing like:-

- Capacity of drum.
- Total number of drum revolutions for complete mixing.
- Mixing speed
- Maximum time limit before completion of discharge and after cement has entered the drum.
- Reduction in time period of discharge due to warm weather or other variables.

All above information shall only form guidelines for the manufacturer/producer of concrete.

4.9.2.2 Fulfilment of the stipulated number of revolutions or elapsed time shall not be the acceptable criterion. As long as the mixing water limit is not exceeded and the concrete has satisfactory plastic physical properties and is of satisfactory consistency and homogeneity for satisfactory placement and consolidation and is without initial set, the concrete shall be acceptable.

4.9.2.3 When the concrete is totally mixed in transporting trucks volume of concrete being transported shall not exceed

63% of the rated capacity of the drum. In case the concrete is totally mixed in the central batching plant, the transporting truck may be loaded up to 80% of the rated capacity of the drum. In this case the drum shall be rotated at charging speed during loading and reduced to agitating speed after loading is complete.

4.9.2.4 When transporting concrete by truck mixers, delivery time shall be restricted to 90 minutes or initial setting time whichever is less from the time cement has entered the mixer to completion of discharge.

4.9.3 Transporting by Agitating / Non-agitating Trucks.

4.9.3.1 Transporting ready mix concrete by this method shall consist of truck chassis mounted with open top bodies. The metal body shall be smooth and streamlined for easy discharge. Discharge may be from the rear when the body is mechanically tilted. Body of the truck shall have a provision of discharge gate. Mechanical vibrators shall be installed at the discharge gate for control of discharge flow.

4.9.3.2 Agitators, if mounted, also aid in the discharging of concrete from the truck in addition to keeping the concrete alive.

4.9.3.3 Water shall not be added to concrete in transport through this system.

4.9.3.4 Bodies of trucks shall be provided with protective covers during period of inclement weather.

4.9.3.5 Delivery period, when adopting this system of transporting concrete shall be restricted to 30 minutes from the moment all ingredients including cement and water enter in mixer to completion of discharge.

4.9.4 Transporting by Buckets

4.9.4.1 This method of transportation is very common for transportation of centrally mixed concrete. Buckets of suitable capacities may be filled with concrete which is totally mixed in central plant and hauled to the job site. Buckets then may be conveyed to the actual point of placement either with the help of crane/hoist or they may be carted.

4.9.4.2 As in the case of open truck transportation, extra water shall not be added to concrete transported in buckets. Concrete shall be protected from inclement weather by necessary covering arrangements. Also, maximum delivery period for this system of transportation from the time cement is introduced into the mixer

to completion of discharge shall not exceed 30 minutes.

4.9.5 Cleaning

Before loading concrete in either truck mixer, open bodied trucks or buckets, the containers shall be thoroughly cleaned, washed and dried, so that there is no water or moisture in the container which may affect the designed water content of the concrete.

4.9.6 Other Methods of Transportation

4.9.6.1 Transportation of concrete either by belt conveyors or by pumping is envisaged in some works.

4.9.6.2 If, the producer/manufacturer/purchaser of ready mix concrete desires to use such methods of transportation, they may do so provided their scheme and complete specifications are submitted to the Engineer for his record and approval.

4.9.7 Objective

4.9.7.1 Method of transportation used shall ensure:-

Efficient delivery of concrete

No significant alteration of properties with regard to water cement ratio, slump, air content and homogeneity.

4.9.7.2 All variables in transportation, considering type and accessibility of placement locations, distance, time interval etc., shall be carefully studied before arriving at the method used.

4.9.8 Pumpable Concrete (Extracted from Para 8.9 of Concrete Bridge Code, 1997)

4.9.8.1 General- Pumpable concrete is the concrete which is conveyed by pressure through either rigid pipe or flexible hose and discharged directly into the desired area. It is especially used where space for construction equipment is very limited.

4.9.8.2 Pumping Rate and Range – Depending on the equipment, pumping rate should be 10 to 70 cum. per hour. Effective pumping range is upto 300m horizontally and 90m vertically.

4.9.8.3 Proportioning Pumpable Concrete

a) **Basic Consideration** More emphasis on quality control is essential to the proportioning and use of a dependable pump mix. Concrete mixes for pumping must be plastic. Particular attention must be given to the mortar and to the amounts and sizes of coarse aggregates.

b) The maximum size of angular coarse aggregate is limited to one-third of smallest inside diameter of the hose or pipe. Provisions should be made for elimination of oversized particles in the concrete by finish screening or by careful selection of aggregates.

4.9.8.4 Pumping Concrete

a) Proper planning of concrete supply, pump locations, line layout, placing sequences and the entire pumping operation will result in saving of cost and time. The pump should be placed as near the placing area as practicable and the entire surrounding area must have adequate bearing strength. Lines from the pump to the placing area should be laid out with a minimum of bends. The pipe line shall be rigidly supported.

b) While pumping downward 15m or more, it is desirable to provide an air release valve at the middle of the top bend to prevent vacuum or air build up. When pumping upward, it is desirable to have a valve near the pump to prevent reverse flow.

4.10 PRECAST REINFORCED CONCRETE DOOR AND WINDOW FRAMES

4.10.1 Manufacture

Manufacture of precast reinforced concrete door and window frames is described here. These will conform to IS 6523 in all respects unless otherwise specified. Frames shall be manufactured in an approved factory with all necessary arrangements for fixing hinges or hinges fixed at position as specified with hole for receiving Tower bolt, sliding bolt etc., as specified.

4.10.2 Shapes and Dimensions

4.10.2.1 Precast reinforced concrete door and window frames shall be 60 x 100 mm or 70 x 75 mm in cross section for single shutter and 60 x 120 mm for double shutter door, cross section generally conforming to **Figures 4.5A to 4.5C**. Where specified, suitable groove for receiving wall plaster shall be provided.

4.10.2.2 The over all sizes (width and height) shall be as per **Figures 4.5A to 4.5C** or as specified.

4.10.3 Materials

4.10.3.1 Standard

Materials used for manufacturing of the frames shall comply with standards given in Table 1 of IS:6523.

4.10.3.2 Aggregate: The aggregate used shall be of well graded mixture of clean

coarse and fine aggregates. The normal size of coarse aggregate shall not exceed 10 mm.

4.10.3.3 Concrete: Concrete shall be as specified or as directed by the Engineer. But the mix shall not be weaker than M20 controlled mix or 1:1 ½ :3 (1 cement : 1 ½ coarse sand: 3 stone aggregate 10mm nominal size by volume mix) and shall be suitable for producing a dense concrete without voids after proper vibration.

4.10.3.4 Reinforcement: There shall be a minimum of three bars of 6 mm dia or equivalent. The longitudinal reinforcement for each vertical or horizontal member shall be one piece and shall be firmly held by 3 mm dia ties spaced at not more than 300 mm center to center.

The longitudinal reinforcement shall have a maximum cover of 12mm or twice the diameter of main bar, whichever is higher.

4.10.4 Casting

The entire frame may be cast complete in one piece or each of the vertical and horizontal members of the frames may be cast separately to be assembled into the complete frame at site. When the frame is cast in separate parts, one of the reinforcing bars of the vertical members of the frame

shall be kept projecting so as to tennon into the corresponding hole in the horizontal member. The holes in the horizontal member for taking the projecting reinforcement from the vertical members shall be slightly larger than the bar diameter to facilitate easy insertion of the projecting bars. After assembly at site, the holes shall be grouted with cement slurry of 1 cement : 2 coarse sand.

4.10.5 Mould

The mould for casting shall preferably be of steel to ensure better surface finish of the cast frame. Provision shall be made in the mould to accommodate fixing devices for hinges and the hold fasts. Where specified, suitable rebates may also be provided to act as plaster groove.

4.10.6 Protection and Curing

After casting in moulds, during setting and in first stage of hardening the concrete shall be protected from shocks, running or surface water and the harmful effect of frost, sunshine drying winds, and cold. The concrete shall be cured for at least 7 days unless special curing methods are adopted which shall conform to IS:6523.

The frames shall be matured before testing or dispatch for the following periods.

Type of cement used	Period
Ordinary Portland cement, Portland blast furnace slag cement Portland pozzolana cement	28 days
Rapid hardening cement (to be used with approval of the Engineer)	14 days

4.10.7 Arrangements for fixing of hinges to frames

Suitable arrangements for fixing hinges shall be provided in the frame by one of the following methods as directed (Ref. **Figures 4.6A to 4.6F**).

a) Hardwood fixture

Hardwood blocks of well seasoned teak or other suitable timber 150 mm long, 45 to 50 mm x 30 to 40 mm in cross section, one block for each of the hinge, shall be fixed in position with 6 mm mild steel bolts, nuts, and washers, after the frame has been cast, cured and matured. After tightening the nuts, the bolt heads and the butts shall be suitably covered with hard wood fillets, finished flush with concrete surfaces of the frame.

b) Hinge directly attached to frame. L Type flap hinge may be attached directly to

the frame with the help of 6 mm dia. mild steel bolts and nuts.

c) Hinge welded to frame.

The hinge may be welded to 3 mm thick mild steel flat embedded in a frame.

4.10.8 Arrangements for Door and Window Fixtures

Suitable arrangements shall be provided in the frame for receiving tower bolts, sliding bolts and other door and window fixtures as indicated.(See **Figure 4.6G**)

4.10.9 Fasteners

Arrangements for fixing the frames with hold fasts or metallic fasteners shall be provided in vertical members of frames as specified. In case of door frame, there will be 3 Nos. Hold fasts and in case of window, there will be 2 Nos. Hold fasts on each vertical member in contact with the

opening where the frame is to be fixed. Holes to accommodate 10 mm dia bolts to be fixed to Hold fasts and the nuts shall be left at appropriate locations. In case of windows wider than 1.20 mts the no of hold fasts or metallic fasteners in the vertical member should be increased to 3. Similarly if the height of doors or windows is more than 2.10 mts one additional unit should be provided for better stability.

4.10.10 Erection

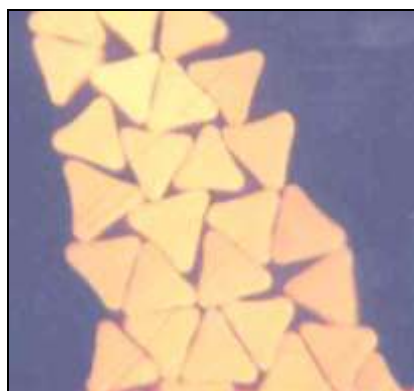
4.10.10.1 When a three piece frame is used, the vertical members shall be held in position with top member placed over them, the whole frame plumbed and firmly supported till the concrete around the hold fasts in the masonry has properly set and hardened. Cement and coarse sand mortar slurry 1:2 shall be used in grouting the joints between the vertical horizontal members of door frame. In case where four members are used, the bottom member shall be first placed in position and other erected on this base.

4.11 Use of Fibre reinforcement in plain cement concrete / RCC and plaster -

Due to inherent cement property, despite best curing efforts; micro-cracks develop in concrete and plaster due to plastic and early shrinkage during initial and final setting of concrete and plasters. These fine cracks elongate with age, increasing porosity of concrete and plastered surfaces and become a source for ingress of water resulting in seepage, leakage and development of wet patches.

Advancement in concrete technology has encouraged use of fibre reinforcement wherein the fibres act as secondary reinforcement to enhance durability and improve characteristics of concrete / cement work. Usage of Polyester Synthetic Triangular Fibres may be done in such cases. These fibres should be 100% Virgin Polymer (free of Iso Pthalic Acid). The brief Specifications of Polyester Synthetic Triangular Fibres for Plain Concrete, RCC & Cement Mortar are as below :

Description	Material	Shape	Length (mm)	Specific Gravity	Melting Point	Alkali Resistance
Plain Concrete	Polyester	Triangular	12 to 18	1.33 – 1.35	240 – 260° C	Excellent
RCC	Polyester	Triangular	12	1.33 – 1.35	240 – 260° C	Excellent
Plaster Mortar	Polyester	Triangular	6	1.33 – 1.35	240 – 260° C	Excellent



Cross-section of Triangular Polyester Fibre

1. In Batching Plant, Fibre to be dosed preferably alongwith aggregate.
2. In Site Mixer, Fibre is to be added after some water is put in mixer. Then Sand, Cement & Aggregate can be added in any sequence.
4. In Manual Mix, Fibre is to be shaken into water container and then poured over dry mix concrete/mortar etc. and then mixed by spade.

Code Relevance : IS 456 Amendment no. 3, August 2007 is as below :

Dosage : 0.25 % By Cement Weight

Mixing Method : Fibre has water based dispersion.

Fibres : Fibres may be added to concrete for special applications to enhance properties for which specialist literature may be referred to.

ANNEXURE 4.1**NOTE ON THERMO MECHANICALLY TREATED BARS****1.0 Introduction**

Thermo Mechanically Treated (TMT) Bars is a recent technological advancement for production of high strength deformed steel bars for concrete reinforcement. In this process higher strength is obtained by thermo mechanical treatment, wherein the steel bars get intensive cooling immediately after rolling. Sudden reduction in temperature creates a hardened surface layer with the internal core still being hot. While further cooling in atmosphere, tempering takes place by the heat from the core. The process is expected to improve the properties of strength and ductility of the bars.

2.0 Advantage

Generally, the higher strength in steel can be obtained by increasing Carbon content, Micro alloying, Thermo Mechanical Treatment or cold Twisting. So far in India, cold twisting of bars was used extensively for production of high strength bars. These bars can easily be identified by the two main ribs being helical, whereas in hot rolled bars these ribs are straight. In the case of TMT Bars the higher strength is obtained by thermo mechanical treatment and the Carbon content also has been brought down leading to improved Ductility.

3.0 Properties

This steel is currently being produced in various grades by M/s. Steel Authority of India Ltd., (SAIL) M/s. Tata Steel and M/s. Rashtriya Ispat Nigam Ltd., The trade names for these bars are SAIL-TMT, TISCON-TMT and REBARS respectively. The grades, chemical properties and mechanical properties are indicated in Table A, B & C respectively.

TABLE - A
GRADES

SL	M/s Sail	M/s Tata Steel	M/s Rashtriya Ispat Nigam Ltd..	Yield Stress (0.2% proof Stress) Considering Equivalent As per IS:1786
1.	SAIL TMT 415	TISCON TMT 42	REBARS 415	415 N/MMF
2.	SAIL TMT 500	TISCON TMT 50	REBARS 500	500 N/MMF
3.	SAIL TMT 520			530 N/MMF

TABLE B
CHEMICAL COMPOSITION IN %

IS: – 1786 FE 415	SAIL TMT All Grades	TISCON TMT 42	TISCON TMT 50	(RINL) Rebars all Grades
Carbon	0.30 0.25	0.17	0.190	0.20
Sulphur	0.06 0.05	0.045	0.045	0.04
Phosphorus	0.06 0.05	0.045	0.05	0.05
Sulphur + Phosphorus	0.11 0.10	0.90	0.090	0.09

TABLE C
MECHANICAL PROPERTIES

	IS:-1786	SAIL - TMT			TISCON		VIZAG STEEL (RINL) REBARS	
Grade	Fe 415	415	500	550	TMT42	TMT50	Fe 415	Fe 500
Yield Strength	415	415	500	550	450	530	460	540
Tensile Strength	485	500	580	630	510	580	520	585
Elongation in %	14.5	22	20	18	20	18	20	18

4.0 Limitations

4.1 Standard Table of SP.16 (Design Aid to IS:456) can be used for utilizing these bars in the design process. However, there are limitations when it comes to using the strengths higher than 415 MPa in Earthquake prone areas. IS.13920 forbids using strengths higher than 415 MPa under following situations:-

- i) The structure is located in Seismic zone IV & V.
- ii) The structure is located in Seismic Zone III and has the importance factor (I) greater than 1.0.
- iii) The structure is located in Seismic Zone III and is an Industrial Structure.
- iv) The structure is located in Seismic Zone III and is more than 5 storey high.

4.2 While every care shall be taken to avoid mixing different types and grades of bars in the same structure members as main reinforcement to satisfy clause 25.1 of IS:456. Specific approval of the Engineer will be required in the exigency of more than one grade type being used in the same building.

4.3 This Note does not cover use of corrosion Resistant Steels (CRS) bars.

5.0 Identification

Care shall also be taken to properly identify these bars at site. The staff shall be specially trained for looking for identification marks on these bars. While ordering for TMT Bars, the Manufacturer should be specifically asked to advise on the methods of identification of different grades of their bars by way of identification marks on the bars and by colour code

ANNEXURE 4.2**GRADE CONCRETE****SAMPLING, STRENGTH TESTING AND ACCEPTANCE CRITERIA**

EXTRACTED FROM IS:456-2000

15. SAMPLING AND STRENGTH OF DESIGNED CONCRETE MIX**15.1 General:**

Samples from fresh concrete shall be taken as per IS: 1199 and cubes shall be made, cured and tested at 28 days in accordance with IS: 516.

15.1.1 In order to get a relatively quick idea of the quality of concrete, optional tests on beams for modulus of rupture at 72 ± 2 hours or at 7 days, or compressive strength tests at 7 days may be carried out in addition to 28 days compressive strength tests. For this purpose, the values should be arrived at based on actual testing. In all cases, the 28 days compressive strength specified in Table 2 shall alone be the criterion for acceptance or rejection of the concrete.

(Note:-Table 2 mentioned above is reproduced as Table 3.6 on "Grades of Concrete", Chapter 3 on Concrete Work, in terms of which the specified characteristic compressive strength at 28 days in N/mm^2 is 20 in case of M-20, 25 in case of M-25 and so on)

15.2 Frequency of sampling**15.2.1 Sampling Procedure -**

A random sampling procedure shall be adopted to ensure that each concrete batch shall have a reasonable chance of being tested that is, the sampling should be spread over the entire period of concreting and cover all mixing units.

15.2.2 Frequency

The minimum frequency of sampling of concrete of each grade shall be in accordance with the following :

Quantity of concrete in the work, m ³	Number of Samples
1-5	1
6-15	2
16-30	3
31-50	4
51 and above	4 plus one additional sample for each additional 50m ³ or part thereof.

NOTE - At least one sample shall be taken from each shift. Where concrete is produced at continuous production unit, such as ready-mixed concrete plant, frequency of sampling may be agreed upon mutually by suppliers and purchasers.

15.3 Test Specimen

Three test specimens shall be made from each sample for testing at 28 days. Additional samples may be required for various purposes such as to determine the strength of concrete at 7 days or at the time of striking the formwork, or to determine the duration of curing, or to check the testing error. Additional samples may also be required for testing samples cured by accelerated methods as described in IS: 9013. The specimen shall be tested as described in IS: 516.

15.4 Test Results of Sample

The test results of the sample shall be the average of the strength of three specimens. The individual variation should not be more than ± 15 percent of the average. If more, the test results of the sample are invalid.

16. ACCEPTANCE CRITERIA**16.1 Compressive Strength**

The concrete shall be deemed to comply with the strength requirements when both the following condition are met:

1. The mean strength determined from any group of four consecutive test results complies with the appropriate limits in col 2 of Table 11.

2. Any individual test result complies with the appropriate limits in col 3 of Table 11.

16.2 Flexural strength

When both the following conditions are met, the concrete complies with the specified flexural strength:

(a) The mean strength determined from any group of four consecutive test results exceeds the specified characteristic strength by at least 0.3 N/mm^2 .

(b) The strength determined from any test result is not less than the specified characteristic strength less 0.3 N/mm^2 .

16.3 Quantity of Concrete Represented by Strength Test Results

The quantity of concrete represented by a group of 4 consecutive test results shall include the batches from which the first and last samples were taken together with all intervening batches.

For the individual test result requirements given in col 2 of Table 11 or in item (b) of

16.2, only the particular batch from which the sample was taken shall be at risk.

Where the mean rate of sampling is not specified the maximum quantity of concrete that four consecutive test results represent shall be limited to 60 m^3 .

16.4 If the concrete is deemed not to comply pursuant to 16.3, the structural adequacy of the parts affected shall be investigated (see 17) and any consequential action as needed shall be taken.

16.5 Concrete of each grade shall be assessed separately.

16.6 Concrete is liable to be rejected if it is porous or honey combed; its placing has been interrupted without providing a proper construction joint, the reinforcement has been displaced beyond the tolerances specified; or construction tolerances have not been met. However, the hardened concrete may be accepted after carrying out suitable remedial measures to the satisfaction of the engineer-in-charge.

Table 11 Characteristic Compressive Strength Compliance Requirements

(Clauses 16.1 & 16.3)

Specified grade	Mean of the group of 4 Non-Overlapping Consecutive Test Results in N/mm^2	Individual Test Results in N/mm^2
(1)	(2)	(3)
M 15	$\geq f_{ck} + 0.825 \times \text{established standard deviation}$ (rounded off to nearest 0.5 N/mm^2) or $f_{ck} + 3 \text{ N/mm}^2$ whichever is greater.	$\geq f_{ck} \text{ N/mm}^2$
M 20 or above	$\geq f_{ck} + 0.825 \times \text{established standard deviation}$ (rounded off to nearest 0.5 N/mm^2) or $f_{ck} + 4 \text{ N/mm}^2$ whichever is greater	$\geq f_{ck} \text{ N/mm}^2$

(NOTE – In the absence of established value of standard deviation, the values given in Table 8 of IRC Concrete Bridge Code (Reproduced as Table 4.5 of this Chapter) may be assumed and attempt should be made to obtain results of 30 samples as early as possible to establish the value of standard deviation.)

ANNEXURE 4.3**ORDINARY CONCRETE – MANDATORY
LAB TEST**

(Cube Test for Compressive Strength of
Concrete)

A-0 One sample (consisting of six cubes 15 x 15 x 15 cm) shall be taken for every 20 cum or part thereof of concrete work, ignoring any part less than 5 cum or as often as considered necessary by the Engineer. The test of concrete cubes shall be carried out in accordance with the procedure as described below. A register of cubes shall be maintained at the site of work as prescribed in Annexure 4.5. The casting of cubes, concrete used for cubes and all other incidental charges such as curing, carriage to the testing laboratory shall be borne by the Contractor. The testing fee for the cubes, if any, shall also be borne by the Contractor.

A-1 Test procedure**A – 1.1 Mould**

The mould shall be of size 15 cm x 15 cm x 15 cm for the maximum nominal size of aggregate not exceeding 40 mm. For concrete with aggregate size more than 40 mm, size of mould shall be specified by the Engineer, keeping in view the fact that the length of size of mould should be about four times the size of aggregate.

The moulds for test specimens shall be made of non-absorbent material and shall be substantially strong enough to hold their form during the moulding of test specimens. They shall not vary from the standard dimensions by more than one percent. The moulds shall be so constructed that there is no leakage of water from the test specimen during moulding. All the cube moulds for particular site should, prior to use, be checked for accuracy in dimensions and geometric form and such test should at least be made once a year.

Each mould shall be provided with a base plate having a plane surface and made of non-absorbent material. This plate shall be large enough in diameter to support the moulds properly without leakage. Glass plates not less than 6.5 mm thick or plain metal not less than 12 mm thick shall be used for this purpose. A similar plate shall be provided for covering the top surface of the test specimen when moulded.

Note Satisfactory moulds can be made from machine or steel castings, rolled metal plates or galvanized iron.

A.1.2 Sample of Concrete

Sample of concrete for test specimen shall be taken at the mixer or in the case of ready mixed concrete from the transportation vehicle discharge or as directed by the Engineer. Such samples shall be obtained by repeatedly passing a scoop or pail through the discharge stream of concrete. The sampling operation should be spread over evenly to the entire discharging operation. The samples thus obtained shall be transported to the place of moulding of the specimen. To counteract segregation, the concrete shall be mixed with a shovel until it is uniform in appearance. The location in the work of the batch of concrete thus sampled shall be noted for further reference. In case of paving concrete, samples shall be taken from the batch immediately after deposition of the sub-grade. At least five samples shall be taken from different portion of the pile and these samples shall be thoroughly mixed before being used to form the test specimen. The sampling shall be spread as evenly as possible throughout the day. When wide changes occur during concreting, additional samples shall be taken if so desired by the Engineer.

A.1.3. Preparation of Test Specimens

The interior surfaces of the mould and base plate shall be lightly oiled before the concrete is placed in the mould. The samples of concrete obtained as described under the test specimen shall be immediately moulded by one of the following methods as indicated below:-

When the job concrete is compacted by manual methods, the test specimen shall be moulded by placing the fresh concrete in the mould in three layers, each approximately one third of the volume of the mould. In placing each scoopful of concrete the scoop shall be moved around the top edge of the mould as the concrete there slides from it, in order to ensure a uniform distribution of concrete within the mould. Each layer shall be pounded 35 times with 16mm rod, 60 cm in length, bullet pointed at the lower end. The strokes shall be distributed in uniform manner over the cross section of the mould and shall penetrate into underlying layer. The bottom layer shall be pounded through its depth. After the top layer has been rodded, the surface of the concrete shall be

struck off with a trowel and covered with a glass plate at least 6.5 mm thick or a machined plate. The whole process of moulding shall be carried out in such a manner as to preclude the alteration of water-cement ratio of the concrete by loss of water, either by leakage from the bottom or overflow from the top of the mould.

When the job concrete is placed by vibration and the consistency of the concrete is such that the test specimens cannot be properly moulded by handrodding as described above, the specimens shall be vibrated to give a compaction corresponding to that of the job concrete. The fresh concrete shall be placed in mould in two layers, each approximately half the volume of the mould. In placing each scoopful of concrete the scoop shall be moved around the top edge of the mould as the concrete there slides from it, in order to ensure a symmetrical distribution of concrete within the mould. Either internal or external vibrators may be used. The vibration of each layer shall not be continued longer than is necessary to secure the required density. The internal vibrators shall vibrate only the layer to be compacted. In compacting the first layer, the vibrators shall not be allowed to rest on the bottom of the mould. In placing the concrete for top layer there should be no mortar loss during vibrations. After vibrating the second layer enough concrete shall be added to bring level above the top of the mould. The surface of the concrete shall then be struck off with a trowel and covered with a glass or steel plate as specified above. The whole process of moulding shall be carried out in such a manner as to preclude the alteration of water-cement ratio of the concrete by loss of water, either by leakage from the bottom or over flow from the top of the mould.

A 1-4 Curing and Storage of Specimen

In order to ensure reasonably uniform temperature and moisture conditions during the first 24 hours for curing the specimen and to protect them from damage, moulds shall be covered with wet straw or gunny sacking and placed in a storage box so constructed and kept on the work site that its air temperature when containing concrete shall remain 22°C to 33°C , Other suitable

means which provide such a temperature and moisture conditions may be used.

NOTE:- It is suggested that the storage box be made of 25 mm dressed tongued and grooved timber, well braced with battens to avoid warping. The box should be well painted inside and outside and should be provided with a hinged cover and padlock.

The test specimen shall be removed from the moulds at the end of 24 hours and stored in a moist condition at a temperature within 24°C to 30°C until the time of test. If storage in water is desired, a saturated lime solution shall be used.

A – 1.5 Testing

The specimens shall be tested in accordance with procedure as described below:-

(a) The tests shall be made at an age of concrete corresponding to that for which the strengths are specified.

(b) Compression tests shall be made immediately upon removal of the concrete test specimen from the curing room i.e. the test specimen shall be loaded in damp condition. The dimensions of the test specimens shall be measured in mm accurate to 0.5 mm.

(c) The metal bearing plates of the testing machine shall be placed in contact with the ends of the test specimens. Cushioning materials shall not be used. In the case of cubes, the test specimen shall be placed in the machine in such a manner that the load is applied to sides of the specimens as cast. An adjustable bearing block shall be used to transmit the load to the test specimen. The size of the bearing block shall be the same or slightly larger than that of test specimen. The upper or lower section of the bearing block shall be kept in motion as the head of the testing machine is brought to a bearing on the test specimen.

(c) The load shall be applied axially without shock at the rate of approximately 140 kgs. per/ Sqcm per minute. The total load indicated by the testing machine at failure of test specimen shall be recorded and the unit compressive strength is calculated in kg per sqcm using the area computed from the measured dimensions of the test specimen. The type of failure and appearance of the concrete shall be noted.

ANNEXURE 4.4**REGISTER OF WORK TEST OF CONCRETE**

(7 days Test)

(a) Name of work	Concrete mix.(By volume)	Compressive strength in kg/cm ² on 7 days
(b) Name of contractor	1:1 ¹ / ₂ :3	175
(c) Agreement No	1:2:4	140
(d) Sample No.		
(e) Identification mark		
(f) Portion of work and quantity represented by sample.		
(g) Date and time of casting cube		
(h) Proportion of mix		

1. Due date of test Cube No
2. Actual date of test
3. (a) Minimum Strength
 (b) Maximum strength
 (c) Average strength of three cubes
 (d) Difference between 3a and 3 b
 (e) Difference in % age in terms of average strength
 i.e. $3b-3a \times 100 =$

 3c
4. Specified compressive strength of concrete mix used

REGISTER OF WORK TEST OF CONCRETE

(28 days Test)

(a) Name of work	Concrete mix.(By volume)	Compressive strength in 28 days Kg/cm ²
(b) Name of contractor	1:1 ¹ / ₂ :3	265
(c) Agreement No	1:2:4	210
(d) Sample No.		
(e) Identification mark		
(f) Portion of work and quantity represented by sample.		
(g) Date and time of casting cube		
(h) Proportion of mix		

1. Due date of test Cube No.
2. Actual date of test
3. Actual compressive strength of cubes
 (Min. number of cubes to be tested-three)
- (a) Minimum strength
- (b) Maximum strength
- (c) Average strength of three cubes
- (d) Specified compressive strength of concrete mix used

RECOMMENDED LIST OF TESTS ON MATERIALS AND WORKS

Material	Test	Field/ Lab.	Test Procedure	Minimum quantity of material for carrying out test	
Reinforced Cement Concrete (Ordinary Concrete)	(a) Slump Test	Field / Lab	Annexure 3.5 of Chapter 3	(i) 5 cum in case of column. (ii) 20 cum for slabs, beams and connected columns. (iii) 20 cum for other R.C.C. Work for all other small items and where R.C.C. done in a day is less than 5 cum test may be carried out as required by the Engineer	(i) Every 5 cum or part thereof. (ii) Every 20 cum or part thereof. (iii) -do-
	(b) Cube Test	Lab	Annexure 4.3	(i) 5 cum in case of column. (ii) 20 cum for slabs, beams and connected columns. (iii) 20 cum for other R.C.C. Work for all other small items and where R.C.C. done in a day is less than 5 cum test may be carried out as required by the Engineer	(i) Every 5 cum or part thereof. (ii) Every 20 cum or part thereof. (iii) -do-

Material	Test	Field/ Lab	Test Procedure	Minimu m quantity of material for carrying out test	Frequency of Testing	
					For consign-ment below 100 tonnes.	For consignment over 100 tonnes
Steel for Reinforc ement in RCC	Mild Steel and Medium Tensile Steel Bars (a) Nominal Mass (b)Tensile test (c) Bend test	Lab/Field	IS: 1732	As prescrib ed in IS: 1786	(i) Under 10 mm dia: one sample for each 25 t or part thereof.	(i) Under 10 mm dia, one sample for each 40 t or part thereof.
		Lab/Field	I.S:1608		(ii) 10mm to 16mm dia:one sample for each 35 t or part thereof	ii)10mm to 16mm dia, one sample for each 45 t or part thereof
	High Strength Deformed Steel Bars (a) Nominal Mass (b)Tensile test (c)Bend Test (d) Rebend Test	Lab/Field	IS: 1599		iii) Over 16mm dia: one sample for each 45 t or part thereof	iii) Over 16mm dia: one sample for each 50 t or part thereof
		Lab/Field	I.S:1786			
		Lab/ Field	I.S:1608			
		Lab/Field	IS: 1599			
		Lab/Field	IS: 1786			

FIGURE 4.1 A
SKETCH SHOWING U-TYPE HOOK FOR REINFORCEMENT

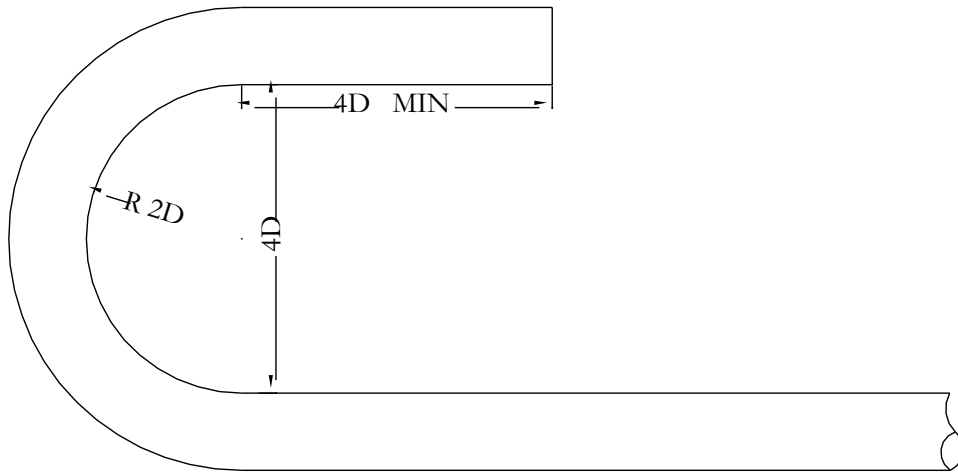


FIGURE 4.1 B
SKETCH SHOWING BENDS FOR REINFORCEMENT

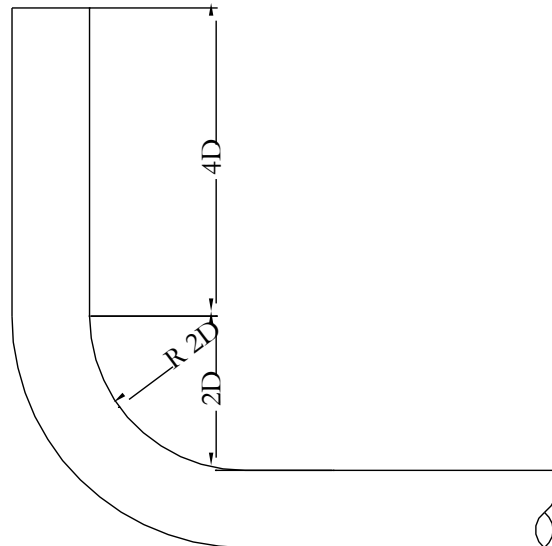
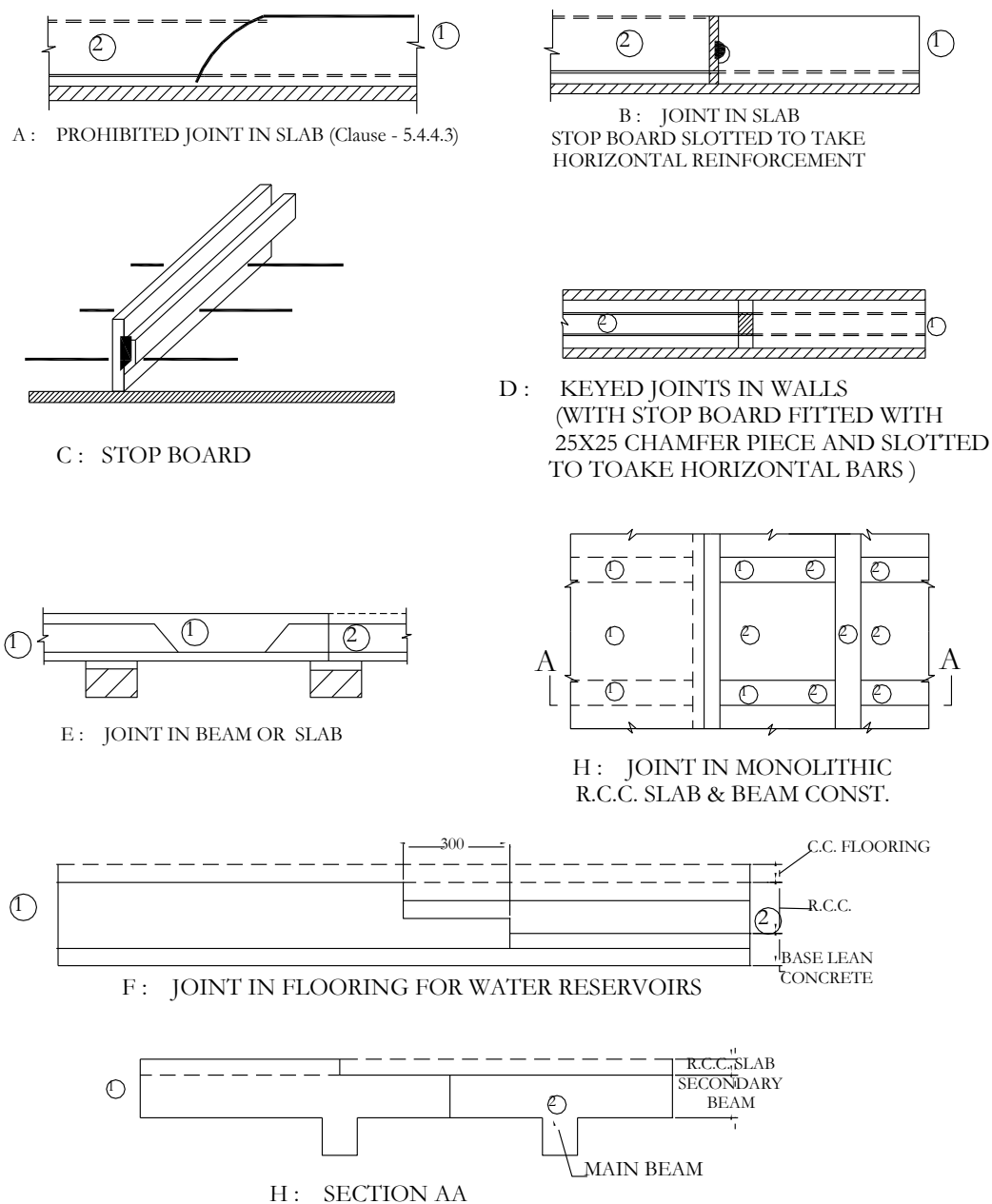


FIGURE 4.2

CONSTRUCTION JOINT AT VARIOUS LOCATIONS



1 : REPRESENTS FIRST PLACING OF CONCRETE.

2 : REPRESENTS SUBSEQUENT PLACING OF CONCRETE.

ALL DIMENSIONS ARE IN MM
DRAWINGS NOT TO SCALE

FIGURE 4.3 A & 4.3 B
DETAIL OF EXPANSION JOINTS IN VARIOUS LOCATIONS

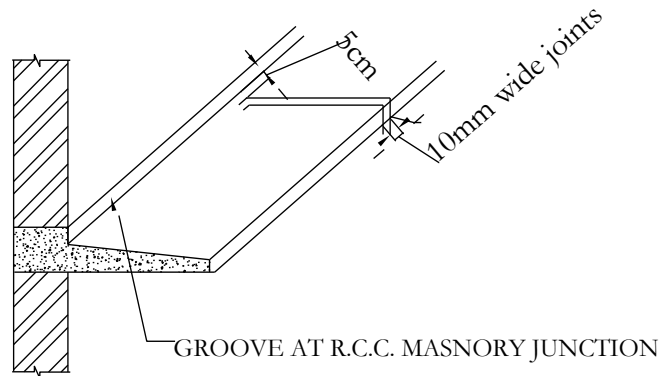


FIGURE 4.3 A : EXPANSION JOINTS IN LONG SUN SHADE

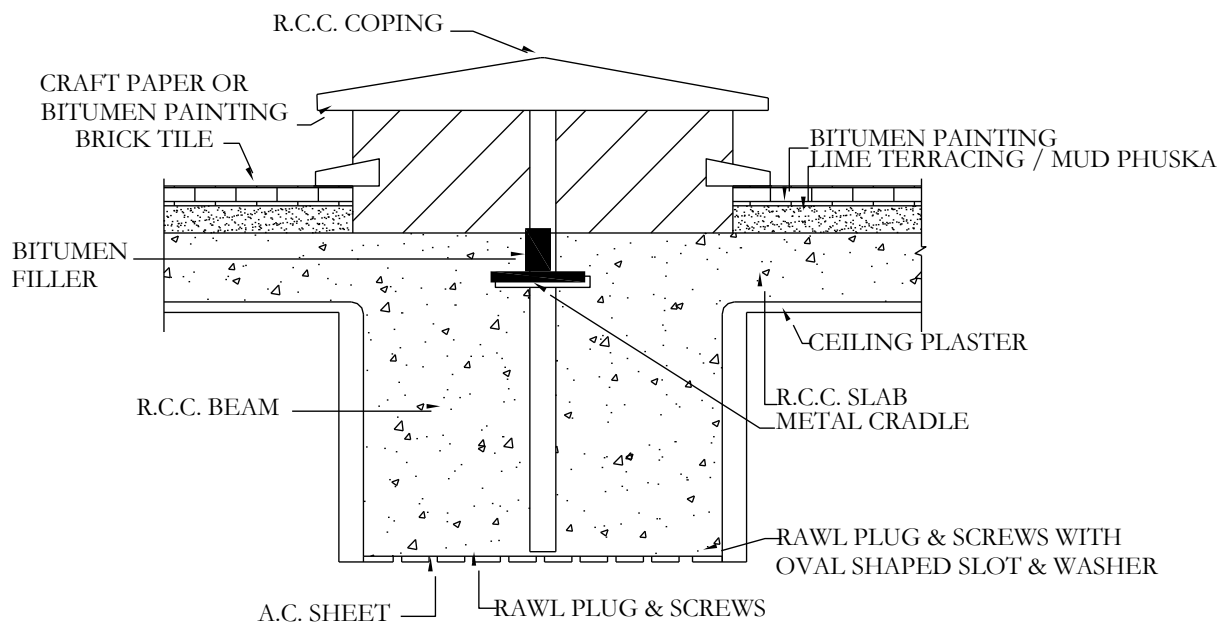


FIGURE 4.3 B : DETAILS OF RAISED TYPE EXPANSION JOINT AT ROOF

FIGURE 4.3C to 4.3E

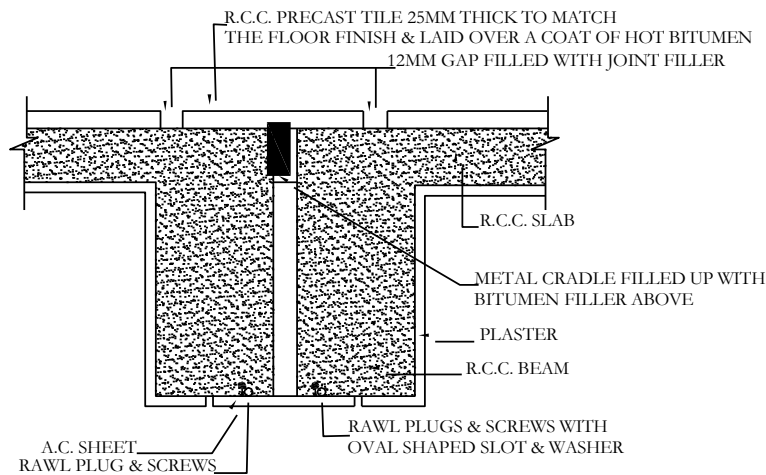


Fig 4.3C :Typical Details of Expansion joint at Floor

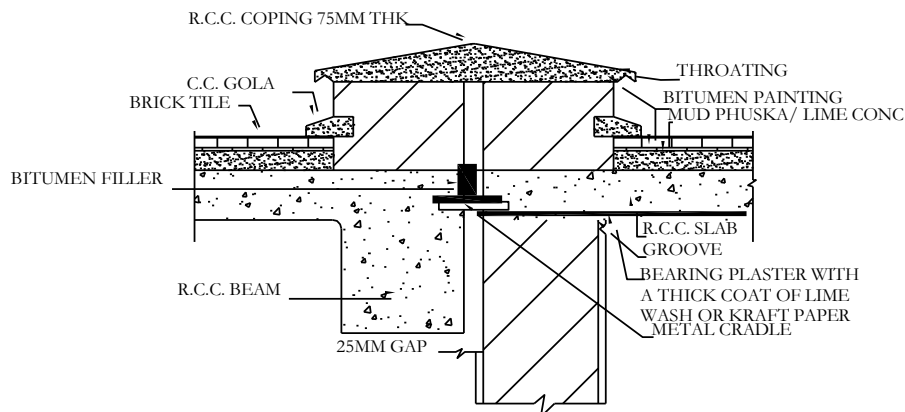


FIGURE 4.3 D :Typical Details of Expansion joint at wall & Beam Junction

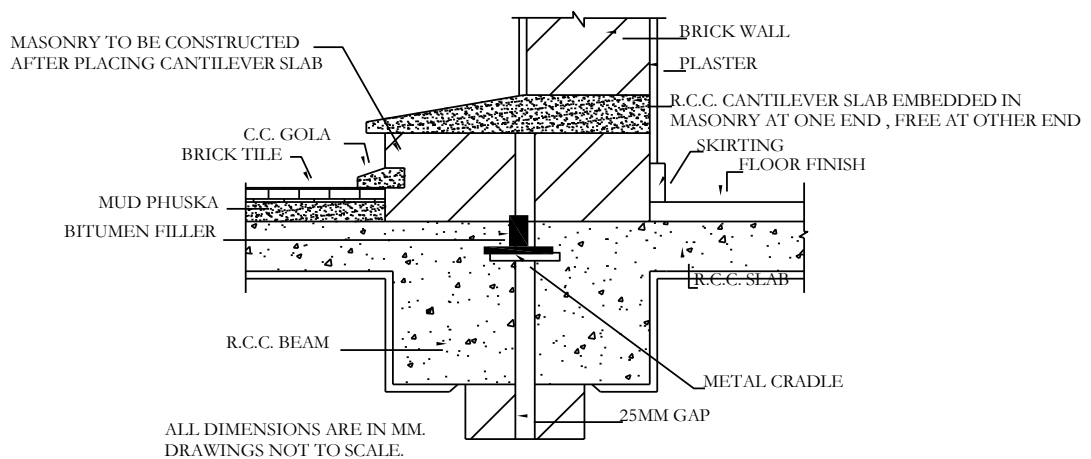


FIGURE 4.3 E :Typical Details of Expansion joint at Roof & Floor Junction

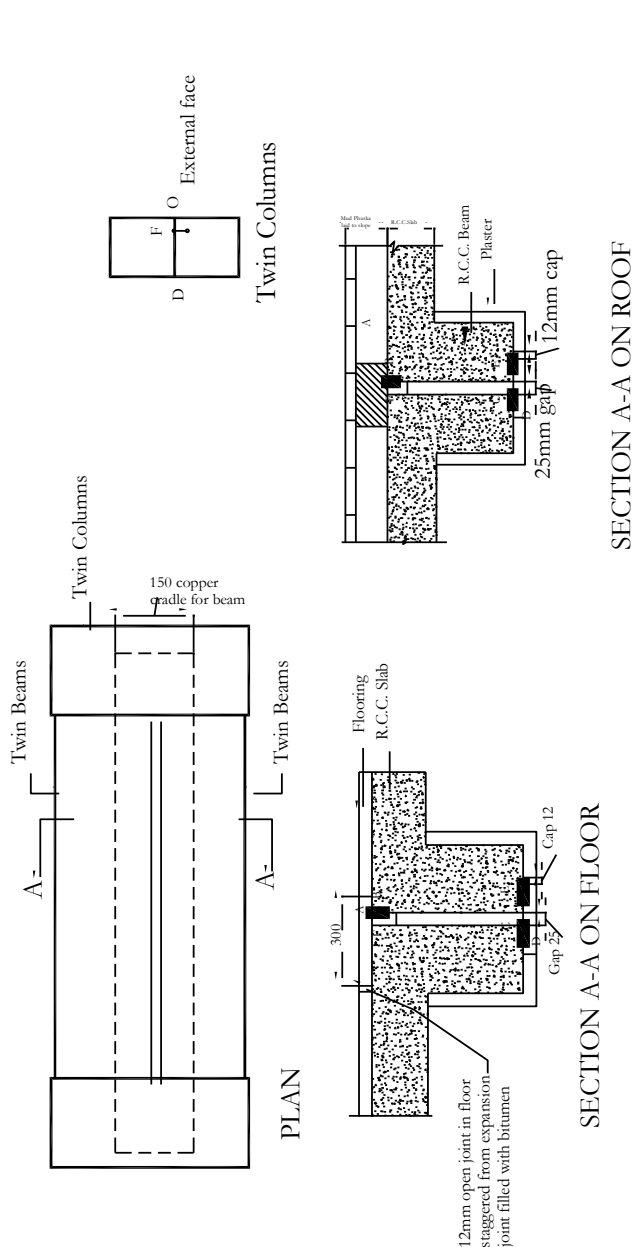


FIGURE 4.3(F) TWIN BEAM WITH TWIN COLUMNS

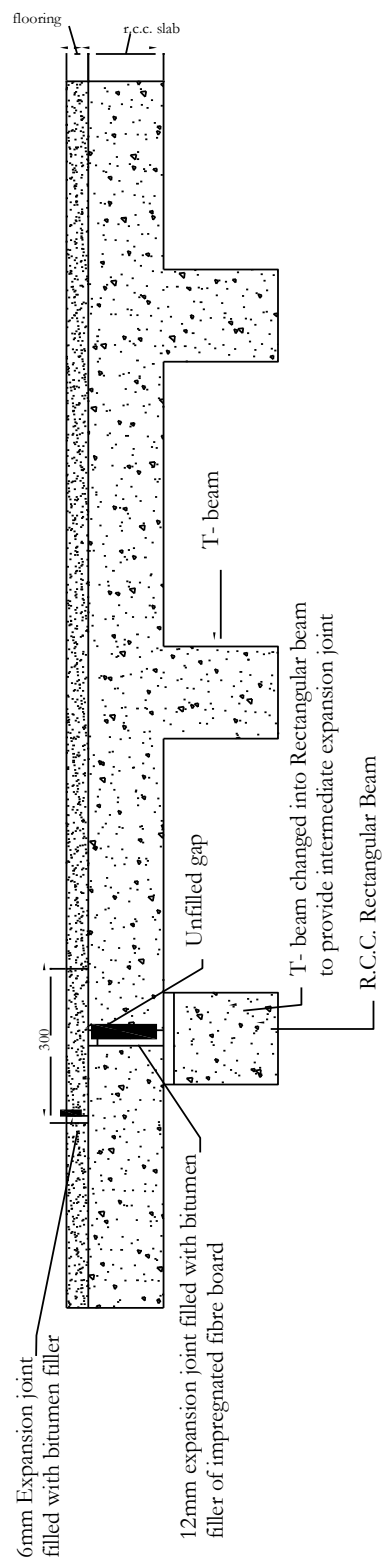


Figure 4.3 (G) Slab & T-Beam construction of Long Length

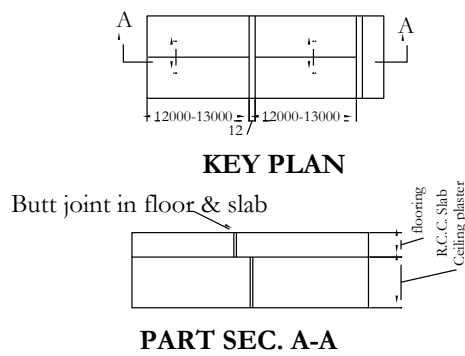


Figure 4.3 (H) Long Verandah Slab

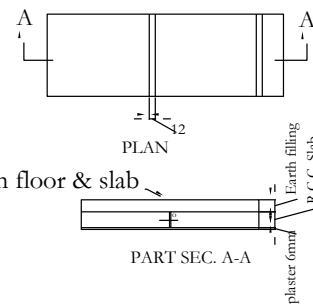


Fig 4.3 (I) Long -Water Reservoir Slab

- A Hot bitumen painting @ 1.7kg/sqm
- B Bitumen filler
- C Raw Plugs & 50mm screws @ 300mm c/c.
- D Asbestos sheet 150mm wide or P.V.C. sheet.
- E Raw Plugs & screws with oval shaped slot & washers @ 300 mm c/c.
- F Copper cradle

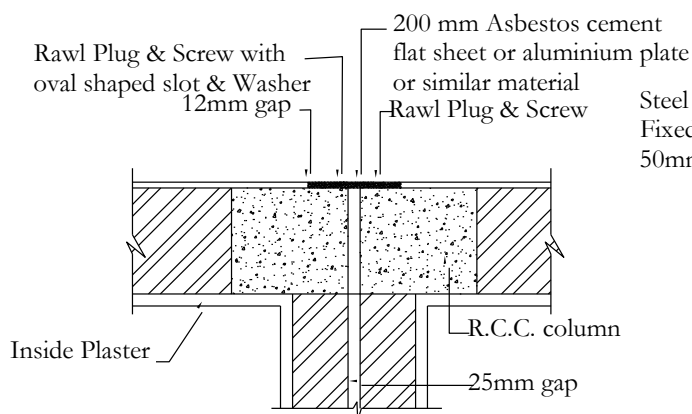


Fig 4.3 J
Typical Detail of Expansion Joint Covering
on Outer Face of Columns (Plan)

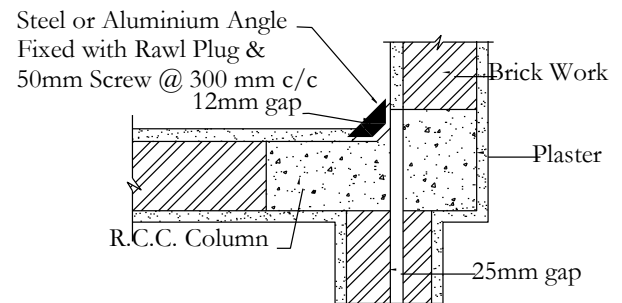


Fig 4.3 K
Typical Detail of Expansion Joints
at corner column

ALL DIMENSIONS ARE IN MM

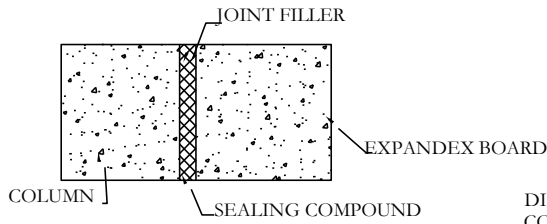


Fig 4.3 L
Typical Details of Expansion
Joint at Isolated Twin Columns

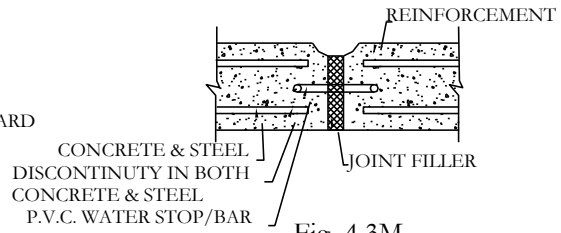
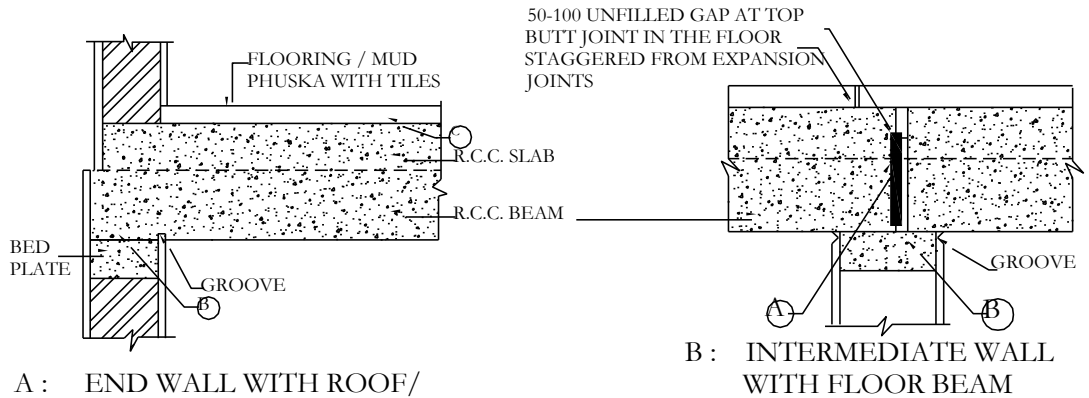


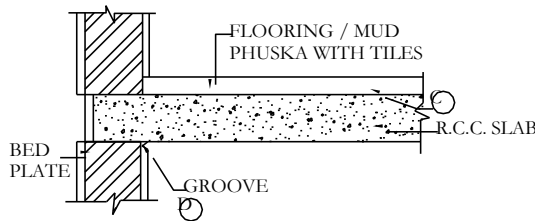
Fig 4.3M
Expansion Joint Subjected to Water
Pressure (for water Tanks)

Fig 4.3N

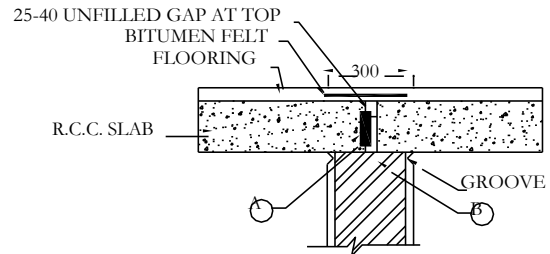


A : END WALL WITH ROOF/
SUSPENDED FLOOR SLAB

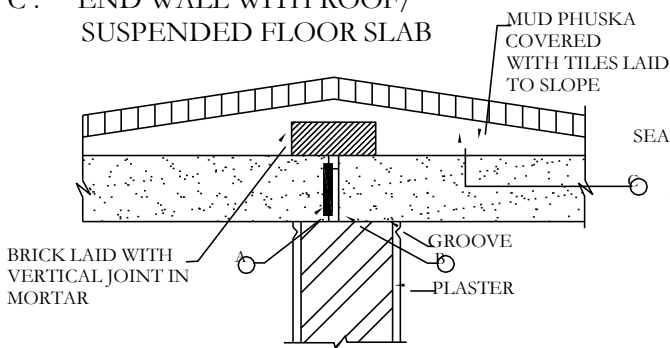
B : INTERMEDIATE WALL
WITH FLOOR BEAM



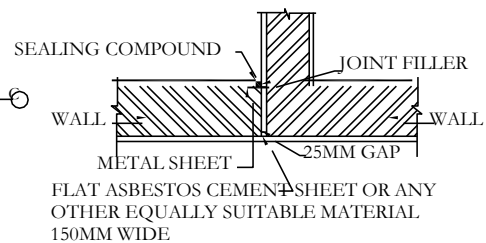
C : END WALL WITH ROOF/
SUSPENDED FLOOR SLAB



D : INTERMEDIATE WALL
WITH FLOOR SLAB



E : INTERMEDIATE WALL
WITH ROOF SLAB



F : EXPANSION JOINT USING
JOINT FILLER & SEALING
COMPOUND

- A 12MM EXPANSION JOINTS FILLED WITH BITUMEN FILLER OR IMPREGNATED FIBRE.
B 6MM CEMENT PLASTER 1:3 (1C:3F:SAND) FINISHED WITH A FLOATING COAT OF NEAT CEMENT AND A THICK COAT OF LIME WASH OR LAID WITH KRAFT PAPER.
C HOT BITUMEN PAINTING @ 1.7KG/SQM IN CASE OF ROOF SLAB/B EAM
D HOT BITUMEN PAINTING @ 1.7KG/SQM BELOW BRICK WALL ONLY ON SUSPENDED FLOOR BEAM/SLAB

ALL DIMENSIONS ARE IN MM
DRAWINGS NOT TO SCALE

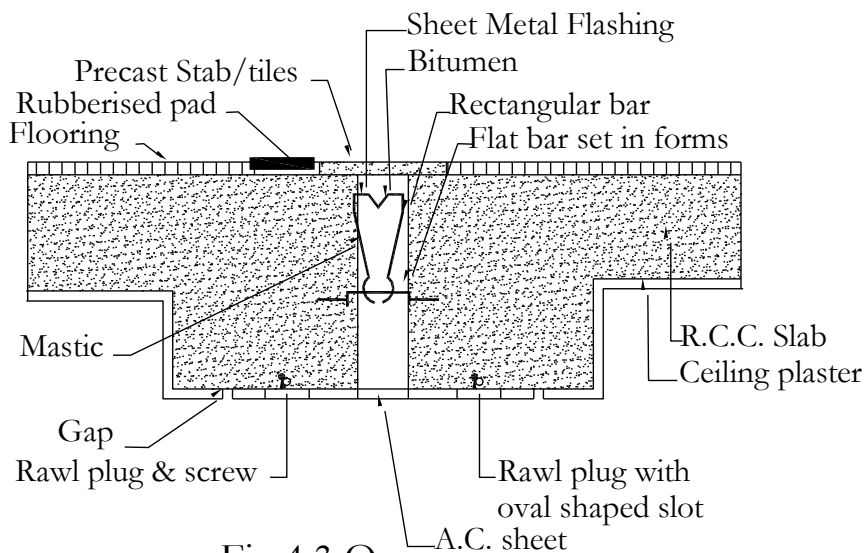


Fig 4.3 O
Seismic Separation at Floor Level

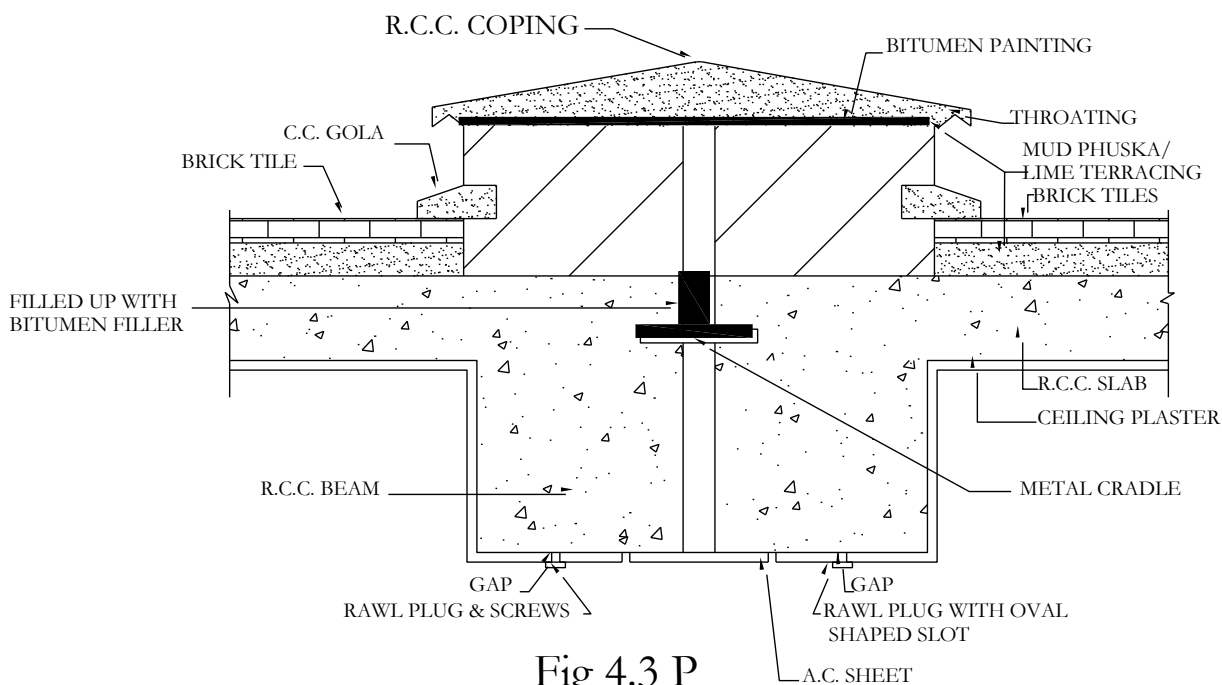
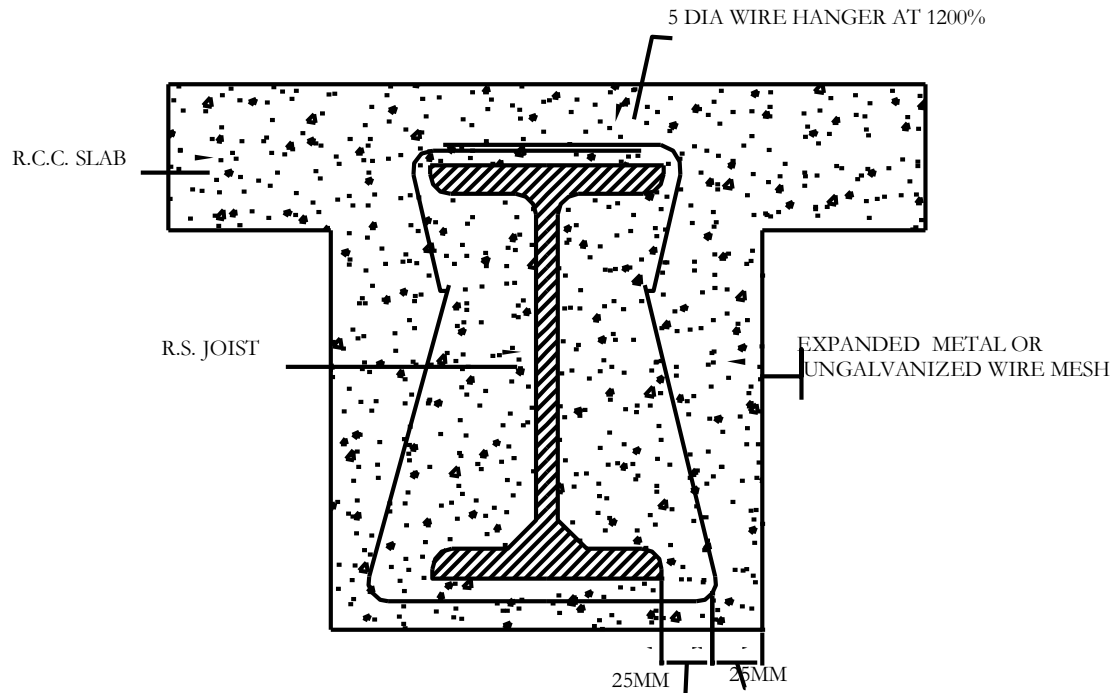


Fig 4.3 P
Seismic Separation Joints detail at Roof

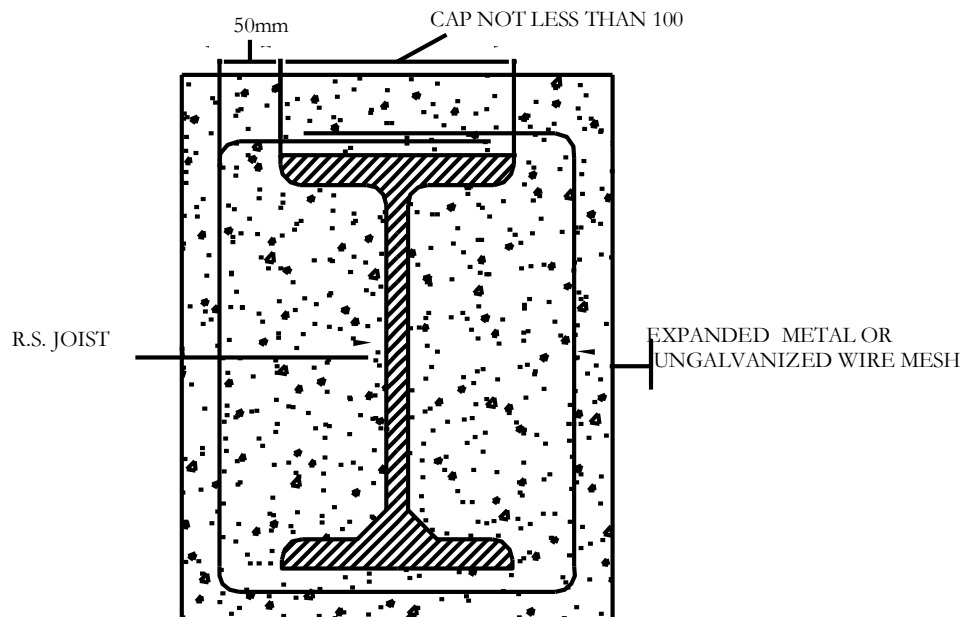
ALL DIMENSIONS ARE IN MM
DRAWINGS NOT TO SCALE

FIGURE 4.4B

ENCASING STEEL BEAM WITH SLAB



ENCASING STEEL COLUMN



Normally Cement Concrete 1:2:4 (1 Cement :2 Coarse Sand :
4 Graded Stone Aggregate 12.5 Nominal Size) shall be used.

ALL DIMENSIONS ARE IN MM.
DRAWINGS NOT TO SCALE.

FIGURE 4.5A to 4.5C

PRECAST R.C.C. DOOR - WINDOW FRAMES

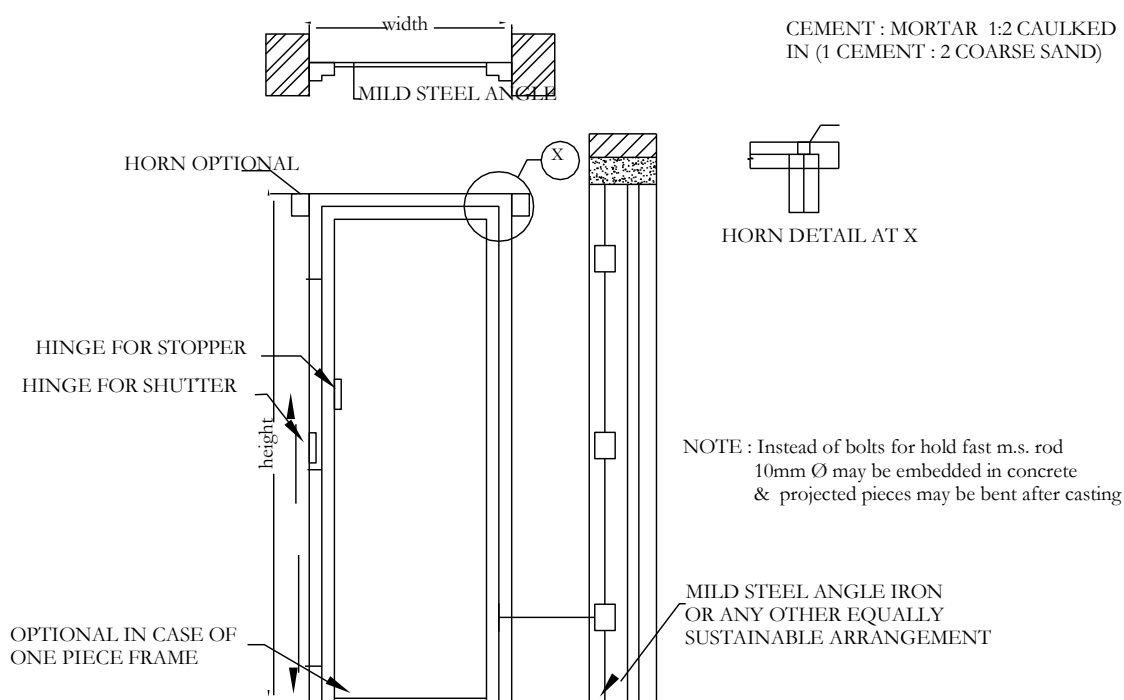


Fig 4.5A : Overall Dimensions of Precast Reinforced Concrete Door Frame

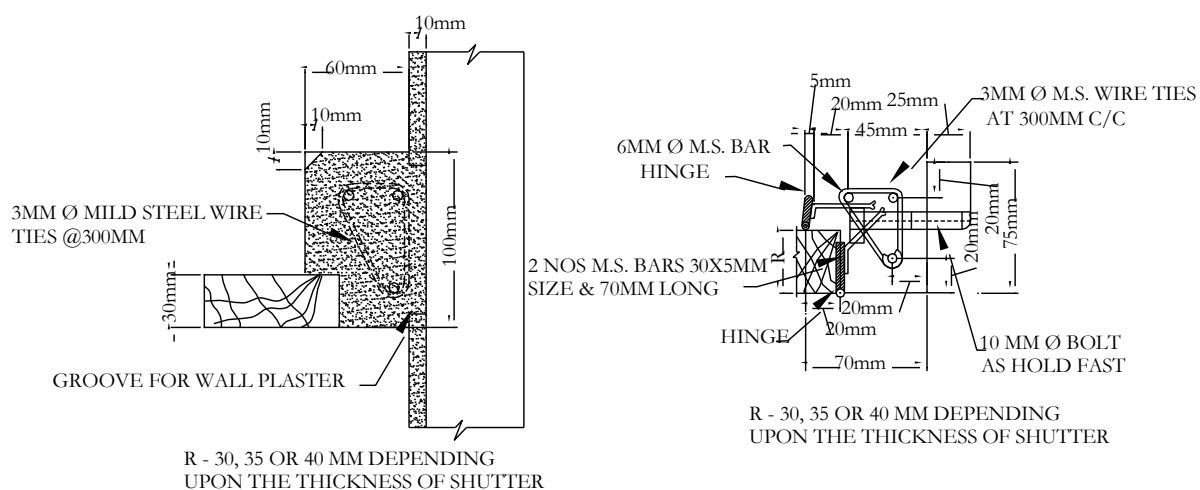
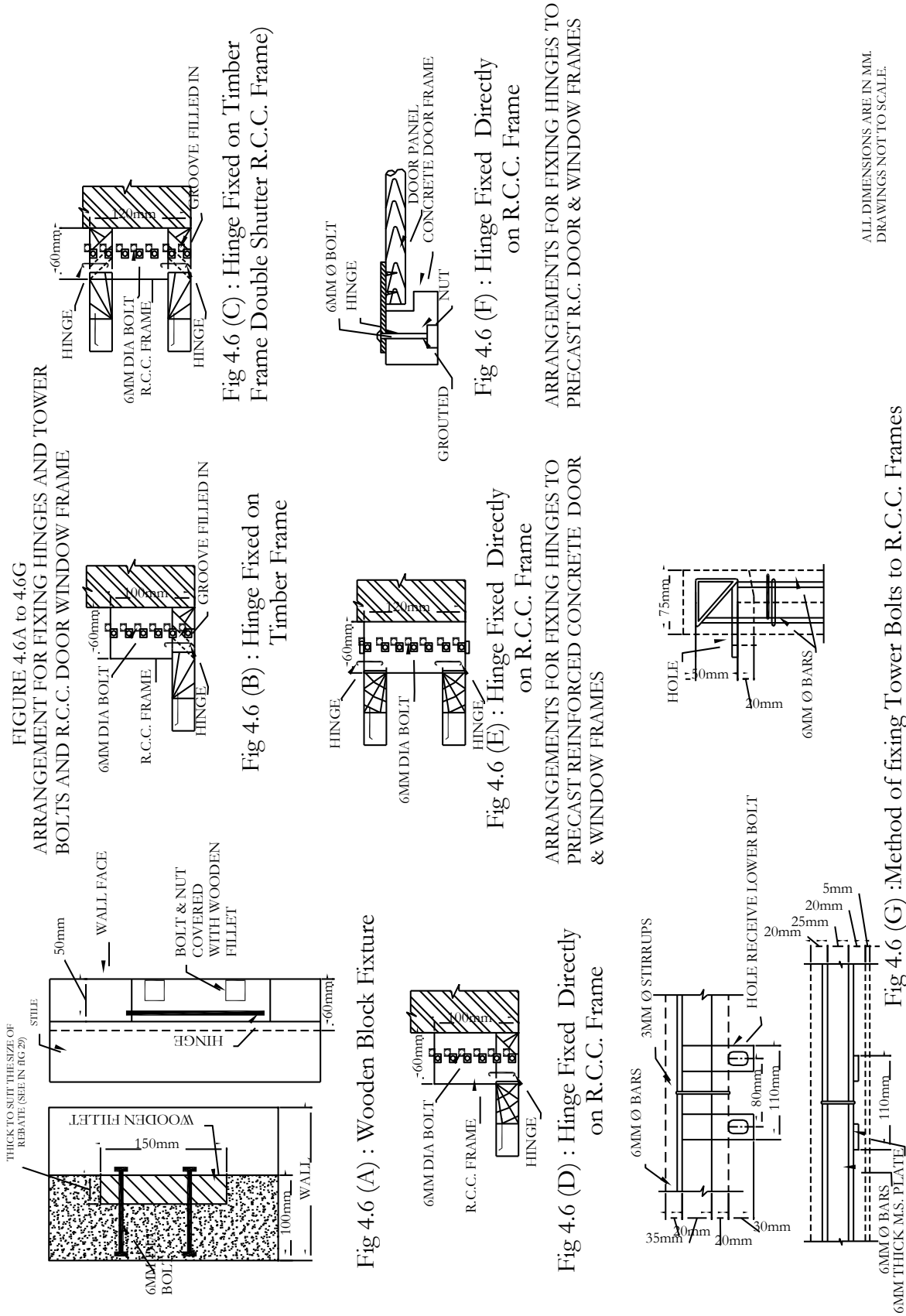


Fig 4.5 (B) : Cross Section of Precast Reinforced Concrete Door & Window Frame Showing Reinforcement

Fig 4.5 (C) : Alternative Details of Precast Reinforced Concrete Door & Window Frame Showing Arrangement for Reinforcement, Hold fast & Hinges



Chapter 5

Brick Work

5.0. TERMINOLOGY

Arrises : The edges of a brick are formed by the inter section of the plain surfaces of the brick. The edges thus formed are called arrises. The arrises should be free from any damage and be sharp and square.

Bond : The arrangement of the bricks in successive courses to tie the brick work together both longitudinally and transversely. The arrangement is usually designed to ensure that no vertical joint of one course is exactly over the one in the next course above or below it, and there is greatest possible amount of overlap.

Bed : When the brick is laid flat the lower surface of the brick is called the bed.

Bed Joint : Horizontal joint in brick work or masonry with a layer of mortar (see Fig. 5.1A).

Closer : Any portion of a brick used in constructing a wall, to close up the bond next to the end brick of a course (See Fig.5.2A to 5.2D for Closers of different types and the purposes for which they are used).

Coping or Weathering : The cover applied over or the geometrical form given to a part of structure to enable it to shed rain water.

Corbel : A cantilever projecting from the face of wall to form a bearing (See Fig. 5.1D).

Cornice : Horizontal or ornamental feature projecting from the face of a wall (See Fig. 5.1D).

Course : A layer of bricks including bed mortar.

Cross joint : A joint other than a bed joint normal to the wall face.

Efflorescence : A powdery incrustment of salts left by evaporation. This may be visible on the surface or may be below surface. In the latter case, this is termed as crypto Efflorescence.

Frog : Indentation of depth 10 to 20mm on one of the flat sides of Hand moulded bricks of 90mm or 70mm height, with shape and size conforming to Figures referred to in Para 5.2 of IS 1077. No Frogs need to be provided in Bricks of 40mm height as well as those made by extrusion process.

Header : A brick laid with its length across the wall. (See Fig. 5.1A)

Indenting : The process of leaving recesses into which future work can be bonded.

Jamb : The part of the wall at the side of an opening.

Joint : A junction of bricks.

Jointing : The operation of finishing joints as the masonry work proceeds.

Lap : Lap is a horizontal distance between the joint of stretcher course with header course in case of brickwork in English Bond. For a good brick work the length of the lap should be equal to atleast one fourth of the length of brick. (See Fig.5.1A)

Perpends : The vertical joints of the bricks on header course and stretcher course are called as perpends. These perpends should be one above the other in alternate course. (See Fig.5.1A)

Pier : A thickened section forming integral part of the wall placed at intervals along the wall primarily to increase the stiffness of the wall or to carry a vertical concentrated load. The thickness of a pier is the over all thickness including the thickness of the wall, or when bonded into one leaf of a cavity wall the thickness obtained by treating this leaf as an independent wall (see Fig.5.1B).

Pillar : Pillar means a detached masonry support. This can be rectangular, circular, elliptical etc. In case of rectangular pillar, the breadth shall not exceed three times the thickness and thickness itself shall not exceed more than thrice the length of brick (see Fig.5.1C).

Quoin : An external corner in brick work, the term may also denote the brick used to form the quoin. (see Fig.5.1A)

Scaffolding : A temporary erection of timber or steel work used in the construction, alteration, demolition or repairs of a building to support or to assist in the hoisting or lowering of workmen, their tools and materials.

Sill : A brick work forming the lower boundary of door or window opening (see Fig.5.1D).

Spandrel : The space between the haunches and the road decking of an arch.

Strecher : A brick laid with its length in the direction of the wall. (see Fig.5.1A)

String course : A horizontal course projecting from a wall usually introduced at every floor level or windows or below parapet for imparting architectural appearance to the

structure and also keeping off the rain water (see **Fig.5.1D**).

Template : A pattern of sheet metal used as a guide for setting out specific section and shape.

Tooththing : When a brick wall has to be terminated and then continued after a considerable time, the wall is terminated vertically but to secure bondage with the new construction, alternate layer bricks are projected beyond the face of termination, and this projection of alternate bricks is called tooththing.

Wall Joint : A joint parallel to the wall face.

5.1. BRICKS/BRICK TILES/BRICK BATS

5.1.1 General : Bricks used in the masonry may be of the following types:

(a) **Common burnt clay bricks** : They shall conform to IS:1077 shall be hand moulded or machine moulded. They shall be free from nodules of free lime, visible cracks, flaws, warpage and organic matter, have a frog 100 mm in length 40 mm in width and 10 mm to 20 mm deep on one of its flat sides. Bricks made by extrusion process and brick tiles may not be provided with frogs. Each brick shall be marked (in the frog where provided) with the manufacturer's identification mark or initials.

(b) **Fly Ash Lime Bricks** : The Fly Ash Lime Bricks (FALG Bricks) shall conform to IS.12894. Visually the bricks shall be sound, compact and uniform in shape free from visible cracks, warpage, flaws and organic matter. The bricks shall be solid and with or without frog on one of its flat side.

Fly Ash : Fly ash shall conform to grade 1 or grade 2 of IS. 3812.

Note : This item will be operated only for load bearing structure up to 2 storeys and for non-load bearing walls 23 cms thick for multi-storeyed building. Fly ash used as replacement of sand shall not have more than 12% loss on ignition when tested.

Sand : Deleterious materials, such as clay and silt in the sand shall preferably be less than 5%.

Lime : Lime shall conform to class 'C' hydrated lime of IS:712.

Additives : Any suitable additive considered not detrimental to the durability of bricks may be used.

(c) **Clay fly Ash Bricks** : The clay fly ash bricks shall conform to IS.13757. The bricks shall be sound, compact and uniform in shape and colour. Bricks shall have smooth rectangular faces with sharp and square corners. The bricks shall be free from visible cracks, flaws, warpage, nodules of free lime and organic matter. The bricks shall be hand or machine moulded. The bricks shall have frog of 100 mm in length 40 mm width and 10 to 20 mm deep on one of its flat sides. If made by extrusion process may not be provided with frogs. Fly ash shall conform to grade I or grade II of IS 3812.

(d) **Tile Brick** : The bricks of 4 cm height shall be moulded without frogs. Where modular tiles are not freely available in the market, the tile bricks of F.P.S. thickness 44 mm (1.¾ ") shall be used unless otherwise specified.

(e) **Brick Bats** : Bricks bats shall be obtained from well burnt bricks. The bats shall be stacked in rectangular heaps, not less than one metre height. One cubic metre of bats shall be considered as equal to 265 Non modular bricks of size 230 x 110 x 70mm. On stack measurement shrinkage shall be deducted at 20% of the gross quantity.

(f) **Jhama Bricks** : These are over burnt bricks and as a result discoloured and distorted in shape. They are, therefore, normally unfit for good brick work.

5.1.2 Dimensions

The bricks may be modular or non-modular. Sizes of both types of bricks/tiles shall be as per **Table 5.1**. While use of modular bricks/tiles is recommended, non-modular (FPS) bricks/tiles can also be used where so specified. Non-modular bricks/tiles of sizes other than the sizes mentioned in **Table 5.1** may also be used where specified.

Table 5.1
STANDARD SIZES

(BASED ON PARA 6.1.1 & 6.1.2 OF IS 1077)

TYPES OF BRICKS/TILES	LENGTH L (mm)	WIDTH W (mm)	HEIGHT H (mm)
Modular Bricks	190	90	90
Modular tile bricks	190	90	40
Non-Modular bricks	230	110	70
Non- Modular Tile Bricks	230	110	44

Special Bricks for obtaining proper Bond arrangement and Modular dimensions for the Brickwork with the non-modular sizes	70	110	1/3 Length of Brick
--	----	-----	---------------------

5.1.3. Classification - Bricks/Brick tiles shall be classified on the basis of their minimum

compressive strength as given in **Table 5.2** below -

Table 5.2

(CLASSES OF COMMON BURNT CLAY BRICKS BASED ON TABLE 1 OF IS 1077)

Class Designation	Average compressive strength	
	Not less than	
	N/mm ²	kgf/cm ² (Approx.)
12.5	12.5	(125)
10	10.0	(100)
7.5	7.5	(75)
5	5.0	(50)
3.5	3.5	(35)

The bricks shall have smooth rectangular faces with sharp corners and shall be uniform in colour and emit clear ringing sound when struck.

5.1.4 Sampling and Tests

5.1.4.1 Samples of bricks shall be subjected to the following tests:

- Dimensional tolerance.
- Water absorption.
- Efflorescence.
- Compressive strength.

5.1.4.2 Sampling: For carrying out compressive strength, water absorption, efflorescence and dimensional tests, the samples of bricks shall be taken at random according to the size of lot as given in **Table 5.3**. The sample thus taken shall be stored in a dry place until tests are made. For the purpose of sampling, the following definition shall apply.

(a) **Lot:** A collection of bricks of same class and size, manufactured under relatively similar conditions of production. For the purpose of sampling a lot shall contain a maximum of 50,000 bricks. In case a consignment has bricks more than 50,000 of the same classification and size and manufactured under relatively similar conditions of production, it shall be divided into lots of 50,000 bricks or part thereof.

(b) **Sample:** A collection of bricks selected for inspection and/or testing from a lot to reach the decision regarding the acceptance or rejection of the lot.

(c) **Defective:** A brick failing to meet one or more of the specified requirements.

5.1.4.3 The samples shall be taken as below:

(a) **Sampling from a Stack:** When it is necessary to take a sample from a stack, the stack shall be divided into a number of real or imaginary sections and the required number of bricks drawn from each section. For this purpose bricks in the upper layers of the stack shall be removed to enable units to be sampled from places within the stack.

Note: For other methods of sampling i.e. sampling in motion and sampling from lorries or trucks, IS.5454 may be referred.

(b) **Scale of sampling and criteria for conformity for visual and dimensional characteristics:-**

(i) **Visual characteristics :** The bricks shall be selected and inspected for ascertaining their conformity to the requirements of the relevant specification. The number of bricks to be selected from a lot shall depend on the size of lot and shall be in accordance of Col.1 and 2 of **Table 5.3** for visual characteristics in all cases and dimensional characteristics if specified for individual bricks. All the bricks selected above in accordance with Col.1 and 2 of **Table 5.3** shall be examined for visual characteristics. If the number of defective bricks found in the sample is less than or equal to the corresponding number as specified in Col.3 of **Table 5.3** the lot shall be considered as satisfying the requirements of visual characteristics; otherwise the lot shall be deemed as not having met the visual requirements.

(ii) **Dimensional Characteristics:** The number of bricks to be selected for

inspecting the dimensions and tolerance shall be in accordance with Col.1 and 4 of **Table 5.3**. These bricks will be divided into groups of 20 bricks at random and each of the group of 20 bricks thus formed will be tested for all the dimensions and tolerances.

A lot shall be considered having found meeting the requirements of dimensions and tolerance if none of the groups of bricks inspected fails to meet the specified requirements.

TABLE 5.3
SCALE OF SAMPLING AND PERMISSIBLE NUMBER OF DEFECTIVES FOR VISUAL AND DIMENSIONAL CHARACTERISTICS

No. of bricks in the lot	For characteristics specified for individual bricks		For dimensional characteristics for group of 20 bricks
	No. of bricks to be selected	Permissible no. of defective in the sample	No. of bricks to be selected
2001-10000	20	1	40
10001-35000	32	2	60
35001-50000	50	3	80

(Note : In case the lot contains 2000 or less bricks the sampling shall be as per decision of the Engineer).

(c) Scale of Sampling and Criteria for Physical Characteristics: The lot which has been found satisfactory in respect of visual and dimensional requirements shall be next tested for physical characteristics like compressive strength, water absorption,

efflorescence as specified in relevant material specifications. The bricks for this purpose shall be taken at random from those already selected above. The number of bricks to be selected for each of these characteristics shall be in accordance with relevant columns of **Table 5.4**.

TABLE 5.4
SCALE OF SAMPLING FOR PHYSICAL CHARACTERISTICS

Lot size	Sample size for compressive strength, water absorption and efflorescence	Permissible No. of defectives for efflorescence
2001-10000	5	0
10001-35000	10	0
35001-50000	15	1

(Note : In case the lot contains 2000 or less bricks, the sampling shall be as per decision of the Engineer).

A lot shall be considered having satisfied the requirements of physical characteristics if the conditions stipulated here in are all satisfied.

(a) From the test results for compressive strength, the average shall be calculated and shall satisfy the requirements specified in relevant material specification.

(Note : In case any of the test result for compressive strength exceeds the upper limit for the class of bricks, the same shall be limited to the upper limit of the class for the purpose of averaging.)

(b) Wherever specified in the material specification, the compressive strength of

any individual bricks tested in the sample shall not fall below the minimum average compressive strength specified for the corresponding class of brick by more than 20 percent.

(c) From the test results for water absorption, the average for the bricks in the sample shall be calculated and shall satisfy the relevant requirements specification in material specification.

(d) The number of bricks failing to satisfy the requirements of the efflorescence specified in the relevant specification should not be more than the permissible no. of defectives given in Col.3 of **Table 5.4**.

5.1.4.4 Dimensional tolerances : The dimensions of modular and Non modular

bricks when tested as described above as per procedure described in **Annexure 5.1** shall be within the following limits per 20 bricks. Refer Para 6.2 of IS 1077 for details.

Modular Size Bricks and Tile Bricks

Length 372 to 388 cm (380 ± 8 cm)

Width 176 to 184 cm (180 ± 4 cm)

Height 176 to 184 cm (180 ± 4 cm) for 90 mm high bricks

Height 76 to 84 cm (80 ± 4 cm) for 40 mm high tile bricks

Non-Modular Size Bricks and Tile Bricks

Length 452 to 468 cms (460 ± 8 cm)

Width 216 to 224 cms (220 ± 4 cm)

Height 136 to 144 cms (140 ± 4 cm) For 70mm high bricks

Height 84 to 92 cms (88 ± 4 cm) For 44 mm high Tile Bricks

5.1.4.5 Compressive strength: The bricks, when tested in accordance with the procedure laid down in **Annexure 5.2** shall have a minimum average compressive strength for various classes as given in **Table 5.2**. The compressive strength of any individual brick tested shall not be fall below the min, compressive strength specified for the corresponding class of brick.

5.1.4.6 Water absorption: The average water absorption of bricks when tested in accordance with the procedure laid down in **Annexure 5.3** shall be not more than 20% by weight upto Class 12.5 and 15% by weight for higher classes.

5.1.4.7 Efflorescence: The rating of efflorescence of bricks when tested in accordance with the procedure laid down in **Annexure 5.4** shall be not more than moderate upto Class 12.5 and slight for higher classes.

5.1.5 Perforated Building Bricks

Perforated Bricks are light in weight and provide better thermal insulation as compared to common bricks. They are commonly used in walls and partitions. The area of perforations shall be between 30 percent and 45 percent of the total area of the corresponding face of the bricks. The perforations shall be uniformly distributed over the surface and may be of rectangular or circular shape. The area of each perforation shall not exceed 500 mm². The thickness of any shell shall not be less than 15 mm and of any web not less than 10mm. IS 2222 may be referred to further details on general quality, dimensions and tolerances, compressive strength, water absorption,

efflorescence, warpage, sampling and criterion of conformity and marking.

5.2 BRICK WORK

5.2.1. Classification - The brick work shall be classified as per the class designation of bricks used **Table 5.2** may be referred to.

5.2.2. Mortar

The mortar for the brick work shall be as specified in **Annexure 26.7 of Chapter 26 on "Mortars"** and conform to accepted standards. Lime shall not be used where reinforcement is provided in brick work.

5.2.3. Soaking of Bricks

Bricks shall be soaked in water before use for a period for the water to just penetrate the whole depth of the bricks. Alternatively bricks may be adequately soaked in stacks by profusely spraying with clean water at regular intervals for a period of not less than six hours. The bricks required for masonry work using mud mortar shall not be soaked. When the bricks are soaked they shall be removed from the tank sufficiently early so that at the time of laying they are skin-dry. Such soaked bricks shall be stacked on a clean place where they are not again spoiled by dirt, earth etc.,

Note : I. 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 to find the extent of water penetration. The least period that corresponds to complete soaking will be the one to be allowed for in construction work.

Note : II. If the bricks are soaked for the required time in water that is frequently changed the soluble salt in the bricks will be leached out, and subsequently efflorescence will be reduced.

5.2.4. Laying

5.2.4.1. Bricks shall be laid in English Bond unless otherwise specified. English Bond is shown in **Figures 5.3A to 5.3D**. In figure 5.3C isometric view of another popular Bond Double flemish bond is shown for comparison. The appearance on the face in Double Flemish Bond is more uniform than in English Bond and requires less number of facing bricks. But in strength, it is considered inferior to English Bond. For brick work in half brick wall, bricks shall be laid in stretcher bond. Half or cut bricks shall not be used except as closer where necessary to complete the bond. Closers in such cases, shall be cut to the required size and used near the ends of the wall. Header bond shall

be used preferably in all courses in curved plan for ensuring better alignment.

Note : Header bond shall also be used in foundation footings unless thickness of walls (width of footing) makes the use of headers impracticable. Where thickness of footing is uniform for a number of courses, the top course of footing shall be headers. In case of foundations offsets shall be preferably left over the layer laid in header.

5.2.4.2. All loose materials, dirt and set lumps of mortar which may be lying over the surface on which brick work is to be freshly started, shall be removed with a wire brush and surface wetted. Bricks shall be laid on a full bed of mortar, when laying. Each brick shall, be properly bedded and set in position by gently pressing with the handle of a trowel. Its inside face shall be buttered with mortar before the next brick is laid and pressed against it. Joints shall be fully filled and packed with mortar such that no hollow spaces are left inside the joints.

5.2.4.3. The walls shall be taken up truly in plumb or true to the required batter where specified. All courses shall be laid truly horizontal and all vertical joints shall be truly vertical. Vertical joints in the alternate course shall come directly one over the other. Quoins, Jambs and other angles shall be properly plumbed as the work proceeds. Care shall be taken to keep the perpend properly aligned within the maximum permissible tolerances given below.

(a) Deviation from vertical within a storey shall not exceed 6 mm per 3 m height.

(b) Deviation in verticality in total height of any wall of building more than one storey in height shall not exceed 12.5 mm.

(c) Deviation from position shown on plan of any brick work shall not exceed 12.5 mm.

(d) Relative displacement between load bearing walls in adjacent storey intended to be in vertical alignment shall not exceed 6 mm.

A set of tools comprising of wooden straight edge, Masonic spirit levels, square, 1 metre rule line and plumb shall be kept on the site of work for every 3 masons for proper check during the progress of work.

5.2.4.4. All quoins shall be accurately constructed and the height of brick courses shall be kept uniform. This will be checked using graduated wooden straight edge or storey rod indicating height of each course including thickness of joints. The position of damp proof course, window sills, bottom of lintels, top of the wall etc., along the height of

the wall shall be marked on the graduated straight edge or storey rod. Acute and obtuse quoins shall be bonded, where practicable in the same way as square quoins. Obtuse quoins shall be formed with squint showing three quarters brick on one face and quarter brick on the other.

5.2.4.5. The brick work shall be built in uniform layers. No part of the wall during its construction shall rise more than one metre above the general construction level. Parts of wall left at different levels shall be raked back at an angle of 45 degrees or less with the horizontal. Toothing shall not be permitted as an alternative to raking back. For half brick partition to be keyed into main walls, indents shall be left in the main walls.

5.2.4.6. All pipe fittings and specials, spouts, hold fasts and other fixtures which are required to be built into the walls shall be embedded, as specified, in their correct position as the work proceeds unless otherwise directed by the Engineer.

5.2.4.7. Top courses of all plinths, parapets, steps and top of wall below floor and roof slabs shall be laid with brick on edge, unless specified otherwise. Brick on edge laid in the top courses at corner of walls shall be properly radiated and keyed into position to form cut corners as shown in **Fig.5.3B**. Where bricks cannot be cut to the required shape to form cut corners, cement concrete 1:2:4 (1 cement:2 coarse sand: 4 graded stone aggregate 20 mm nominal size) equal to thickness of course shall be provided in lieu of cut bricks.

5.2.4.8. Bricks with Frogs shall be laid with frog down if the frog is 2cm deep. If it is 1 cm deep, the bricks may be used either frog down or up. For the bricks to be laid with frog down, the frog shall be filled with mortar before placing the bricks in position.

5.2.4.9. In case of walls one brick thick and under, one face shall be kept even and in proper plane, while the other face may be slightly rough. In case of walls more than one brick thick, both the faces shall be kept even and in proper plane.

5.2.4.10. To facilitate taking service lines later without excessive cutting of completed work, sleeves (to be paid separately) shall be provided, where specified, while raising the brick work. Such sleeves in external walls shall be sloped down outward so as to avoid passage of water inside.

5.2.4.11. Top of the brickwork in coping and sills in external walls shall be slightly tilted. Where brick coping and sills are projecting

beyond the face of the walls, drip course/throating (to be paid separately) shall be provided where indicated.

5.2.4.12. Care shall be taken during construction that edges of jambs, sills and projections are not damaged. In case of rain, new built work shall be covered with gunny bags or tarpaulins so as to prevent the mortar from being washed away. Damage, if any, shall be made good to the satisfaction of the Engineer.

5.2.4.13. Vertical reinforcement in the form of bars (MS or high strength deformed bars), considered necessary at the corners and junctions of walls and jamb opening doors, windows etc., shall be encased with cement mortar not leaner than 1:4 (1 cement : 4 coarse sand) or cement concrete mix as specified. The reinforcement shall be suitably tied, properly embedded in the foundation and at roof level. The dia. of bars shall not be less than 8 mm and concrete grade shall be minimum 1:3:6 (1 cement : 3 coarse sand : 6 graded stone aggregate 20 mm nominal size).

5.2.4.14. In retaining walls and the like, where water is likely to accumulate, weep holes, 50 to 75 mm square shall be provided at 2 m vertically and horizontally unless otherwise specified. The lowest weep hole shall be at about 30 cm above the ground level. All weep holes shall be surrounded by loose stones and shall have sufficient fall to drain out the water quickly.

(Note: Work of providing such loose stones will be payable extra).

5.2.4.15. Work of cutting chases, wherever required to be made in the walls for housing G.I. pipe, CI pipe or any other fixtures shall be carried out in various locations as per guidelines given below:-

(a) Cutting of chases in one brick thick and above load bearing walls.

(i) As far as possible services should be planned with the help of vertical chases. Horizontal chases should be avoided.

(ii) The depths of vertical chases and horizontal chases shall not exceed one-third and one-sixth of the thickness of the masonry respectively.

(iii) When narrow stretches of masonry (or short length of walls) such as between doors and windows, cannot be avoided they should not be pierced with openings for soil pipes or waste pipes or timber joints, etc., Where there is a possibility of load concentration, such narrow lengths of walls shall be checked for stresses and high strength

bricks in mortar or concrete walls provided, if required.

(iv) Horizontal chases when unavoidable should be located in the upper or lower one-third of height of storey and not more than three chases should be permitted in any stretch of a wall. No continuous horizontal chase shall exceed one metre in length. Where unavoidable, stresses in the affected area should be checked and kept within the permissible limits.

(v) Vertical chases should not be closer than 2 metres in any stretch of a wall. These shall be kept away from bearings of beams and lintels. If unavoidable, stresses in the affected area should be checked and kept within permissible limits.

(vi) Masonry directly above a recess, if wider than 30 cm horizontal dimension should be supported on lintel. Holes in masonry may be provided up to 30 cm width and 30 cm height without any lintel. In the case of circular holes in the masonry, no lintel need be provided for holes up to 40 cm in diameter.

(b) Cutting of chases in half brick load bearing walls: No chase shall be permitted in half brick load bearing walls and as such no recessed conduits and concealed pipes shall be provided with half brick thick load bearing walls.

(c) Cutting of chases in half brick non-load bearing walls: Services should be planned with the help of vertical chases. Horizontal chase should be provided only when unavoidable.

5.2.4.16 Pilasters : These shall be so set out to avoid a broken bond.

5.2.4.17 Openings : a) The depths of reveals and rebates, shall, where practicable conform to standard brick sizes to avoid cutting of bricks and thereby weakening the masonry. The arrangement of bonds at Quoins and at jambs of openings shall be symmetrical.

(b) Openings shall be of such size and so spaced in walls as to reduce the cutting of bricks to minimum. The width of openings shall, as far as possible, be a multiple of width of brick.

In the external walls, it is desirable to rebate the sills, jambs and heads of openings so as to form a barrier for rainwater. The sill may be sloped slightly to allow the rain water to drain off.

5.2.4.18 Parapets and Copings

(a) The parapets and copings shall be of thickness such that their base covers the junction of roof slab and wall which shall be further effectively treated against possible leakage of rain water. Normally a cement lime mortar 'gola' /cement concrete gola or fillet is done. **Figure 5.4** maybe seen for details.

(b) Coping may be of stone, concrete, brick or terracota. It is to be throated underside of the projections. The top of the coping shall be slightly sloped to allow water to drain off.

5.2.4.19 Brick work in Mud Mortar:-

a) Unless otherwise specified, all Brickwork in mud mortar shall have the top 30 cm of walls and partitions as well as 30 cm alround door, window and other openings built in cement mortar.

b) Thickness of Joints shall not exceed 12mm.

5.2.5. Joints

5.2.5.1 The thickness of all types of joints including brick wall joints and cross joints shall be such that four courses and three joints taken consecutively shall measure as follows:-

(i) In case of modular bricks conforming to IS.1077 specification for common burnt clay buildings bricks, equal to 39 cm.

(ii) In case of non-modular bricks, it shall be equal to 31 cm.

Note: Specified thickness of joints shall be of 1 cm. Deviation from the specified thickness of all joints shall not exceed one-fifth of specified thickness i.e. 8 mm -12 mm.

5.2.5.2 Finishing of Joints: The face of brick work may be finished flush or by pointing. In flush finishing 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 brick work or the joints shall be squarely raked out to a depth of 1 cm while the mortar is still green for subsequently 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 brick work. In pointing, the joints shall be squarely raked out to a depth of 1.5 cm while the mortar is still green and raked joints shall be brushed to remove dust and loose particles and well wetted, and shall be later refilled with mortar to give ruled finish. Some such finishes are 'flush', 'weathered', "keyed", "tucked" and "Raked" as shown in **Figure 5.5**.

5.2.6. Curing

The brick work shall be constantly kept moist on all faces for a minimum period of seven days. Brick work done during the day shall be suitably marked indicating the date on which the work is done so as to keep a watch on the curing period.

5.2.7. Scaffolding

Scaffolding shall be strong to withstand all dead, live and impact loads which are likely to come on them. Scaffolding shall be provided to allow easy approach to every part of the work.

5.2.7.1. Single Scaffolding : Where plastering, pointing or any other finishing has been indicated for brick work, single scaffolding may be provided, unless otherwise specified. In single scaffolding, one end of the put-logs /pole shall rest in the hole provided in the header course of brick masonry. Not more than one header for each put-log/pole shall be left out. Such holes shall not be allowed in the case of pillars, brick work less than one metre in length between the openings or near the structural member supported by the walls. The holes for put-logs/poles shall be made good with brick work and wall finishing as specified.

5.2.7.2. Double Scaffolding : Where the brick work or tile work is to be exposed and not to be finished with plastering etc., double scaffolding having two independent supports, clear of the work, shall be provided.

5.2.8. Measurements

5.2.8.1. Brick work shall be measured in cubic metres unless otherwise specified. Any extra work over the specified dimensions shall be ignored. Dimensions shall be measured correct to the nearest 0.01 m i.e. 1 cm. Areas shall be calculated to the nearest 0.01 sqm and the cubic contents shall be worked out to the nearest 0.01 cum.

5.2.8.2. Brick work shall be measured separately in the following stages:

- (a) In foundation and plinth
- (b) From Plinth level to floor two levels
- (c) Beyond floor two level above plinth level for every additional floor or part thereof

Note : (1) Brick work in parapet walls, mummy, lift machine room and water tanks constructed on the roof upto 1.2 m height above roof shall be measured together with the corresponding work of the floor next below.

(2) Plinth Level:- For the purpose of measurement for masonry in plinth and foundation and for masonry in super-

structure, the plinth level shall be determined as given below:

- i) For buildings : Ground floor level or 1.2 metres above GL whichever is lower.
- ii) For abutments, piers & return walls of culverts & bridges, walls of water reservoirs and basements - Floor level
- iii) For retaining walls where floor level is not determinate : 1.2 metres above average ground level or bed level
- iv) For breast walls : Formation level
- v) For platform walls : Formation level

5.2.8.3. No deductions or additions shall be done and no extra payment made for the following:

- (a) Ends of dissimilar materials (that is, joists, beams, lintels, posts, girders, rafters, purlins, trusses, corbels, steps etc.) up to 0.1 m^2 in section.
- (b) Opening up to 0.1 m^2 in area (see Note).
- (c) Wall plates, bed plates and bearing of slabs, chhajjas and the like, where thickness does not exceed 10 cm. and bearing does not extend over the full thickness of walls:
- (d) Cement concrete blocks as for hold fasts and holding down bolts.
- (e) Iron fixtures, such as wall ties, pipes up to 300 mm diameter and hold fasts for doors and windows.
- (e) Chases of section not exceeding 50 cm. in girth; and
- (f) Bearing portion of drip course, bearing of moulding and cornice.

Note : i) In calculating area of an opening, any separate lintel or sills shall be included with the size of the opening but end portions of lintel shall be excluded. Extra width of rebated reveals, if any, shall also be excluded.

ii) Where minimum area is defined for deduction of an opening, void or both, such areas shall refer only to opening or void within the space measured.

5.2.8.4. Walls half brick thick and less shall each be measured separately in square metres stating thickness.

5.2.8.5. Walls beyond half brick thickness shall be measured in multiples of half brick which shall be deemed to be inclusive of mortar joints. For the sizes of bricks specified in 5.1.2 half brick thickness shall mean 100 mm for modular and 115 mm for non-modular bricks.

Where fractions of half brick occur due to architectural or other reasons, measurement shall be as follows:-

- (a) up to $\frac{1}{4}$ th brick – actual measurements and
- (b) exceeding $\frac{1}{4}$ th brick-full half bricks.

5.2.8.6. String courses, projecting pilasters, aprons, sills and other projections shall be fully described and measured separately in running metres stating dimensions of each projection.

5.2.8.7. Square or rectangular pillars shall be measured separately in cubic metres in multiple of half brick.

5.2.8.8. Circular pillars shall be measured separately in cubic metres as per actual dimensions.

5.2.8.9. Brick work curved on plan including cut brick corners, splays, reveals and cavity walls shall be measured like the brick work in straight walls and shall include all cutting and wastage of bricks, tapered vertical joints and use of extra mortar, if any. Brick work curved on plan to a mean radius not exceeding six metres shall be measured separately and extra shall be payable over the rates for brick work in straight walls. Nothing extra shall be payable if the mean radius of the brick work curved in plan exceeds six metres.

5.2.8.10. Tapered walls shall be measured as normal walls and extra payment shall be allowed for making tapered surface for brick work in walls.

5.2.8.11. Brick work with brick tiles shall be measured and paid for separately.

5.2.9. Rate

The rate shall include the cost of materials and labour required for all the operations described above except the vertical reinforcement and its encasement in cement mortar or cement concrete. The rate shall also include the following:

- (a) Raking out joints or finishing joints flush as the work proceeds;
- (b) Preparing tops of existing walls and the like for raising further new brick work;
- (c) Rough cutting and waste for forming gables, splays at eaves and the like;
- (d) Leaving holes for pipes up to 150 mm dia. and encasing hold fasts etc in masonry.
- (e) Rough cutting and waste for brick work curved in plan and for backing to stone or other types of facing.
- (f) Embedding in ends of beams, joists, slabs, lintels, sills, trusses etc.,

(g) Bedding wall plates, lintels, sills, roof tiles, corrugated sheets etc., in or on walls if not covered in respective items;

(h) Leaving chases of section not exceeding 50 cm in girth or 350 sq.cm. in cross-section; and

(i) Brick on edge courses, cut brick corners, splays reveals, cavity walls, brick works curved on plan to a mean radius exceeding six meters.

5.3. BRICK WORK IN ARCHES (REFER FIGURE 5.6)

5.3.1 General : The detailed specifications for brick work mentioned in Para 5.2 shall apply, in so far as these are applicable. Arch work shall include masonry for both gauged as well as plain arches. In gauged arches, cut or moulded bricks shall be used. In plain arches, uncut bricks shall be used.

Brick forming skew-backs shall be dressed or cut so as to give proper radial bearing to the end voussoirs. Defects in dressing of bricks shall not be covered by extravagant use of mortar, nor shall the use of chips or bats etc., be permitted.

The bricks of the spandrel wall at their junctions with the extrados of the arch shall be cut to fit the curvature of the arch.

5.3.2 Circular Arches

These shall be either (a) plain arches, and shall be built in half brick concentric rings with break joints, or (b) gauged arches built with bricks cut or moulded to proper shape. The arch work shall be carried up from both ends simultaneously and keyed in the center. The bricks shall be flush with mortar and well pressed into their positions so as to squeeze out a part of their mortar and leave the joints thin and compact. All joints shall be full of mortar and thickness of joints shall not be less than 5 mm nor more than 15 mm.

After the arch is completed, the haunches shall be loaded by filling up the spandrels up to the crown level of the arch. Care shall be taken to load the haunches on two sides of the spandrels.

When the arch face is to be pointed (and not plastered), the face bricks shall be cut to proper shape or moulded, so as to have the joints not more than 5 mm thick. These shall be laid with radial joints to the full depth of the arch.

5.3.3 Flat Arches

These shall be gauged arches of brick cut or moulded to proper shape. The extrados shall be kept horizontal and the intrados shall

be given slight camber of 1 in 100 of the span. The center of the arch from which joints shall radiate, shall be determined by the point of the inter-section of the two lines drawn from the ends of the arch at the springing level and at 60° to horizontal.

In flat arches, bricks shall be laid with radial joints to the full depth of arch and voussoirs breaking joints with each other. The arch work shall be carried up from both ends simultaneously and keyed in the center. The thickness of the joints shall not exceed 5 mm. Flat arches may be used for the sake of appearance but for purpose of carrying loads of the wall above, these shall be used in conjunction with relieving arches/ lintels placed below.

5.3.4 Centering and Shuttering

The centering and shuttering for the arch shall be got approved by the Engineer before the arch work is started. It shall be strong enough to bear the dead load of the arch and the live loads that are likely to come upon it during construction, without any appreciable deflections.

The shuttering shall be tightened with hard wood wedges or sand boxes, so that the same could be eased without jerks being transmitted to the arch. The sequence of easing the shuttering shall be got approved from the Engineer. The shuttering shall be struck within 48 hours of the completion of the arch but not before 24 hours. This shall be done after the spandrel has been filled in and the arch loaded. The centering shall not, however, be struck for atleast two weeks after completion of the arch and that too only with the permission of the Engineer.

5.3.5 Measurements

The length of the arch shall be measured as the mean of the extrados and intrados of the arch correct to a cm. The thickness of the arch shall be measured in multiples of the half brick. The breadth in the direction of the thickness of wall shall be measured as specified. The cubical contents shall be calculated in cubic metre, correct to two places of decimal.

For arches exceeding 6 m. in spans extra payment shall be made on the actual area of the soffit for additional cost of centering including all strutting, bolting, wedging, easing, striking and its removal.

5.3.6 Rate

The rate is inclusive of the cost of the materials and labour required for all the operations described above.

5.4. HALF BRICK WORK

5.4.1 General:- Brick work in half brick walls shall be done in the same manner as described above in para 5.2.4 except that the bricks shall be laid in stretcher bond. When the half brick work is to be reinforced as will be required in case of half brick wall in water tanks or long lengths of half brickwork, 2 Nos. M.S. bars normally of 6 mm dia. shall be embedded in every third course. The dia of bars shall not in any case exceed 8 mm. These shall be securely anchored at their end where the partitions end. The free ends of the reinforcement shall be keyed into the mortar of the main brick work to which the half brick work is joined. The mortar used for reinforced brick work shall be rich dense cement mortar of mix 1:4 (1 cement : 4 coarse sand). Lime mortar shall not be used. Over-laps in reinforcement, if any shall not be less than 30 cm.

The mortar interposed between the reinforcement bars and the brick shall not be less than 5 mm. The mortar covering in the direction of joints shall not be less than 15 mm.

5.4.2 Measurement :

The length and height of the wall shall be measured correct to a cm. The area shall be calculated in sqm. Where half brick wall is joined to the main walls of one brick or greater thickness, measurements for half brick wall shall be taken for its clear length from the face of the thicker wall.

5.4.3 Rate

The rate includes the cost of the materials and labour involved in all the operations described above except reinforcement which is to be paid for separately.

5.5 BRICK TILE WORK

5.5.1 General : The work shall be done in the same manner as described in para 5.2.4. except that Brick Tile shall be used instead of bricks. The measurement and rate shall be same as specified under para 5.2.

5.6 HONEY COMB BRICK WORK

5.6.1 General : The brick honeycomb work shall be done with specified class of brick, laid in specified mortar. All joints and edges shall be struck flush to give an even surface.

The thickness of the brick honey comb work shall be half-brick only, unless otherwise specified. Openings shall be equal and alternate with half brick laid with a bearing of 2 cm on either side. —

5.6.2 Measurements

The length and height shall be measured correct to a cm. Area shall be calculated in square metres correct to two places of decimal. Honeycomb openings shall not be deducted.

5.6.3 Rate

The rate includes the cost of materials and labour involved in all the operations described above.

5.7 JOINING OLD BRICK WORK WITH NEW BRICK WORK

5.7.1 General : (a) In case the height of the bricks of old as well a new work is same, the old work shall be toothed to the full width of the new wall and to the depth of a quarter of brick in alternate courses. In case the height of the bricks is unequal, then the height of each course of new work shall be made equal to the height of the old work by adjusting thickness of horizontal mortar joints in the new wall. Where necessary, adjustments shall be made equal to thickness of old wall by adjusting the thickness of vertical joints.

(b) For joining new cross wall to old main wall, a number of rectangular recesses of width equal to the thickness of cross wall, three courses in height and half a brick in depth shall be cut in the main walls. A space of the three courses shall be left between two consecutive recesses. The new cross wall shall be bonded into the recesses to avoid any settlement.

(c) Joining of old brick work with the new brick work shall be done in such a way that there shall not be any hump or projection at the joint.

5.7.2 Measurements

The height and thickness of vertical face in contact with new work shall be measured to the nearest 0.01 m and shall be calculated to the nearest 0.01 sqm.

5.7.3 Rate

The rate includes the cost of labour and materials involved in all the operations described above.

5.8 MOULDING AND CORNICES

5.8.1 General : (a) The specifications described under Para 5.2 shall apply in so far these are applicable. Mouldings and cornices shall be made with bricks as specified for brick work. The bricks shall be cut and dressed to the required shape as shown in the architectural drawings.

(b) Cornices shall not ordinarily project by more than 20 cm and this projection shall be obtained by projecting each brick course by not more than one-fourth brick length. For cornices projecting more than 20 cm and requiring more than quarter brick projection, metal cramps shall be used and paid for separately.

5.8.2 Corbelling : Corbel is the term given to a brick or series of bricks which project from a wall. Corbelling is done to thicken a wall or form a decorative feature. Corbelling shall be brought roughly to shape by plastering with the specified mortar. When the mortar is still green, the mouldings shall be finished straight and true with the help of metal templates.

5.8.3. Curing and Protection

The mouldings and cornices shall be cured for at least seven days. These shall be protected from the effects of sun and rain by suitable covering and also from damage during the execution of the work.

5.8.4. Measurements

For the purpose of measurements, the sectional periphery of mouldings and cornices (excluding the portion in contact with wall) shall be measured in centimeters and length in metres as shown in **Figure 5.7**. The girth and length shall be measured correct to a cm., No deduction shall be made from the masonry of wall for the bearing of the moulding and cornices.

5.8.5 Rate

The rate includes the cost of materials and labour involved in all the operations described above.

5.9 BRICK WORK UNDER WATER OR FOUL POSITIONS

5.9.1 General : Brick Work Under following conditions shall be measured separately for payment of extra over and above the quantity measured and paid under para 5.2.8.

- i) Work in or under water/or liquid mud;
- ii) Work in or under foul positions

5.10 EXPOSED BRICK WORK

5.10.1 Facing Bricks

The facing bricks made from suitable soils shall be free from cracks, flaws, nodules of free lime, warpage and organic matter. These shall be thoroughly burnt and shall have plane rectangular faces with parallel sides and sharp straight right angled edges. Facing bricks shall have uniform colour and even texture. Unless otherwise specified, facing bricks shall be machine moulded. Selected hand moulded bricks may also be used as facing bricks where specified. As far as possible, total requirement of facing bricks for a work, shall be arranged from the same kiln. Bricks with chipped edges and broken corners shall not be used.

5.10.2 Dimensions and Tolerances

The standard sizes of machine moulded facing bricks shall be as specified in para 5.1.2.

Permissible tolerances shall be as under :

	Dimension (mm)		Tolerance (For Machine moulded bricks) mm
	Modular	Non Modular	
Length	190	230	± 3
Width	90	110	± 1.5
Thickness	40	44	± 1.5

Note : Tolerance and dimensions for selected hand moulded bricks ± 4 mm in length and ± 3 mm in width and thickness.

5.10.3. Sampling - As per paras 5.1.4.2 and 5.1.4.3.

5.10.4 Physical Requirements

Facing bricks shall be of class designation 7.5 unless otherwise specified. Average compressive strength shall not be less than 7.5 N/mm², water absorption shall not exceed 20 percent by weight and

efflorescence rating shall be nil when tested in accordance with the procedure laid down and tolerance in dimensions shall be checked as per the procedure laid down in **Annexure 5.1**.

Mortar, Soaking of Bricks and laying shall be as specified in paras 5.2.2, 5.2.3. and 5.2.4. respectively.

5.10.5. Joints : Joints in the exposed brick work shall be truly horizontal and vertical and kept uniform with the help of wooden or steel

strips. The thickness of joints shall be as per 5.2.5.1.

5.10.6. Curing and Scaffolding : Curing and scaffolding shall be as specified in paras 5.2.6. and 5.2.7 respectively.

5.10.7. Measurements

Exposed brick work in face using machine moulded and selected hand moulded bricks shall be measured separately and the measurement shall be as specified in para 5.2.8.

5.10.8. Rate

The rates shall be as specified in para 5.2.9. and shall also include the following:

(a) Labour for selecting bricks and wastage of bricks where use of selected hand moulded brick is specified.

(b) Leaving uniform horizontal and vertical grooves of specified depth and providing joints of required thickness using wooden or steel strips as the work proceeds.

5.11. CAVITY WALL

5.11.1. General : (a) It is a wall comprising of two leaves, each leaf being built of masonry units and separated by a cavity so as to provide an air space within the wall and tied together with metal ties or bonding units to ensure that two leaves act as one structural unit as shown in **Figure 5.8**. The width of the cavity shall not be less than 50 mm and not more than 115 mm. Each leaf of the cavity wall shall not be less than 75 mm thick, the space between the leaves being either left as cavity or filled with non-load bearing insulating and water proofing material.

(b) In building cavity walls of half brick-thickness, only stretcher bond shall be used, unless purpose made snap headers are available. When header bricks are cut and used, they are either likely to protrude into the cavity and form a ledge for mortar droppings to collect or they may be so short as to weaken the structure.

(c) At the base of the cavity wall, the foundations and basement shall be solidly constructed upto 300mm above the ground level. The air cavity shall begin not less than 200mm below the upper floor surface of the ground floor and the cavity shall be continued without interruption to the roof.

(d) The cavity shall be ventilated by air slots below the eaves level of the roof to the extent of 50 cm² for every 20 m² of the wall.

(e) At the points where the two leaves of party wall (see Para 5.11.6) come into contact, for example at windows and doors,

they shall be separated by a water tight membrane. Above lintels of doors and windows, a damp-proof membrane shall be inserted sloping downwards and outwards. At solid jambs, a vertical damp-proof course shall be inserted.

(f) The materials of leaves may be different masonry, concrete etc. The thicker leaf shall be arranged on the inside.

5.11.2 Metal Ties

These may be of galvanized iron, wrought iron, gun metal, brass, copper, stainless steel or any such corrosion resistant metal, made of flats 20 x 5 mm cranked or twisted at their mid point with ends split and fish tailed. The ties shall be built into horizontal bed joints during erection, placed sloping towards the exterior side to prevent water from flowing along it from outer to inner leaf side (For details refer **Figure 5.8**).

5.11.3 Bonding Units

These shall be preferably pre cast R.C.C. units having cross-section as shown in **Fig. 5.8**. Length of the Bonding units will be sum of thickness of both leaves plus width of cavity if the leaves are 75 mm or 115 mm. If the leaves are more than 115 mm thick, then the length of a unit will be 2 x 115 + width of cavity as shown in **Fig.5.8**. Pre cast RCC units shall be provided with 2 Nos. 6 mm mild steel reinforcement bars tied with 2 No. and 3 mm. Dia. (M.S. wire/hard drawn wire) cross bars (As shown in **Fig.5.8**) placed in the center of unit.

Cement concrete used in the bonding units shall not be leaner than 1:2:4.

(1 cement : 2 coarse sand : 4 graded stone aggregate 20 mm nominal size).

5.11.4 Spacing of Ties / Bonding Units

Metal ties/bonding units shall be spaced not more than 90 cm apart horizontally and 45 cm vertically and staggered in each course. Additional ties shall be used near openings. A minimum of 5 Ties/ m² of surface area of the wall shall be provided.

5.11.5 Restrictions

Cavity walls shall not normally be built more than 7.5 metres in height and 9 metres in length. Where larger lengths and heights are desired, the wall shall be divided into panels with strengthening measures such as pillars etc., Cavity shall be covered at the top with at least two courses of masonry unit and/or a coping over it.

Adoption of cavity walls is not recommended when heavy concentrated loads from beam, etc., are to be supported by walls.

5.11.6 Precautions

The following precautions shall be taken :

- Parapets- If the top of a hollow wall ends with a parapet, the cavity shall be carried to the full height of the wall or stopped at the roof flashing level;
- Eaves – If a roof projects over the top of the wall, the cavity shall be closed at the top;
- Party walls – In a hollow party wall, the top of a cavity wall shall be closed just above the uppermost ceiling level and the courses over shall be continued as in solid brickwork. A sound insulation material shall be interposed between the hollow wall and solid brick work.

5.11.7 Measurements and Rate

(a) Brick work in cavity walls shall be included and measured with general brick work. The width of the cavity shall not be measured. Skin of cavity wall, half brick thickness shall be measured as and paid as described in paras 5.2.8. and 5.4.

(b) The forming of the cavity shall be given in square metres stating the width of the cavity and shall include the metal ties/bonding unit specifying the numbers per square metre.

(c) Labour and material for closing cavities at the jambs, sills and heads of opening shall be as described and measured separately in running metres.

The item shall include use of device for keeping cavity clear and forming the requisite weep and vent holes and nothing extra on this account shall be payable.

5.12 BRICK DRIP COURSE

5.12.1 General : The brick drip course shall be laid above the junction of the roof with the wall to shield the cracks which may develop at these junctions. The upper corners of the projecting bricks shall be chamfered or rounded off with 8 cm radius. The transverse drip of throating about 1.3cm deep shall be cut on the under side of the projecting bricks. Specially moulded bricks shall be used for the brick course. Where moulded bricks are not available, bricks cut to shape shall be permitted.

5.12.2 Measurements : The drip course shall be measured in running metres correct to a cm and no deduction shall be made from the masonry of walls for the bearing portion of the drip course.

5.12.3 Rate : The rate includes the cost of all materials and labour required for the drop course as stated above but excludes the cost

of the lime concrete gola made at the junction of the wall and the terrace in mud phuska terraced roofs.

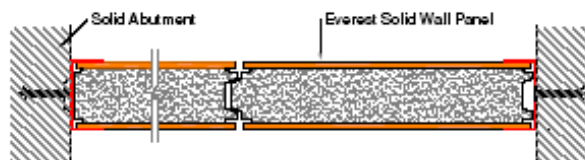
5.13 SOLID WALL PANELS

50 mm thick solid wall panels are sandwich panels made out of FRACC and non asbestos wall boards. These should be provided with tongue and groove joining system to facilitate rapid construction. The 50 mm thick solid wall panels should adhere to following sizes and properties :

- Sizes : (i) 3000 x 600 mm
(ii) 2700 x 600 mm
(iii) 2400 x 600 mm

Or size can be modified according to the site requirement.

- Thickness : 50 mm (thickness of FRCC : 42 mm & thickness of board on both faces 2 x 4 mm = 8 mm)
- Weight : 42.8 kg/m²
- Edge Profile : Square or (bevelled edge)
- Axial compressive : 46.1 kg/cm² Strength
- Tensile strength : 0.35 N/mm²



ANNEXURE 5.1

TEST FOR DIMENSIONAL TOLERANCE OF BRICKS

A-1 Sampling As per paras 5.1.4.1. to 5.1.4.3.

A.2 Procedure : All the blisters, loose particles of clay and small projections shall be removed from the surface of bricks. Each specimen of 20 bricks shall then be arranged upon a level surface successively in contact with each other and in straight line as described in A.4. The overall length of the assembled bricks (20 Nos) shall be measured with a steel tape sufficiently long to measure the whole row at one stretch.

A.3. Tolerance : The actual dimensions of bricks when tested as described in A-2 shall be within the limits per 20 bricks as stipulated in Para 5.1.4.4.

A-4 Criteria for conformity : A lot shall be considered conforming to the requirements of dimensions and tolerances if all the groups of bricks are tested and meet the specified requirements as per clause 5.1.4.4.

ANNEXURE 5.2**TEST FOR COMPRESSIVE STRENGTH OF BRICKS** (Refer IS 3495 (Part 1))

B.1. Specimen : Five whole bricks shall be taken from the samples as specimens for this test. Length and width of each specimen shall be measured correct to 1 mm.

B.2. Apparatus The apparatus consists of compression testing machine, the compression plate of which shall have a ball seating in the form of portion of a sphere the center of which shall coincide with the center of the plate.

B-3 Procedure

(a) Pre-conditioning : Unevenness observed in the bed faces should be removed by grinding to provide two smooth and parallel faces. The specimen shall be immersed in the water for 24 hours at 25° to 29°

(b) Any surplus moisture shall then be allowed to drain at room temperature. The frog of the bricks if it exists should be filled flush with mortar 1:3 (1 Cement: 3 clean coarse sand of grade 3 mm and down) and shall be kept under damp jute bags for 24 hours and after that these shall be immersed in clean water for three days.

After removal from water, the bricks shall be wiped out of any traces of moisture.

(b) Actual Testing: Specimen shall be placed with flat faces horizontal and mortar filled face upward between three 3 ply plywood sheets each of thickness 3 mm and carefully centered between plates of the testing machine. Plaster of Paris can also be used in place of plywood sheets to ensure a uniform surface.

Load shall be applied carefully axially at uniform rate of 14 N/mm² per minute till the failure of the specimen occurs.

B-4 Reporting the Test Results: The compressive strength of each specimen shall be calculated in N/ mm² as under:-

Compressive Strength :

$$= \frac{\text{Maximum load at failure (in N)}}{\text{Area of Specimen (in sq. mm)}}$$

For the purpose of calculating the average compressive strength, Compressive strength of all the individual bricks comprising the sample shall be averaged and reported. In terms of Para C 3.1.3 of Annexure C on Clause 2.3 of Part 2 Brick work and Block work of Chapter 4 of BIS Hand Book on Building Construction practices, if the compressive strength of any brick tested exceeds the specified value (refer Para 5.1.3), that result may be taken into account in reporting the results.

B-5 Criteria for conformity : A lot shall be considered having satisfies the requirements of average compressive strength if it satisfied the minimum average compressive strength specified in Para 5.1.3 for the corresponding class of brick tested. The compressive strength of any individual brick tested shall not fall below the minimum compressive strength specified for the corresponding class of bricks by more than 20%.

ANNEXURE 5.3**TEST FOR WATER ABSORPTION OF BRICKS** (Refer IS 3495 (Pt.2))

C-1 No. of Specimen : Five whole bricks shall be taken from samples as specimen for this test.

C.2. Apparatus : A balance required for this test shall be sensitive to weigh 0.1 per cent of the weight of the specimen.

C.3. Procedure

(a) Pre-conditioning : The specimen shall be allowed to dry in a ventilated oven at a 110° C to 115° C till it attains a substantially constant weight. If the specimen is known to be relatively dry, this would be accomplished in 48 hours, if the specimen is wet, several additional hours may be required to attain constant weight. It shall be allowed to cool at room temperature. In a ventilated room, properly separated bricks will require four hours for cooling, unless electric fan passes air over them continuously in which case two hours may suffice.

The cooled specimen shall be weight and marked as W1. A warm specimen shall not be used for this purpose.

(b) Actual Testing : Specimen shall be completely dried before immersion in the

water. It shall be kept in clean water at a temperature $27^{\circ}\text{C} \pm 2^{\circ}\text{C}$ for 24 hours. Specimen shall be wiped out of the traces of water with a damp cloth after removing from the water and then shall be weighed within three minutes after removing from water. Weight is marked as W2.

C-4 Reporting the Test Results : The water absorption of each specimen shall be calculated as follows and the average of five tests shall be reported.

$$\text{Water Absorption} = \frac{(W2-W1) \times 100}{W1}$$

C-5 Criteria for Conformity : A lot shall be considered having satisfied the requirements of water absorption if the average water absorption is as stipulated in Para 5.1.4.6.

ANNEXURE 5.4

TEST FOR EFFLORESCENCE OF BRICKS

(Refer IS 3495 (Pt.3))

D-1 No. of Specimen : Five whole bricks shall be taken as specimen for this test.

D-2 Apparatus : Apparatus required for this test shall be a shallow flat bottom dish containing distilled water of size 180X180X40 mm deep if of square shape or 200 mm dia X 40mm deep if circular. (As per IS-3495)

D-3 Procedure (actual testing) : The brick shall be placed vertically in the dish with 2.5 cm immersed in the water. The room shall be warm (20°C to 30°C) and well

ventilated. The bricks should not be removed until it absorbs whole water. When the whole water is absorbed and the brick appears to be dry, place a similar quantity of water in that dish and allow it to evaporate as before. The brick shall be examined after the second evaporation.

D-4 Reporting the Test Results : The rating to efflorescence in ascending order shall be reported as 'NIL', 'SLIGHT', 'MODERATE', 'HEAVY' or 'SERIOUS' in accordance with the following:-

(a) NIL : When there is no perceptible deposit of efflorescence.

(b) SLIGHT: When not more than 10 per cent of the area of the brick is covered with a thin deposit of salts.

(c) MODERATE: When there is heavier deposit and covering up to 50% of the area of the brick surface but unaccompanied by powdering or flaking of the surface.

(d) HEAVY: When there is a heavy deposit of salts covering 50% or more of the brick surface but unaccompanied by powdering or flaking of the surface.

(e) SERIOUS: When there is heavy deposit of salts, accompanied powdering and/or flaking of the exposed surface and tending to increase in the repeated wetting of the specimen.

D-5. Criteria for Conformity : A lot may be considered having satisfied the requirements of efflorescence if the permissible number of defectives depending on lot size is not more than that specified in Table 5.4 and the efflorescence is not beyond "moderate" for bricks upto Class 12.5 and not beyond "slight" for higher classes of bricks.

RECOMMENDED LIST OF TESTS ON MATERIALS

Material	Clause	Test	Field/ Laboratory Test	Test Procedure	Minimum quantity of material carrying out test	Frequency of testing
Bricks/ Brick Tiles	5.1.4.1 to 5.1.4.7	Testing of Bricks/Brick Tiles for dimensions, compressive strength, water absorption and efflorescence	Laboratory	ANNEXURES 5.1 to 5.4	As per Tables 5.3 and 5.4	--

BRICK WORK - FIGURES EXPLAINING SOME
ITEMS REFERRED TO

FIGURE 5.1 A to 5.1 D

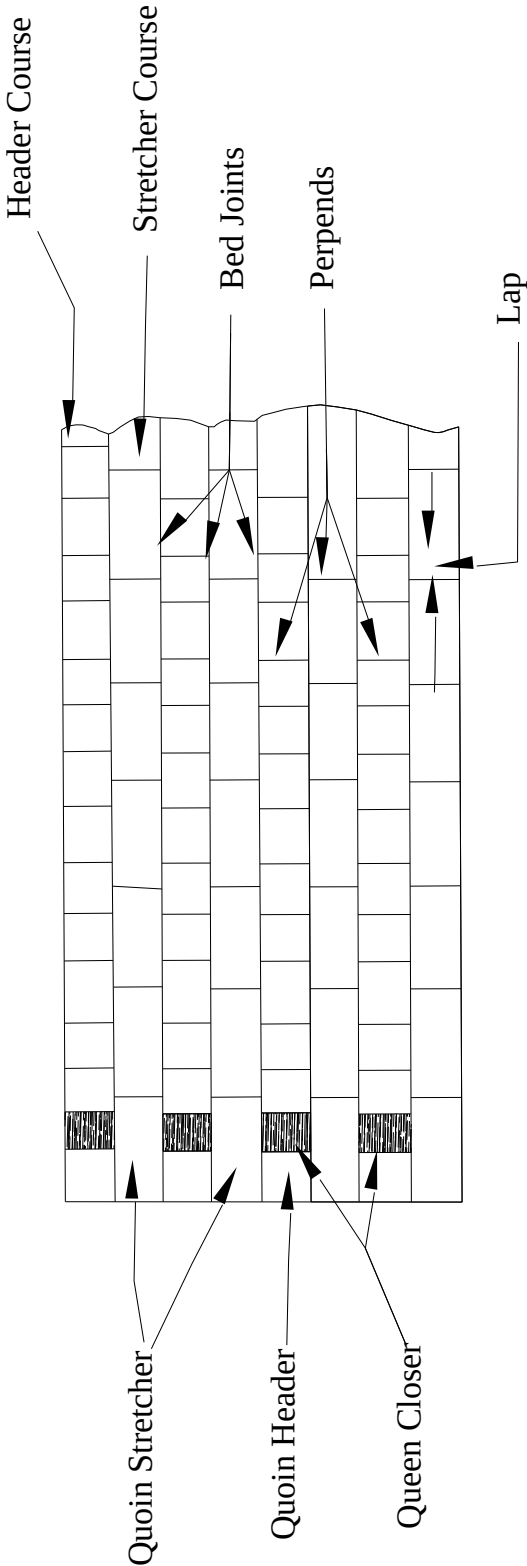


FIGURE 5.1 A

CLOSERS USED IN BRICK WORK

FIGURE 5.2 A to 5.2D

(a) Queen Closer: A solid brick is cut longitudinally in two equal parts and the above half brick is called queen closer. Instead of cutting the brick longitudinally we can cut the same breadth wise in quarter lengths and in that case two closers one from each face will have to be used. However , a single piece is preferable. The queen closer is normally placed next to quoin header.

(b) King Closer: While doing work on jambs during the fixing of doors or windows, brick bats are freely used to get the satisfactory arrangement of mortar joints. At such places one can use these closers very conveniently. The king closer is obtained by cutting half portion of header face and half portion of stretcher face in a triangular position, as shown in Fig. 5.2 B

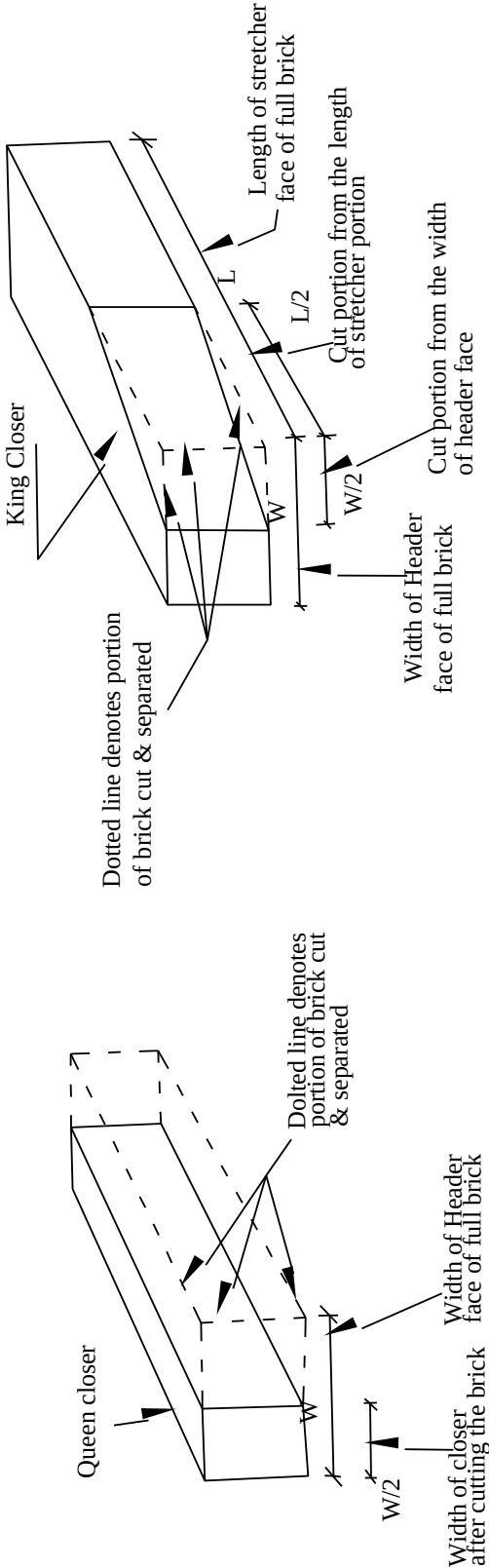


FIGURE 5.2 B King closer

Queen closer

FIGURE 5.2 A

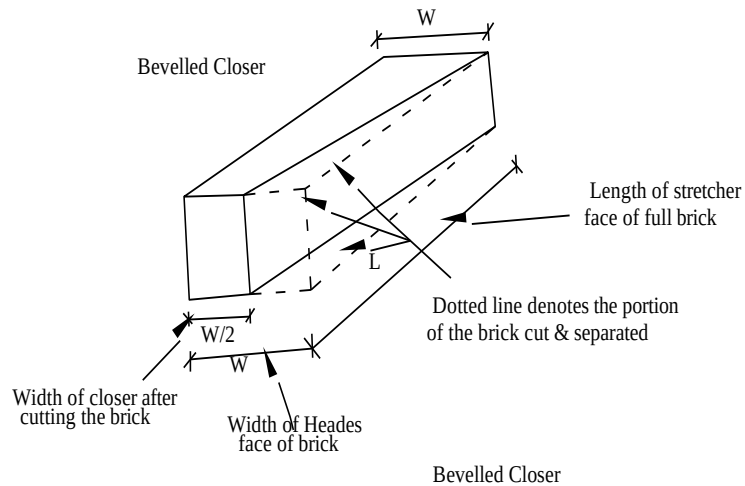


FIGURE 5.2 C

Bevelled Closer. To construct splayed brick work the use of bevelled closer which appears as closer at one face and a header at other face is most convenient.

The bevelled closer is obtained by cutting a triangular portion of the brick, from half the width of the brick to the end of length side as shown in fig. 5.2 C

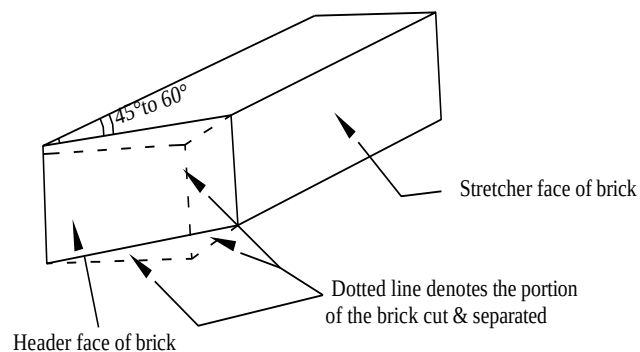


FIGURE 5.2 D

Mitred Closer

Mitred Closer. When a wall is being closed at corners or near pillars the necessity of closer arises. The solution is to use regular closers and these closers are called mitred closers. These closers are made by cutting a triangular portion of the brick through its width at an angle of 45° to 60° with the length of the brick as shown in Fig. 5.2 D

FIGURE 5.1 B

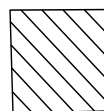
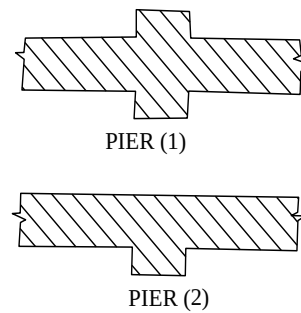


FIGURE 5.1 C

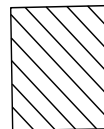
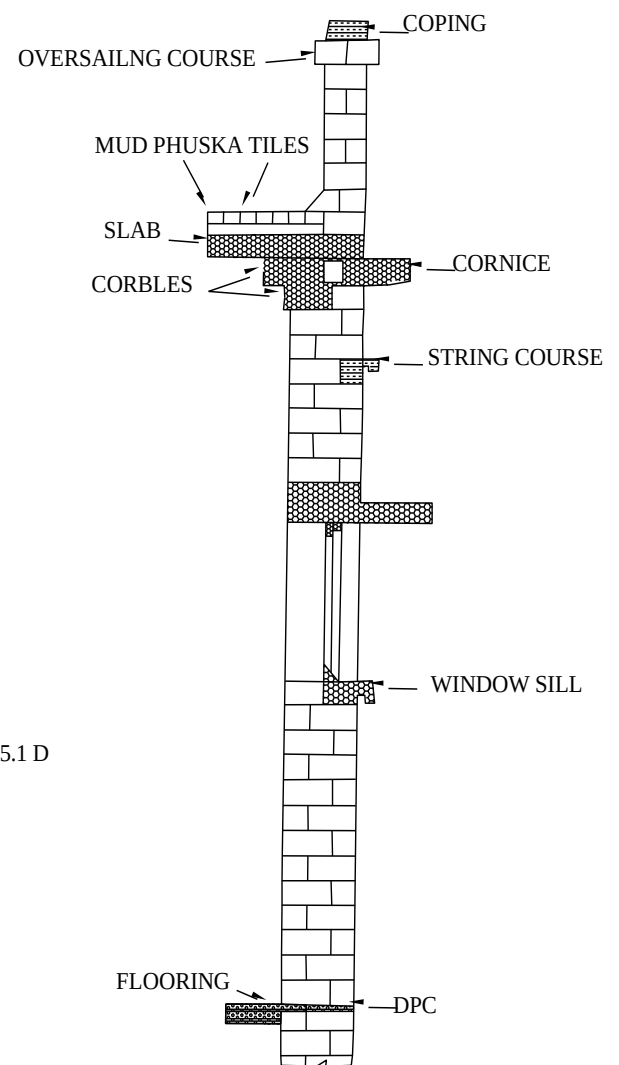


FIGURE 5.1 D

PILLARS

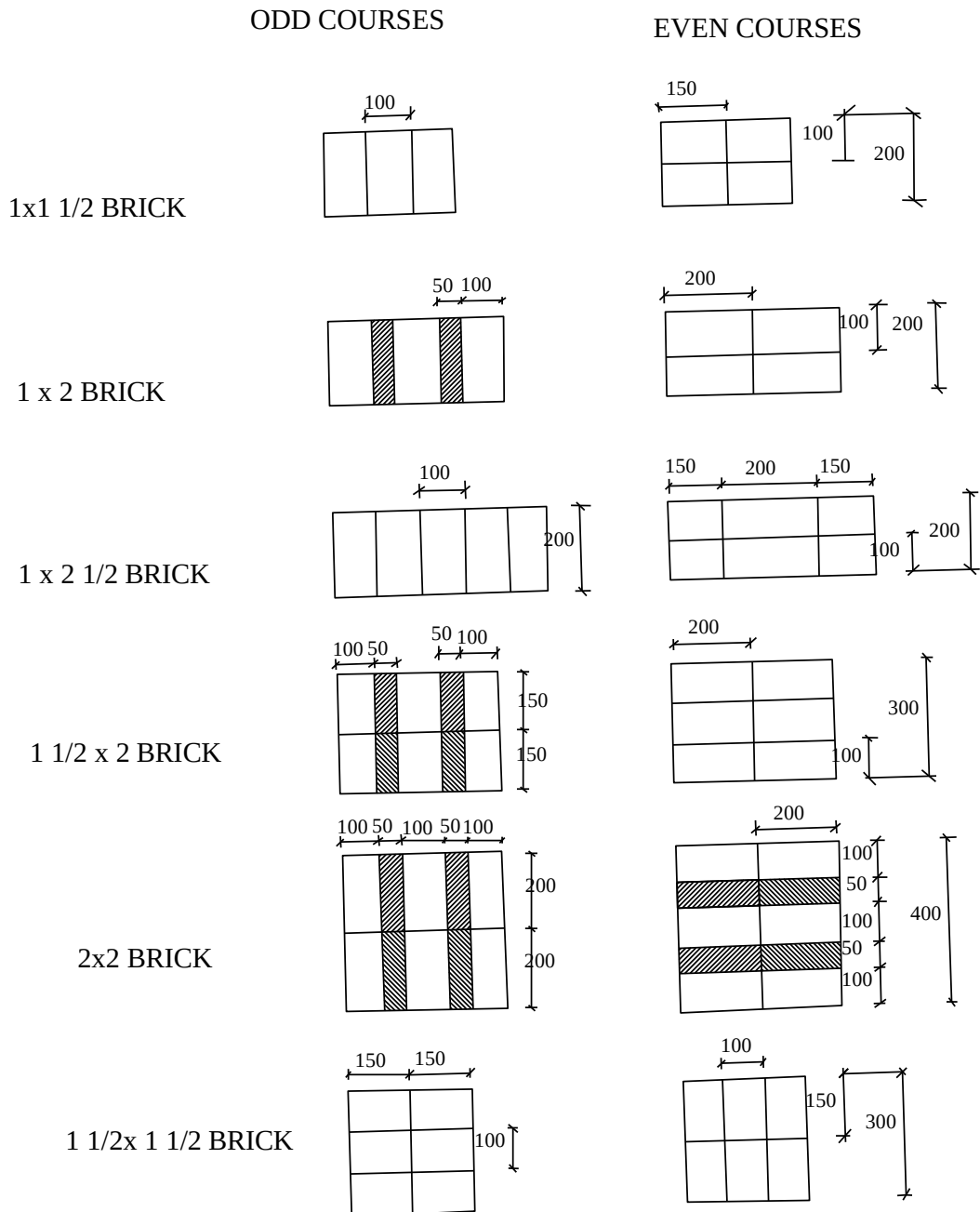


TYPICAL SECTION OF BRICK WALL

Note: IN RECTANGULAR WALLS THE BREADTH SHALL NOT EXCEED THREE TIMES THE THICKNESS AND THICKNESS ITSELF SHALL NOT EXCEED MORE THAN THREE BRICKS

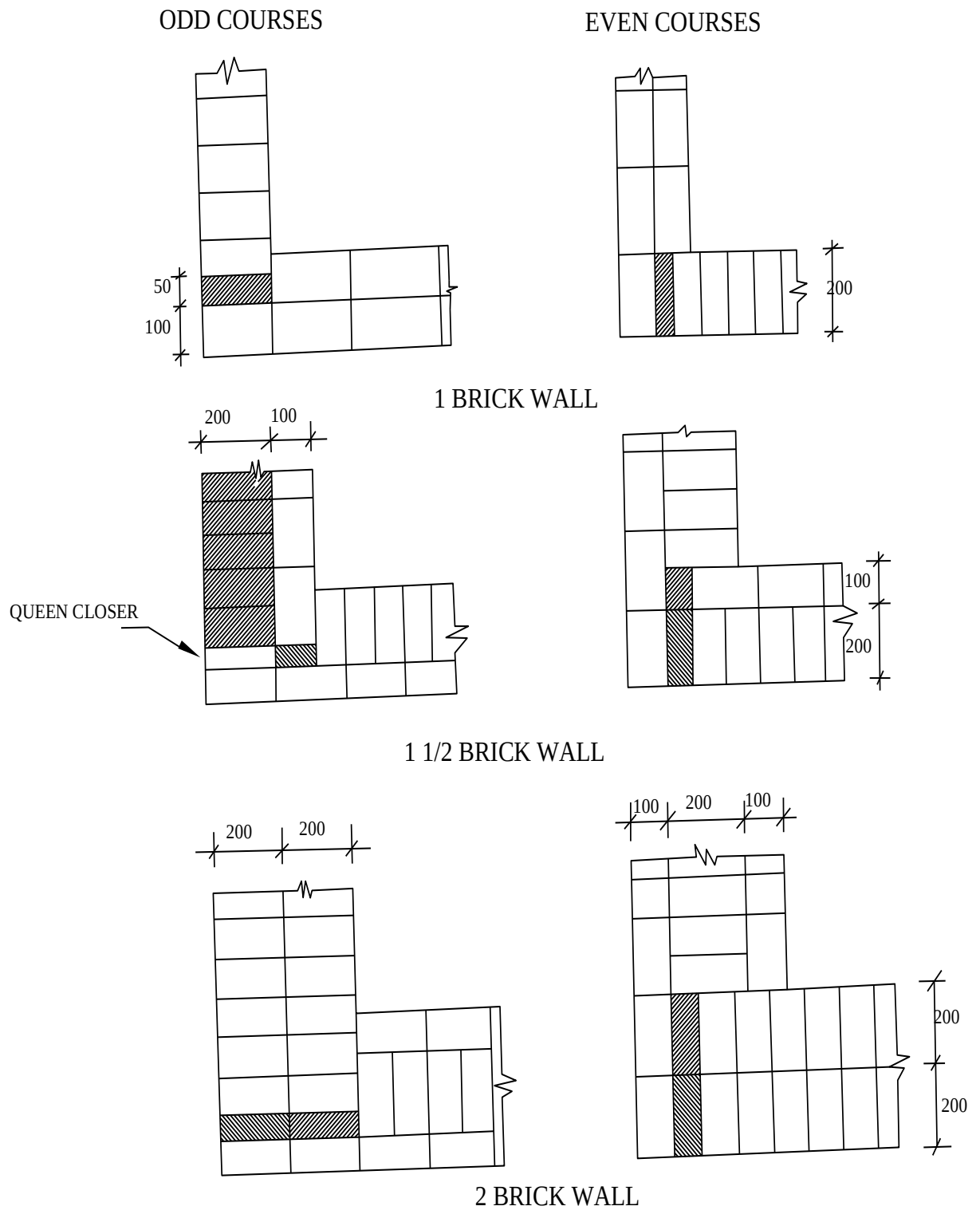
- 5.3 A English bond - Brick Pillars of different sizes
- 5.3 B English Bond - Brick walls of different thickness
- 5.3 C Double Flemish Bond - Brick wall 1 1/2 Brick thick - Isometric view
- 5.3 D English Bond - Brick wall 1 Brick thick - Isometric view

BRICK PILLARS
FIGURE 5.3 A to 5.3D



All dimensions are in mm
Drawings not to scale

FIGURE 5.3 A

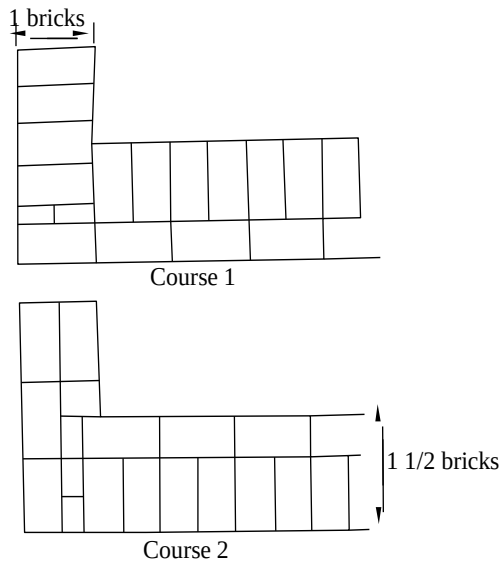


All dimensions are in mm
Drawings not to scale

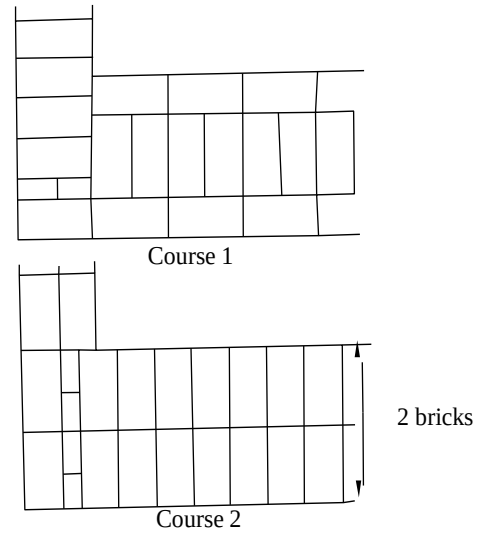
Figure 5.3 B

Figure 5.3 B

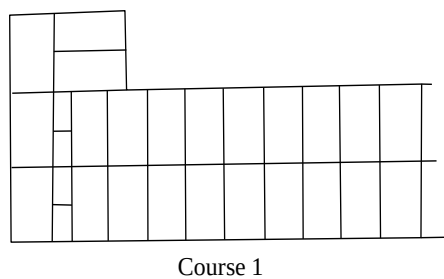
CONTD



1 BRICK WALL JOINING
1 1/2 BRICK WALL



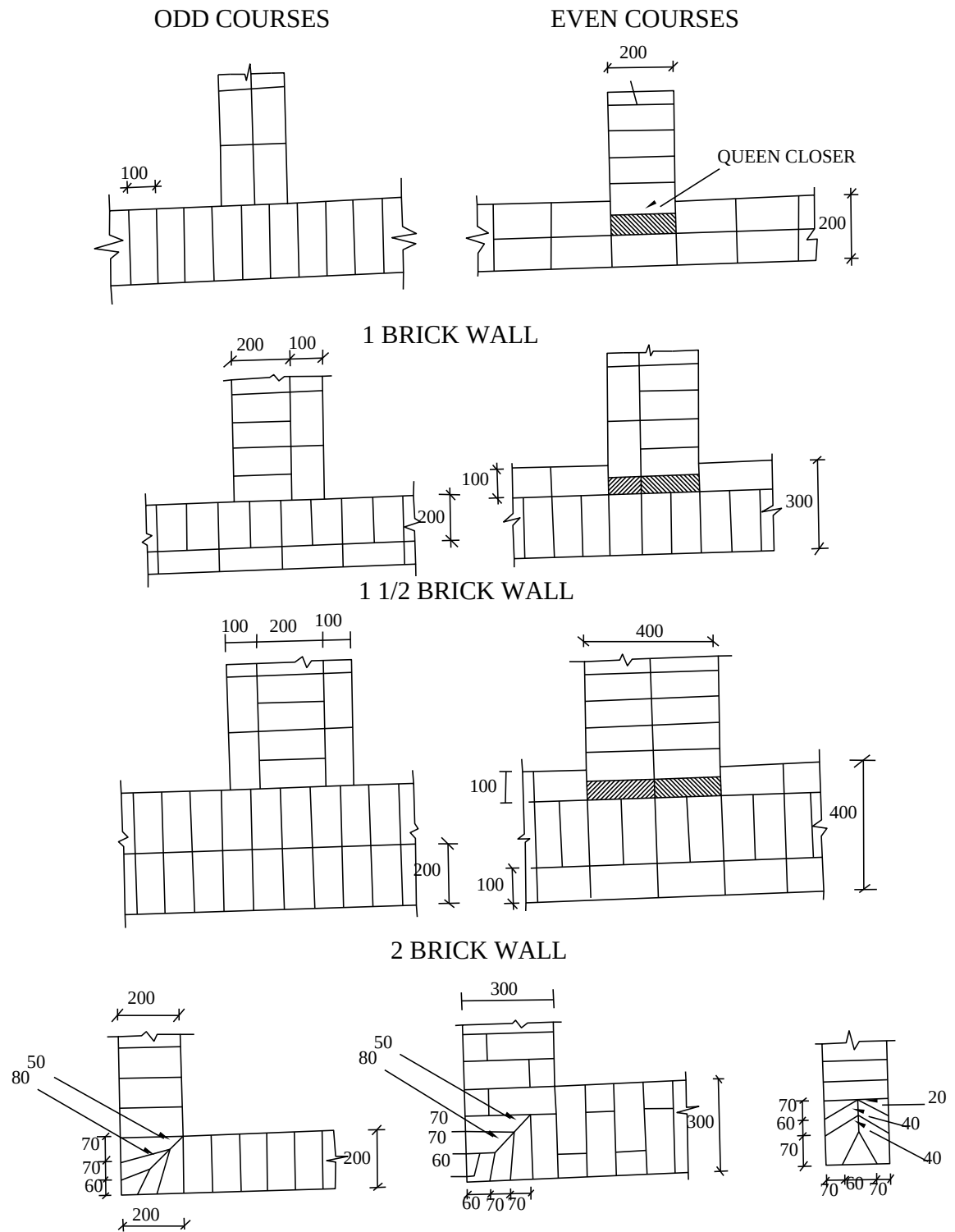
1 BRICK WALL JOINING
2 BRICK WALL



1 1/2 BRICK WALL JOINING
2 BRICK WALL



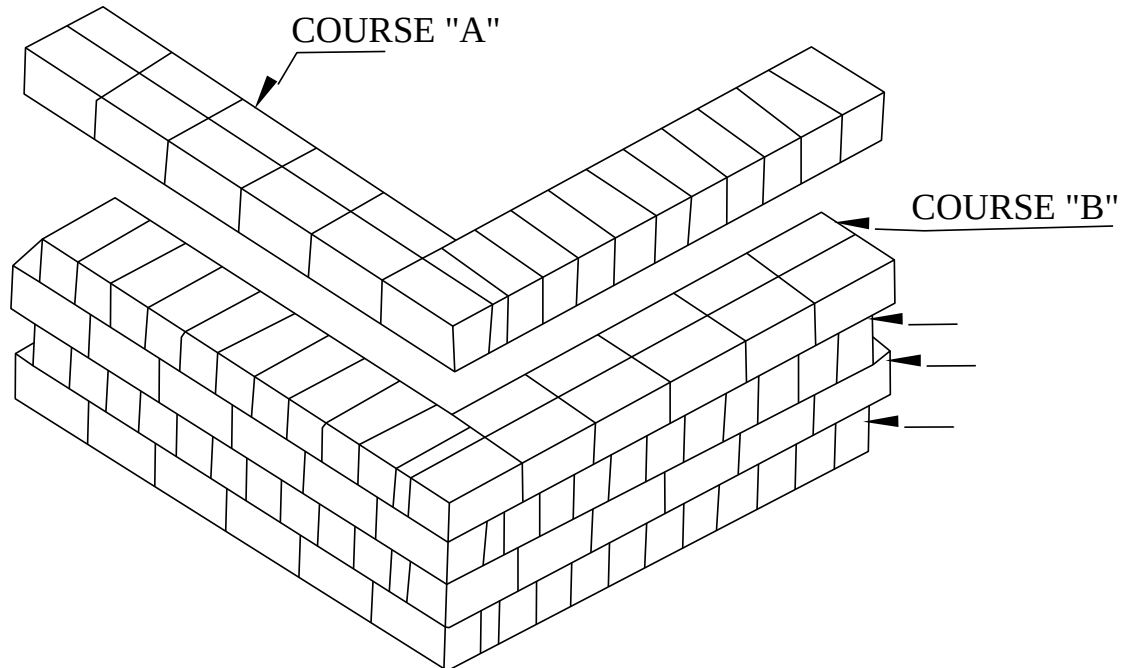
Figure 5.3 B
CONTD



All dimensions are in mm
Drawings not to scale

CUT BRICK CORNER

ENGLISH BOND



DOUBLE FLEMISH BOND FIG 5.3 C

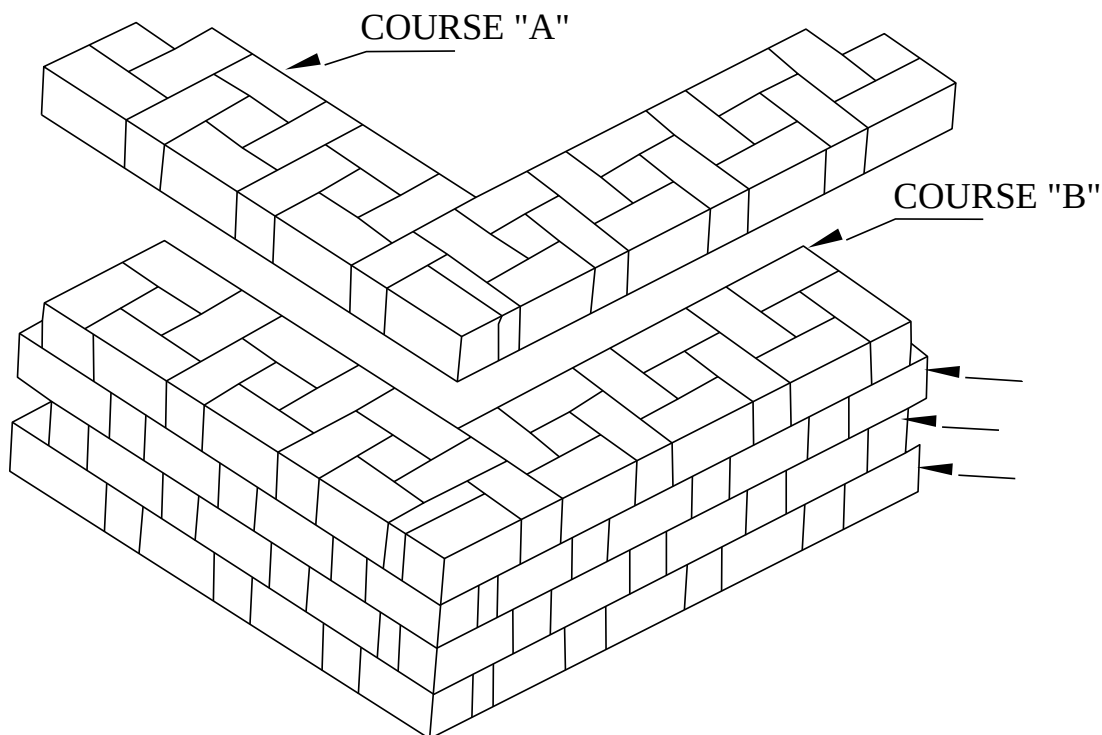
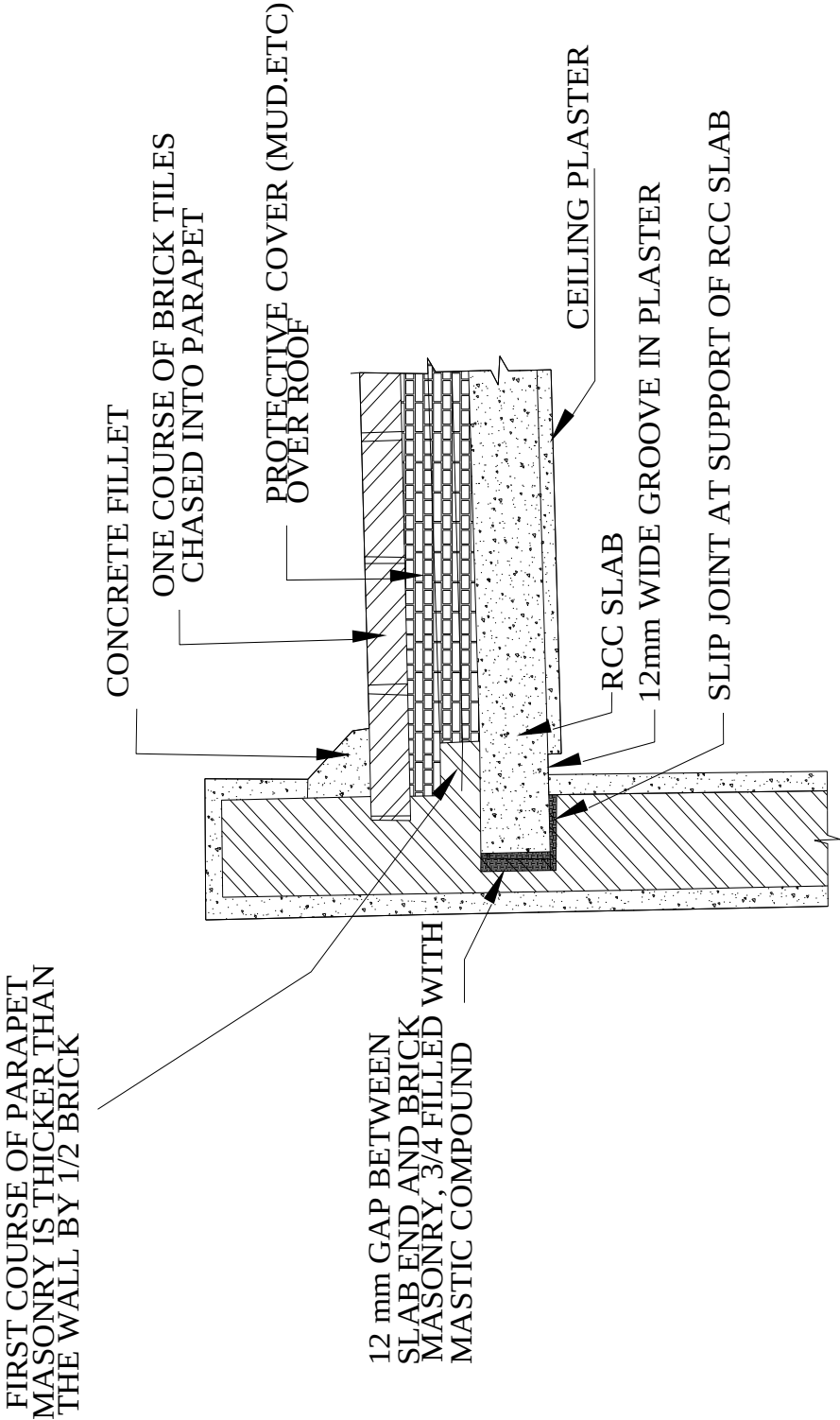


FIG 5.3 D

CONSTRUCTIONAL DETAIL OF BEARING OF RCC ROOF SLAB
OVER A MASONRY WALL

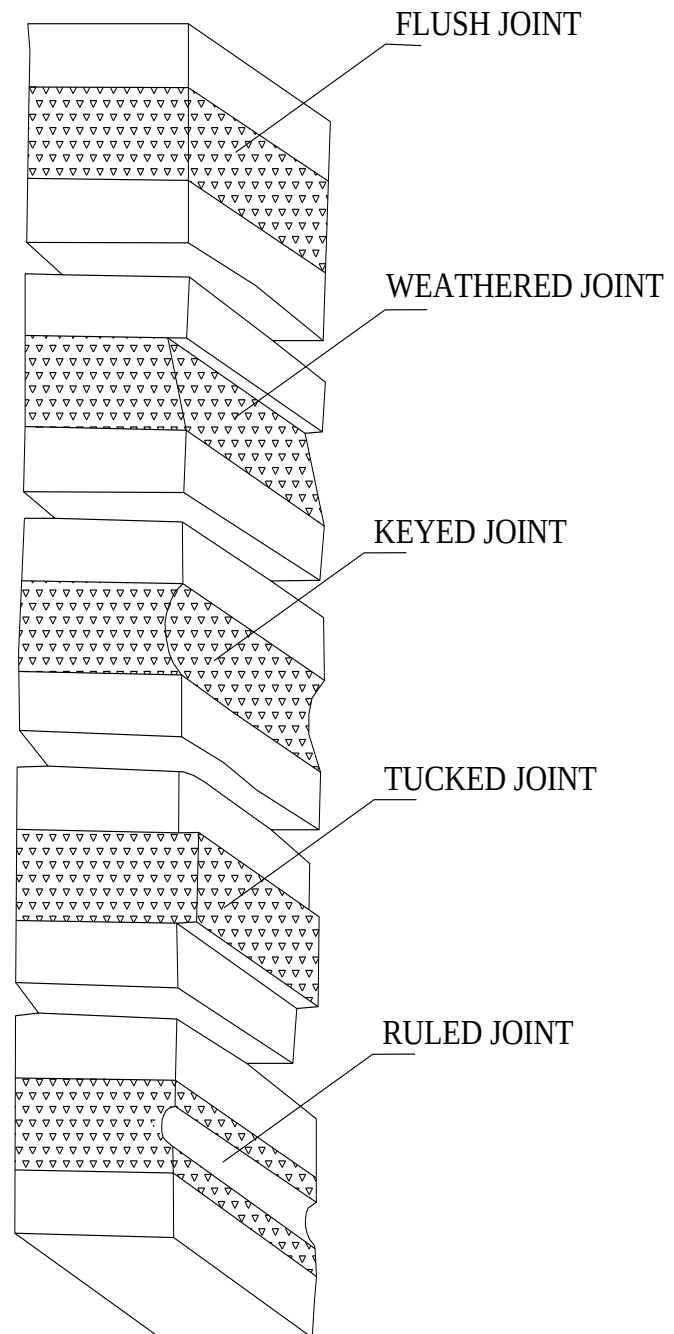
FIGURE 5.4



SECTION

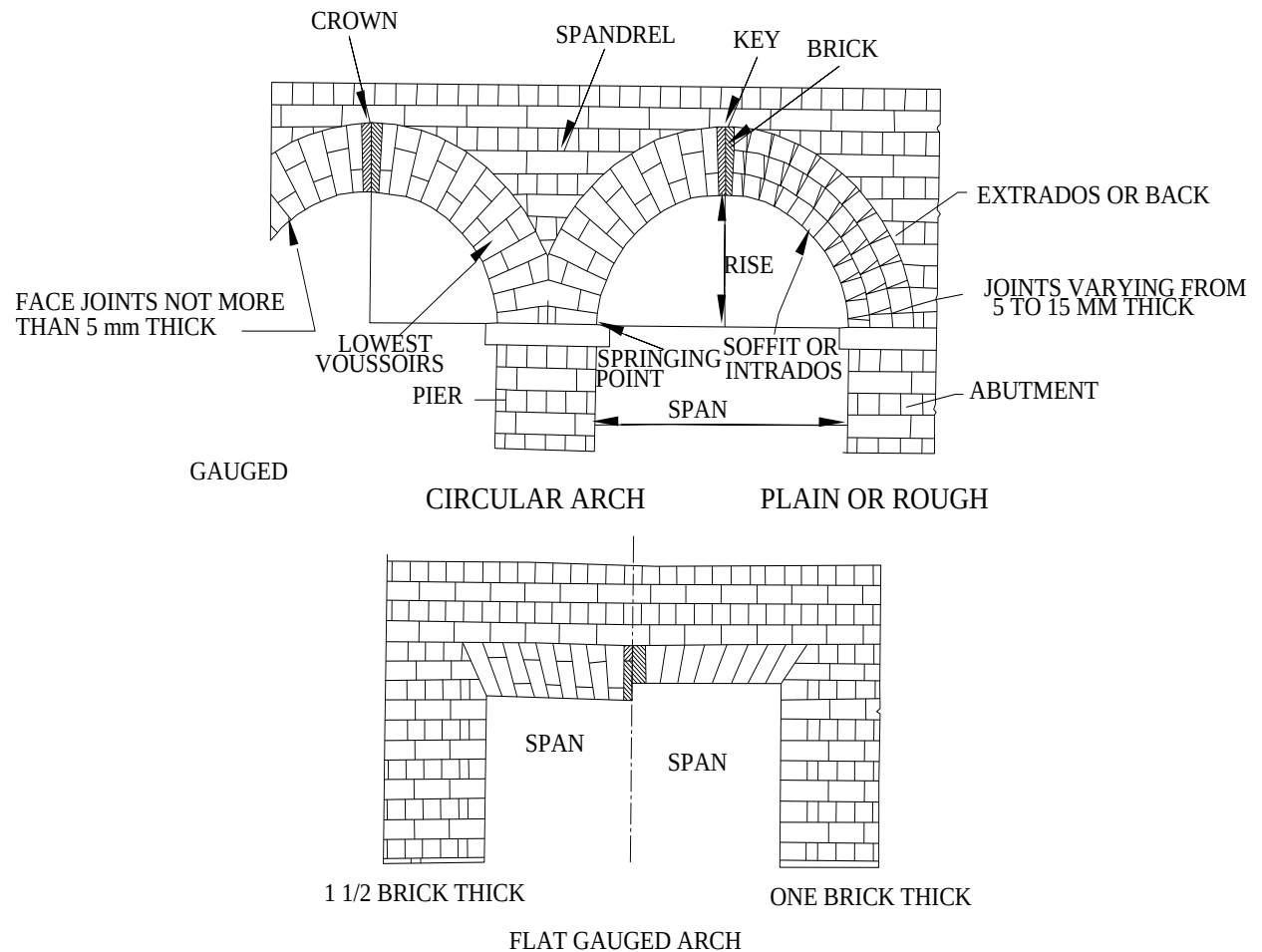
DIFFERENT TYPES OF POINTING FINISHES FOR BRICK WORK

FIGURE 5.5



BRICK WORK IN ARCHES

FIGURE 5.6



Brick work in Arches (Clause 6.3)

Note : Common Terminology

Voussoirs - Individual Wedge-shaped bricks.

Rise - Vertical distance between the springing line and highest point of soffit

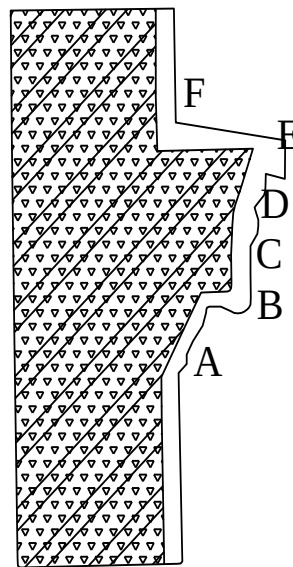
Haunch - Lower part of the Arch from springing line to midway of the crown

Bed joints : Joints between voussoirs

Label course : An extra course built around the Extrados of the arch, usually projecting on the face, giving the arch extra depth without cutting the bricks.

MOULDINGS AND CORNICES

FIGURE 5.7



Notes

1. The sectional periphery Curve ABCDEF to be measured and paid
2. Length FA shall not be measured.

BRICK WORK IN CAVITY WALLS

FIGURE 5.8

