

SPECIFICATION OF DIFFERENT APPROPRIATE TECHNOLOGIES



FOR PRODUCTION OF BUILDING MATERIALS & CONSTRUCTION OF BUILDINGS

Compiled by MGNREGA Division, MoRD, GOI

(January, 2016)

ABBREVIATIONS

BBL	Broken Brick - Lime
BIS	Bureau Of Indian Standards
BMTPC	Building Materials and Technology Promotion Council
EWS	Economically Weaker Sections
FFP	Fast Fluctuating Pressure
FRP	Fibre reinforced plastic
GI	Galvanized Iron
HUDCO	Housing and Urban Development Corporation
In Situ	On site
IS	Indian Standard
MCR	Micro Concrete Roofing Tiles
MS	Mild Steel
NEM plaster	Non Erodable Mud plaster
pH	Potential of Hydrogen
PVC	Poly Vinyl Chloride
r.p.m.	Revolutions per minute
RB	Reinforced Brick
RBC	Reinforced Brick Concrete
RC	Precast Reinforced Cement Concrete
RCC	Reinforced Cement Concrete
RHKN	Rural Housing Knowledge Network
TPI	Thermal Performance Index
W/C ratio	Water Cement ratio

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INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

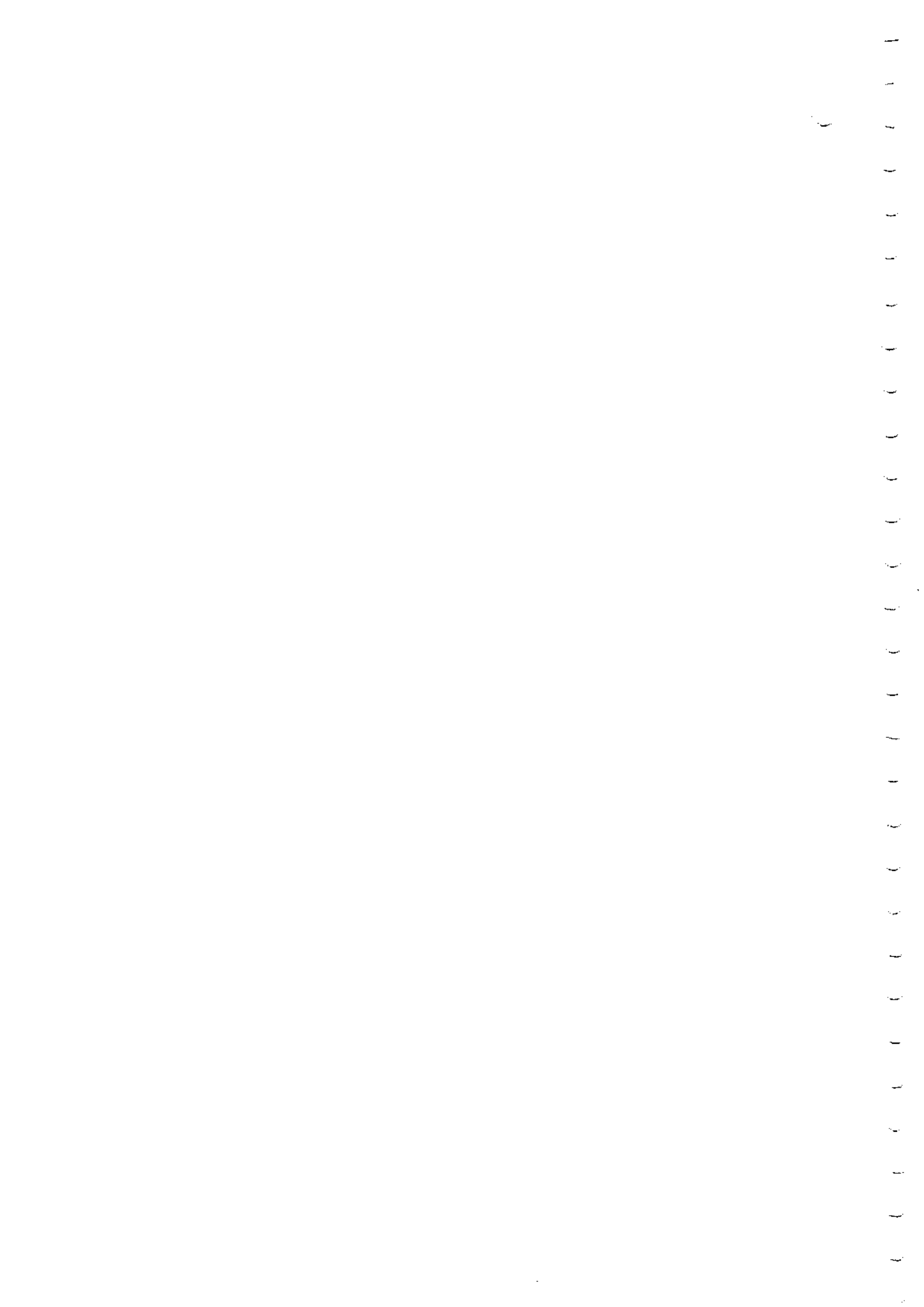
QUANTITY	UNIT	SYMBOL
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

QUANTITY	UNIT	SYMBOL
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

QUANTITY	UNIT	SYMBOL	DEFINITION
Force	newton	N	1 N = 1 kg.m/s ²
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m ²
Frequency	hertz	Hz	1 Hz = 1 c/s (s ⁻¹)
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress,	pascal	Pa	1 Pa = 1 N/m ²



IS 1725 : 2013

भारतीय मानक
सामान्य भवन निर्माण में प्रयुक्त स्थायीकृत
मृदा की ब्लॉक — विशिष्टि
(दूसरा पुनरीक्षण)

Indian Standard

STABILIZED SOIL BLOCKS USED IN GENERAL
BUILDING CONSTRUCTION — SPECIFICATION

(*Second Revision*)

ICS 91.100.15



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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

October 2013

Price Group 5

FOREWORD

This Indian Standard (Second Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Clay and Stabilized Soil Products for Construction Sectional Committee had been approved by the Civil Engineering Division Council.

Soil represents the earliest construction material used by mankind. Pure mud constructions suffer from two major drawbacks, complete loss of strength on saturation and erosion due to rain impact. Soil is therefore stabilized to improve its strength properties and durability and the stabilized soil is used for various engineering applications.

Stabilized soils have been successfully used for the construction of roads, pavements, foundations, earthen bunds, etc, in the past. Use of stabilized soils for the construction of walls of buildings can be seen since thirties.

Further upsurge of interest in the use of stabilized soil blocks for masonry can be seen throughout the world. Large numbers of buildings using stabilized soil blocks have come up in many parts of the world including India. This is mainly attributed to the fact that stabilized soil block is energy efficient and low carbon emission alternative to burnt clay brick and concrete based blocks. Currently large varieties of machines are commercially marketed throughout the world for the production of stabilized soil blocks. Use of these machines has lead to production of stabilized soil blocks of higher compressive strength, proper dimensions and precise edges and has also lead to better block productivity. Both modular and non-modular sizes of stabilized soil blocks are being manufactured in the country.

This standard was first published in 1960 and subsequently revised in 1982. During its first revision the principal modification was in respect of weathering test. The standard covered only modular sizes of stabilized soil blocks having a maximum strength of 3 N/mm². It was brought to the notice of Committee that there is sufficient demand for sizes other than modular sizes and that the manufacturers were meeting such demands at present. This had lead to a situation where bricks satisfying other requirements of the standard, but not the requirements regarding dimensions were classified as not satisfying the requirements of the standard. Therefore, the Committee reviewed the relevant clause of the standard and decided that the current revision of the standard will also include the non-modular sizes of the blocks in addition to the modular sizes specified in the standard. Vast amount of knowledge and experience accumulated due to the research and development efforts of several organizations throughout the world is also the basis for revising the standard.

The major changes incorporated in this revision are given below:

- a) The nomenclature of the product has been modified from the existing soil based blocks to stabilized soil blocks. Accordingly, the title of the standard has also been modified.
- b) A new clause on terminology has been incorporated to define certain terms used in the standard.
- c) Requirement for materials to be used in the manufacture of stabilized soil blocks has been added.
- d) A broad guideline to select and modify soil for production of good quality stabilized soil blocks has been introduced.
- e) More sizes of blocks (both modular and non-modular) have been incorporated and tolerance on dimensions has been modified.
- f) Requirement for minimum average compressive strength, compressive strength of individual block and average water absorption has been modified.
- g) Requirement and test method for dry density of block and linear expansion on saturation has been incorporated.
- h) Requirement and method of weathering test has been modified.

The composition of the committee and the working group responsible for formulation of this standard is given in Annex F.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (revised).'

Indian Standard

**STABILIZED SOIL BLOCKS USED IN GENERAL
BUILDING CONSTRUCTION — SPECIFICATION**

(Second Revision)

1 SCOPE

This standard covers the requirements for general quality, dimensions and physical requirements for solid stabilized soil blocks for use in general building construction.

2 REFERENCES

The standards listed below contain provisions, which through reference in this text constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

<i>IS No.</i>	<i>Title</i>
269 : 2013	Ordinary Portland cement, 33 grade Specification (<i>fifth revision</i>)
383 : 1970	Specification for coarse and fine aggregates from natural source for concrete (<i>second revision</i>)
712 : 1984	Building limes (<i>third revision</i>)
1489 (Part 1) : 1991	Portland pozzolana cement — Specification: Part 1 Flyash based (<i>third revision</i>)
1498 : 1970	Classification and identification of soils for general engineering purposes (<i>first revision</i>)
2248 : 1992	Glossary of terms relating to clay products for buildings (<i>second revision</i>)
2720	Methods of test for soils
(Part 4) : 1985	Grain size analysis (<i>second revision</i>)
(Part 5) : 1985	Determination of liquid limit and plastic limit (<i>second revision</i>)
(Part 26) : 1987	Determination of pH value (<i>second revision</i>)
3495	Methods of tests of burnt clay building bricks
(Part 1) : 1992	Determination of compressive strength (<i>third revision</i>)
(Part 2) : 1992	Determination of water absorption (<i>third revision</i>)
5454 : 1978	Methods for sampling of clay building bricks (<i>first revision</i>)

<i>IS No.</i>	<i>Title</i>
8112 : 2013	Ordinary Portland cement, 43 grade Specification (<i>second revision</i>)
12269 : 2013	Ordinary Portland cement, 53 grade — Specification (<i>first revision</i>)

3 TERMINOLOGY

For the purpose of this standard, the terms and definitions given in IS 2248 and the following shall apply.

3.1 Fresh Block Density — The ratio of mass of the fresh block (ascertained immediately after ejecting the block out of the mould) to the net volume of the block.

3.2 Dry Density of the Block — The ratio of mass of the dry block divided by the net volume of the block.

3.3 Wet Compressive Strength — Compressive strength of the block tested in saturated condition (*see 7.2*).

4 GENERAL QUALITY

4.1 Stabilized soil blocks shall be manufactured from a uniform mixture of suitable soil-sand mixture and stabilizers such as ordinary Portland cement or a combination of lime and ordinary Portland cement. The homogeneous mixture of soil-sand-stabilizer shall then be compacted into a high density block at optimum moisture content.

4.2 All blocks shall be sound and free from cracks, nodules of free lime or other defects which interfere with the proper placing of the unit. Minor chipping resulting from the customary methods of handling during delivery, shall not be deemed grounds for rejection. The faces of blocks shall be flat and rectangular, opposite faces shall be parallel, and all angles shall be square. The bedding surface shall be at right angles to the face of blocks.

5 MATERIALS**5.1 Cement**

The cement shall conform to either IS 269 or IS 1489 (Part 1) or IS 8112 or IS 12269.

5.2 Lime

Lime shall conform to IS 712.

5.3 Sand

The sand to be used for diluting the soils shall be either natural river sand, crushed stone sand or crushed gravel sand conforming to IS 383. It should be free from any type of salt/chemical and organic matter.

5.4 Soil

Soil shall be of the quality suitable for the production of stabilized soil blocks. Generally, soil contains clay minerals and inert particles such as silt and sand. The percentage and type of clay mineral controls the characteristics of soil. In majority of the cases the clay mineral content of the soil has to be controlled and adjusted by diluting the soil with sand, in order to make the soil suitable for stabilized soil blocks.

NOTE — A broad guideline to select or modify soil for the production of stabilized soil blocks is given in Annex A.

5.5 Water

The water to be used in the manufacture of blocks shall not be detrimental to its durability.

6 DIMENSIONS AND TOLERANCES

6.1 Stabilized soil blocks shall be made in sizes and shapes to fit different construction needs. Blocks of special shapes such as rounded corner, corbelled or any other shape for the purposes of enhancing aesthetic appearance of masonry and the building may also be manufactured with special attachments to the mould.

6.2 Dimensions

6.2.1 The modular size of stabilized soil blocks when measured according to the procedure given in Annex B shall be as follows:

<i>Length</i>	<i>Width</i>	<i>Height</i>
mm	mm	mm
290	90	90
290	140	90
240	240	90
190	90	90
190	90	40

6.2.1.1 The dimensions of the units are so designed that taking account of mortar joints, they will produce wall lengths and heights which will conform to the principles of modular co-ordination.

6.2.2 The following non-modular sizes of the bricks may also be used:

<i>Length</i>	<i>Width</i> mm	<i>Height</i> mm
mm	mm	mm
305	143	100
230	190	100
230	105	75
230	105	100

6.2.2.1 The dimensions of the units shall be measured in accordance with the procedure given in Annex B.

6.3 Tolerances

The maximum variation in the dimensions of the units shall not be more than ± 2 mm.

6.4 Frog

Each block may have frogs on both the bed faces in the form of depressions of rectangular or square shape with depth not exceeding 10 mm. In such cases, the area of the frogs on each bed face shall be restricted to 25 percent of the surface area and it is preferable to have at least one frog on either face.

7 PHYSICAL REQUIREMENTS

7.1 Dry Density of the Block

The dry density of the blocks, being the average of three specimens, when determined in accordance with the procedure described in Annex C shall not be less than 1 750 kg/m³.

NOTE — In order to achieve the specified dry density of the block, the fresh block density should be controlled by monitoring the quantum of wet mix that is fed into the machine mould.

7.2 Compressive Strength

7.2.1 The minimum average compressive strength of blocks when determined in accordance with the procedure described in IS 3495 (Part 1) shall be 3.5 MPa.

7.2.1.1 The compressive strength of any individual block shall not fall below the minimum average compressive strength by more than 15 percent.

7.3 Water Absorption

The average water absorption of the blocks when determined in accordance with the procedure described in IS 3495 (Part 2) after immersion in cold water for 24 h shall not be more than 18 percent by weight.

7.4 Linear Expansion on Saturation

The linear expansion on saturation of the blocks, being the average of three specimens, when determined in accordance with the procedure described in Annex D, shall not exceed 0.10 percent.

7.5 Weathering

The maximum loss of weight, being the average of three specimens, when determined in accordance with the procedure described in Annex E shall not exceed 3 percent.

8 SAMPLING AND CRITERIA FOR CONFORMITY

8.1 Sampling and criteria for conformity of the blocks for visual requirements (see 4.2), dimensional characteristics (see 6), wet compressive strength (see 7.2) and water absorption (see 7.3) shall be done in accordance with the procedure laid down in IS 5454.

8.2 Out of the blocks which have been selected as per IS 5454 for checking visual and dimensional requirements and have satisfied the above requirements as given in 8.1, three blocks shall be subjected to the test for dry density of block (see 7.1), three blocks shall be subjected to the test for linear expansion on saturation (see 7.4) and three blocks shall be subjected to the test for weathering test (see 7.5).

8.3 For dry density of block, the mean value determined shall be greater than or equal to the minimum limit specified in 7.1. For linear expansion on saturation and weathering test, the mean value determined shall be equal or less than the maximum limit specified in 7.4 and 7.5 respectively.

9 MANUFACTURER'S CERTIFICATE

The manufacturer shall satisfy himself that the blocks conform to the requirements of this standard and, if requested, shall supply a certificate to this effect to the purchaser or his representative.

10 MARKING

10.1 Each block shall be clearly and permanently marked with the following information:

- a) Identification of the manufacturer; and
- b) Year of manufacture, if required.

10.2 BIS Certification Marking

Each block may also be marked with the Standard Mark.

10.2.1 The use of the Standard Mark is governed by the provisions of the *Bureau of Indian Standards Act, 1986* and the Rules and Regulations made thereunder. The details of conditions under which the license for the use of Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

ANNEX A
(Clause 5.4)

BROAD GUIDELINE TO SELECT OR MODIFY SOIL FOR THE PRODUCTION OF STABILIZED SOIL BLOCKS

A-1 A broad guideline to select or modify a soil for the production of stabilized soil blocks is given in Table 1 and Table 2. The soil or soil-sand mixture meeting the specification given in Table 1 may result in production of good quality stabilized blocks. The recommended values of stabilizer to clay ratio for expansive and non-expansive soil have been given in Table 2.

A-2 Use of soil containing expansive clay minerals such as montmorillonite requires lime as a stabilizing additive to manufacture stabilized soil blocks. Acidic soils having pH less than 6.5 can be stabilized with addition of 1 to 2 percent calcium hydroxide (lime) by

weight in addition to cement. Soil containing excessive silt fraction can lead to stabilized soil block having very low green strength for handling during the block manufacturing process. In such situations, coarse gravel or coarse sand fraction can be added to the soil to overcome the problem. Some soils may contain deleterious salts or chemicals or organic matter which can impair the stabilization process when cement or cement-lime is used. The behaviour of stabilized soil block using such soils depends upon the nature of salts or chemicals or organic matter present. In such situations, the stabilized soil blocks shall be tested to confirm that they meet the requirements specified in 4.2, 6 and 7.

Table 1 Recommended Specification for Soil or Soil-Sand Mixture
(Clause A-1)

Sl No. (1)	Details (2)	Ref to, Indian Standard (3)	Limiting values (4)
i)	Granular composition of soil or soil-sand mixture:		
	a) Clay fraction (<0.002 mm)	IS 2720 (Part 4)	5 to 18 percent
	b) Silt fraction (0.002 – 0.075 mm)	and IS 1498	10-40 percent
	c) Sand fraction (0.075 – 4.75 mm)		50-80 percent
	d) Gravel fraction (4.75 – 6 mm)		0-10 percent
ii)	Liquid limit	IS 2720 (Part 5)	≤ 30 percent
iii)	pH	IS 2720 (Part 26)	6.5-8.5

Table 2 Recommended Stabilizer to Clay Ratio for Different Types of Soils
(Clause A-1)

Sl No. (1)	Type of Soil (2)	Stabilizer to Clay Ratio (by Weight) (3)
i)	For soils having non-expansive clay minerals (for example, kaolinite, illite, etc)	≥ 0.40
ii)	For soils having expansive clay minerals (for example, montmorillonite)	≥ 0.75

NOTE — Stabilizer content should be ≥ 5 percent (by weight).

ANNEX B

(Clause 6.2)

MEASUREMENT OF DIMENSIONS

B-1 APPARATUS

Overall dimensions shall be measured with a steel scale or metal tape graduated in 1 mm divisions.

B-2 Specimens

Samples selected in accordance with IS 5454 shall be measured for length, width and height.

B-3 MEASUREMENTS AND REPORT

B-3.1 Individual measurements of the dimensions of

each specimen shall be read to the nearest division of the scale.

B-3.2 Length shall be measured on the longitudinal centre line of each face, width across the top and bottom bearing surfaces at mid-length, and height on both faces at mid-length.

B-3.3 The report shall show the average length, width and height of each specimen.

ANNEX C

(Clause 7.1)

METHOD FOR DETERMINATION OF DRY DENSITY

C-1 TEST SPECIMENS

Randomly select three full size specimens from the sample of blocks which has been found satisfactory in respect of dimensional and visual requirements. These

blocks shall be designated as specimens A, B and C respectively.

C-2 APPARATUS

A sensitive balance capable of weighing within 0.1

percent of the mass of the specimen, ventilated oven or a thermostatically controlled oven capable of maintaining temperature upto $110 \pm 5^\circ\text{C}$ and a Vernier calliper or a steel scale graduated in 1mm divisions.

C-3 PROCEDURE

- a) Dry the specimens in an oven at $100 \pm 5^\circ\text{C}$ to constant weight.
- b) Measure the dimensions of the dried blocks in centimetres (to the nearest millimetre) and compute the volume, in cm^3 .

- c) Weigh the blocks, in kilograms (to the nearest 10 g).

C-4 CALCULATION AND REPORT

C-4.1 Calculate the density of each specimen as below:

$$\text{Dry density} = \frac{\text{Mass of specimen, in kg}}{\text{Volume of specimen, in cm}^3} \times 10^6 \text{ kg/m}^3$$

C-4.2 The average of the results for the three specimens shall be reported as the average dry density of the blocks.

ANNEX D
(Clause 7.4)

METHOD FOR DETERMINATION OF LINEAR EXPANSION ON SATURATION

D-1 TEST SPECIMENS

Randomly select three full size specimens from the sample of blocks which has been found satisfactory in respect of dimensional and visual requirements. These blocks shall be designated as specimens A, B and C respectively.

D-2 APPARATUS

A vernier calliper with a least count of 0.1 mm and length more than that of the block, ventilated or thermostatically controlled oven capable of maintaining temperature of $110 \pm 5^\circ\text{C}$ and a length comparator attached with a dial gauge having a least count of 0.001mm (see Fig. 1).

D-3 PROCEDURE

- a) Cure the specimens for 28 days.
- b) Remove the specimens from water and dry them in the oven at $60 \pm 5^\circ\text{C}$ till they attain constant weight and then allow them to cool down at ambient temperature such that they attain room temperature.
- c) Measure the lengths of the longest dimensions of all the three specimens using vernier calliper and note them as initial length of the specimens, L_{Ai} , L_{Bi} , and L_{Ci} respectively.
- d) Fix a metal point or small strip using water insoluble glue on the top surface of the dried specimens and position the block in the apparatus as shown in Fig. 1. Now, note down the initial reading of the dial gauge.
- e) Remove the specimens from the apparatus without disturbing the digital dial gauge and

then soak them in water for 24 h at room temperature.

- f) After 24 h take out the saturated specimens and position them in the length comparator apparatus such that the metal point fixed on the surface of the block faces the dial gauge tip. Note the final reading of the digital dial gauge. Ensure that the dial gauge in the apparatus is undisturbed throughout the duration of test. The difference between the initial dial gauge reading and final dial gauge reading gives the linear expansion of the specimens, L_{Ae} , L_{Be} , and L_{Ce} respectively, in mm.

D-4 CALCULATION AND REPORT

D-4.1 Calculate the percentage linear expansion on saturation of each specimen as the difference between the initial length and final length after saturation expressed as a percentage of the initial length.

Percentage linear expansion on saturation for specimen

$$A = \frac{L_{Ae}}{L_{Ai}} \times 100;$$

Percentage linear expansion on saturation for specimen

$$B = \frac{L_{Be}}{L_{Bi}} \times 100; \text{ and}$$

Percentage linear expansion on saturation for specimen

$$C = \frac{L_{Ce}}{L_{Ci}} \times 100.$$

IS 1725 : 2013

D-4.2 Report all results separately for each specimen and as the average for the three specimens.

Linear expansion on = $(L_e / L_i) \times 100$
saturation (percent)

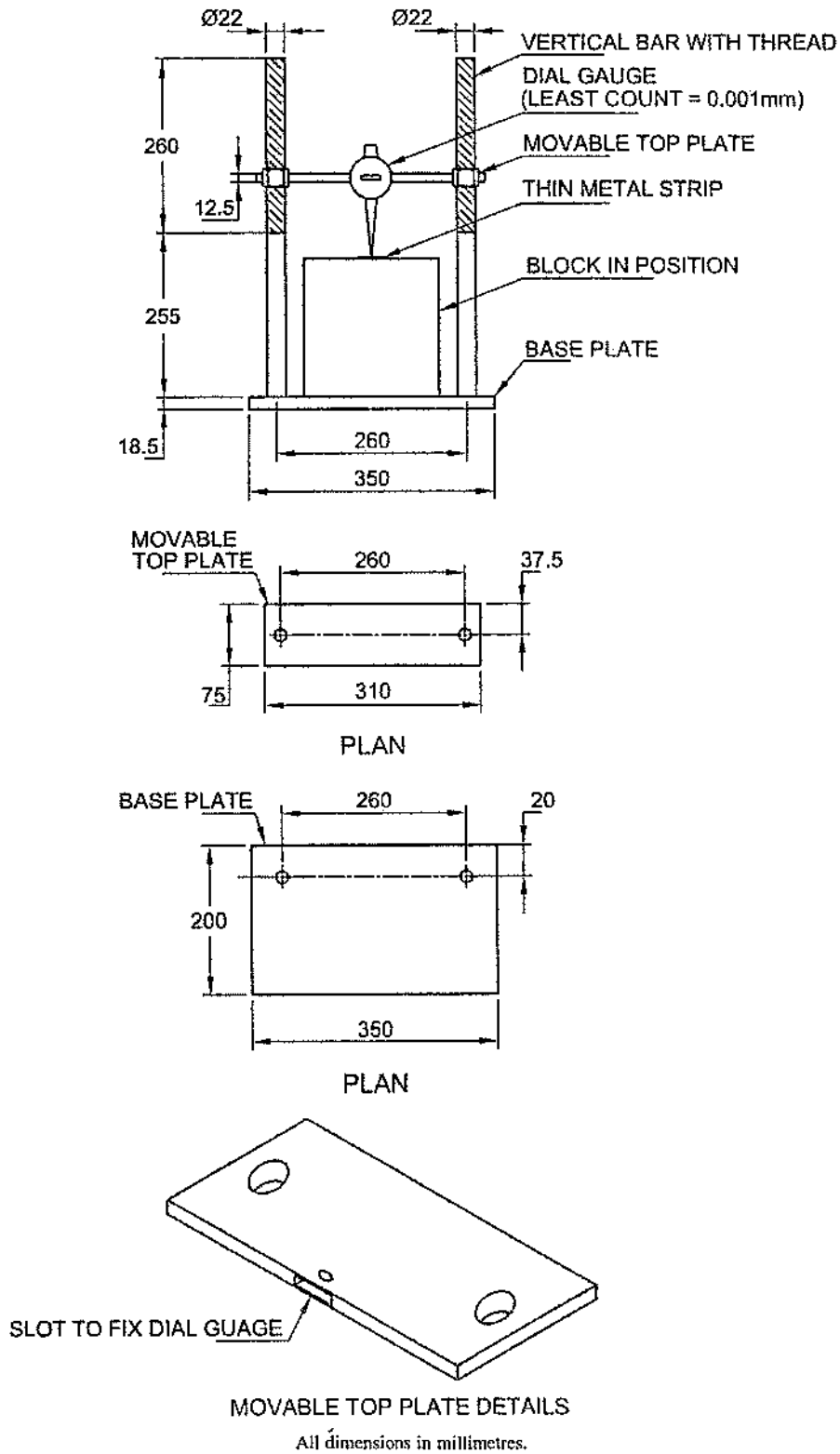


FIG. 1 SET-UP FOR LENGTH COMPARATOR

ANNEX E
(Clause 7.5)
WEATHERING TEST

E-1 TEST SPECIMENS

Randomly select three full size specimens from the sample of blocks which has been found satisfactory in respect of dimensional and visual requirements. These blocks shall be designated as specimens A, B and C respectively.

E-2 APPARATUS

A sensitive balance capable of weighing within 0.1 percent of the mass of the specimen, ventilated oven or a thermostatically controlled oven capable of maintaining temperature of $110 \pm 5^\circ\text{C}$ and a wire scratch brush made of 0.40 mm diameter wire bristles assembled in 50 groups of 10 bristles each and mounted to form 5 longitudinal rows and 10 transverse rows of bristles on 200 mm x 60 mm hardwood block.

E-3 PROCEDURE

- a) Dry the specimens in the oven at $60 \pm 5^\circ\text{C}$ till they attain constant weight.
- b) Determine the initial constant weight of the individual specimens and note them as W_{Ai} , W_{Bi} and W_{Ci} .
- c) Soak the specimens in water at room temperature for 5 h. Remove the specimens from water and dry them in the oven at $70 \pm 5^\circ\text{C}$ for 42 h. Remove the partially dried blocks from the oven and scratch all the six faces of the specimens twice with wire scratch brush. Hold the brush with its long axis parallel to the longitudinal axis of the specimen or parallel to the ends, as required to cover all areas of the specimen. Apply firm strokes corresponding to 1.5 kg force (see Note). Approximately eighteen to twenty brush strokes will be required for scratching the wider sides of the specimen twice and four

strokes for each end. This procedure constitutes one cycle of weathering test.

- d) Repeat procedure given at E-3 (c) 12 times to complete 12 cycles.
- e) After completion of 12 cycles, dry the specimens at $60 \pm 5^\circ\text{C}$ such that they attain constant weight.
- f) Determine the final oven dried constant weight of the specimens and note them as W_{Af} , W_{Bf} and W_{Cf} .

NOTE — The pressure of the brush stroke can be measured by clamping the wider face of the specimen on one corner of platform scale and the scale to zero and putting a standard weight of 1.5 kg on the brush.

E-4 CALCULATION AND REPORT

E-4.1 Calculate the percentage weight loss of each specimen as the difference between the initial constant weight and final oven dried constant weight after conducting 12 cycles of weathering expressed as a percentage of the initial constant weight.

Percentage weight loss for specimen,

$$A = \frac{W_{Ai} - W_{Af}}{W_{Ai}} \times 100;$$

Percentage weight loss for specimen,

$$B = \frac{W_{Bi} - W_{Bf}}{W_{Bi}} \times 100; \text{ and}$$

Percentage weight loss for specimen,

$$C = \frac{W_{Ci} - W_{Cf}}{W_{Ci}} \times 100.$$

E-4.2 Report all results separately for each specimen and as the average for the three specimens.

ANNEX F
(Foreword)

COMMITTEE COMPOSITION

Clay and Stabilized Soil Products for Construction Sectional Committee, CED 30

<i>Organization</i>	<i>Representative(s)</i>
In personal capacity (651/37, Ganga Enclave, Sainik Colony, Roorkee 247667)	DR J. M. BHATNAGAR (<i>Chairman</i>)
A. Albuquerque and Sons, Mangalore	SHRI GEORGE ALBUQUERQUE PAI SHRI J. L. PAVAMANI (<i>Alternate</i>)
A. P. Engineering Research Laboratories, Hyderabad	SHRI G. CHETTI BABBU SHRI P. JOIN VICTOR (<i>Alternate</i>)
All India Brick and Tile Manufacturers' Federation, New Delhi	SHRI R. P. S. CHANDEL SHRI R. K. VERMA (<i>Alternate</i>)
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IS 12894 : 2002

भारतीय मानक
ईंधन राख-चूने की ईंटें — विशिष्टि
(पहला पुनरीक्षण)

Indian Standard

**PULVERIZED FUEL ASH-LIME
BRICKS — SPECIFICATION**

(First Revision)

ICS 691.421.2 : [666.924 + 662.613.13]

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

April 2002

Price Group 2

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Building Lime and Lime Products Sectional Committee had been approved by the Civil Engineering Division Council.

This standard was first issued in 1990 covering modular size bricks of only four class designer that is 7.5, 10, 15 and 20.

Pulverized fuel ash commonly known as fly ash is a useful by-product from thermal power stations using pulverized coal as fuel and has considerable pozzolonic activity. This national resource has been gainfully utilized for manufacture of Pulverized fuel ash-lime bricks as a supplement to common burnt clay building bricks leading to conservation of natural resources and improvement in environmental quality.

Pulverized fuel ash-lime bricks are obtained from materials consisting of pulverized fuel ash in major quantity, lime and an accelerator acting as a catalyst. Pulverized fuel ash-lime bricks are generally manufactured by intergrinding or blending various raw materials which are then moulded into bricks and subjected to curing cycles at different temperatures and pressures. On occasion as and when required, crushed bottom fuel ash or sand is also used in the composition of the raw material. Crushed bottom fuel ash or sand is used in the composition as a coarser material to control water absorption in the final product. Pulverized fuel ash reacts with lime in presence of moisture to form a calcium-silicate hydrate which is a binder material. Thus pulverized fuel ash-lime brick is a chemically bonded bricks.

These bricks are suitable for use in masonry construction just like common burnt clay bricks. Production of pulverized fuel ash-lime bricks has already started in the country and it is expected that this standard would encourage its production and use on mass scale. This standard lays down the essential requirements of pulverized fuel ash-lime bricks so as to achieve uniformity in the manufacture of such bricks.

Further technological advancement in this field advocated inclusion of more class designation like 3.5, 5, 12.5, 17.5, 25 and 30 and non modular sizes. Various sizes, class designation and tolerances have been taken on the basis of IS 13757 that is for Burnt clay fly ash building bricks.

The composition of the Committee responsible for formulation of this standard is given in Annex A.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (revised)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

**AMENDMENT NO. 1 JULY 2011
TO
IS 12894 : 2002 PULVERIZED FUEL ASH-LIME
BRICKS — SPECIFICATION**

(First Revision)

(Page 1, clause 2) — Delete the entry '3812 : 1981' along with its title.

(Page 1, clause 2) — Insert the following at the end:

'15648 : 2006 Pulverized fuel ash for lime pozzolana mixture applications — Specification'

(Page 2, clause 6.1) — Substitute the following for the existing:

'6.1 Pulverized Fuel Ash

Pulverized fuel ash shall conform to IS 15648.'

(CED 4)

Indian Standard
**PULVERIZED FUEL ASH-LIME
 BRICKS — SPECIFICATION**
(First Revision)

1 SCOPE

This standard lays down the requirements for classification, general quality, dimensions and physical requirements of pulverized fuel ash-lime bricks used in buildings.

NOTE — Pulverized fuel ash-lime bricks having wet compressive strength less than 30 N/mm² approximately 300 kgf/cm² are covered in this standard and for higher strength (see IS 2180 and IS 1077).

2 REFERENCES

The following Indian Standards contain provisions which, through reference in this text, constitute provision of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below :

<i>IS No.</i>	<i>Title</i>
712:1984	Specification for building limes (<i>third revision</i>)
1727:1967	Methods of test for pozzolanic materials (<i>first revision</i>)
3495	Methods of tests of burnt clay building bricks:
(Part 1):1992	Determination of compressive strength (<i>second revision</i>)
(Part 2):1992	Determination of water absorption (<i>second revision</i>)

*IS No.**Title*

(Part 3):1992	Determination of efflorescence (<i>second revision</i>)
3812:1981	Specification for fly ash for use as pozzolana and admixture (<i>first revision</i>)
4139:1989	Specification for calcium silicate bricks (<i>second revision</i>)
5454:1978	Methods for sampling of clay burnt building bricks (<i>first revision</i>)

3 GENERAL REQUIREMENTS

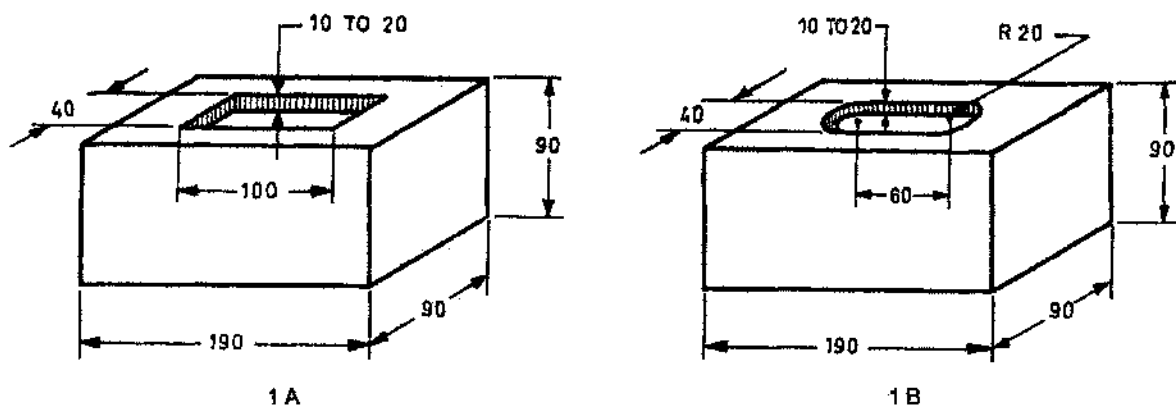
3.1 Visually the bricks shall be sound, compact and uniform in shape. The bricks shall be free from visible cracks, warpage and organic matters.

3.2 The bricks shall be solid and with or without frog 10 to 20 mm deep on one of its flat side. The shape and size of the frog shall conform to either Fig. 1A or Fig. 1B.

3.3 In case of non-modular size of bricks, frog dimensions shall be the same as for modular size bricks.

3.4 Hand-moulded bricks of 90 mm or 70 mm height shall be moulded with a frog 10 to 20 mm deep on one of its flat sides; the shape and size of the frog shall conform to either Fig. 1A or Fig. 1B (see 5.1.1 for *L*, *W* and *H*). Bricks of 40 or 30 mm height as well as those made by extrusion process may not be provided with frogs.

3.5 The bricks shall have smooth rectangular faces with sharp corners and shall be uniform in shape and colour.



All dimensions in millimetres.

FIG. 1 SHAPE AND SIZE OF FROGS IN BRICKS

4 CLASSIFICATION

4.1 Pulverized fuel ash-lime bricks shall be classified on the basis of average wet compressive strength as given in Table 1.

Table 1 Classes of Pulverized Fuel Ash-Lime Bricks

Class Designation	Average Wet Compressive Strength not Less Than	
	N/mm ²	kgf/cm ² (Approx)
(1)	(2)	(3)
30	30.0	(300)
25	25.0	(250)
20	20.0	(200)
17.5	17.5	(175)
15	15.0	(150)
12.5	12.5	(125)
10	10.0	(100)
7.5	7.5	(75)
5	5.0	(50)
3.5	3.5	(35)

5 DIMENSIONS AND TOLERANCES

5.1 Dimensions

5.1.1 The standard modular sizes of pulverized fuel ash-lime bricks shall be as follows (see Fig. 1A and 1B):

Length (L)	Width (W)	Height (H)
mm	mm	mm
190	90	90
190	90	40

5.1.2 The following non-modular sizes of the bricks may also be used (see Fig. 1A and Fig. 1B):

Length (L)	Width (W)	Height (H)
mm	mm	mm
230	110	70
230	110	30

5.1.2.1 For obtaining proper bond arrangement and modular dimensions for the brickwork, with the non-modular sizes, the following sizes of the bricks may also be used:

Length (L)	Width (W)	Height (H)
mm	mm	mm
70	110	70 ¹ / ₃ length brick
230	50	70 ¹ / ₂ width brick

5.2 Tolerances

The dimensions of bricks when tested in accordance with 5.2.1 shall be within the following limits per 20 bricks:

a) For Modular Size

Length 3 720 to 3 880 mm (3 800 ± 80 mm)

Width 1 760 to 1 840 mm (1 800 ± 40 mm)

Height 1 760 to 1 840 mm (1 800 ± 40 mm)

(For 90 mm high bricks)

760 to 840 mm (800 ± 40 mm)

(For 40 mm high bricks)

b) For Non-modular Size

Length 4 520 to 4 680 mm (4 600 ± 80 mm)

Width 2 160 mm to 2 240 (2 200 ± 40 mm)

Height 1 360 mm to 1 440 (1 400 ± 40 mm)

(For 70 mm high bricks)

560 to 640 mm (600 ± 40 mm)

(For 30 mm high bricks)

5.2.1 Twenty (or more according to the size of stack) whole bricks shall be selected at random from the sample selected under 8. All blisters, loose particles of clay and small projections shall be removed. They shall then be arranged upon a level surface successively as indicated in Fig. 2A, 2B and 2C in contact with each other and in a straight line. The overall length of the assembled bricks shall be measured with a steel tape or other suitable inextensible measure sufficiently long to measure the whole row at one stretch. Measurement by repeated application of short rule or measure shall not be permitted. If, for any reason it is found impracticable to measure bricks in one row, the sample may be divided into rows of 10 bricks each which shall be measured separately to the nearest millimetre. All these dimensions shall be added together.

NOTE — By the agreement between the purchaser and the manufacturer pulverized fuel ash-lime bricks may be manufactured in other sizes also. The tolerance requirements of length, width and height shall remain the same as given above.

6 MATERIALS

6.1 Pulverized Fuel Ash (Commonly Known as Fly Ash)

Pulverized fuel ash commonly known as fly ash shall conform to Grade 1 or Grade 2 of IS 3812.

6.2 Bottom Ash

Bottom ash used as replacement of sand shall not have more than 12 percent loss on ignition when tested according to IS 1727.

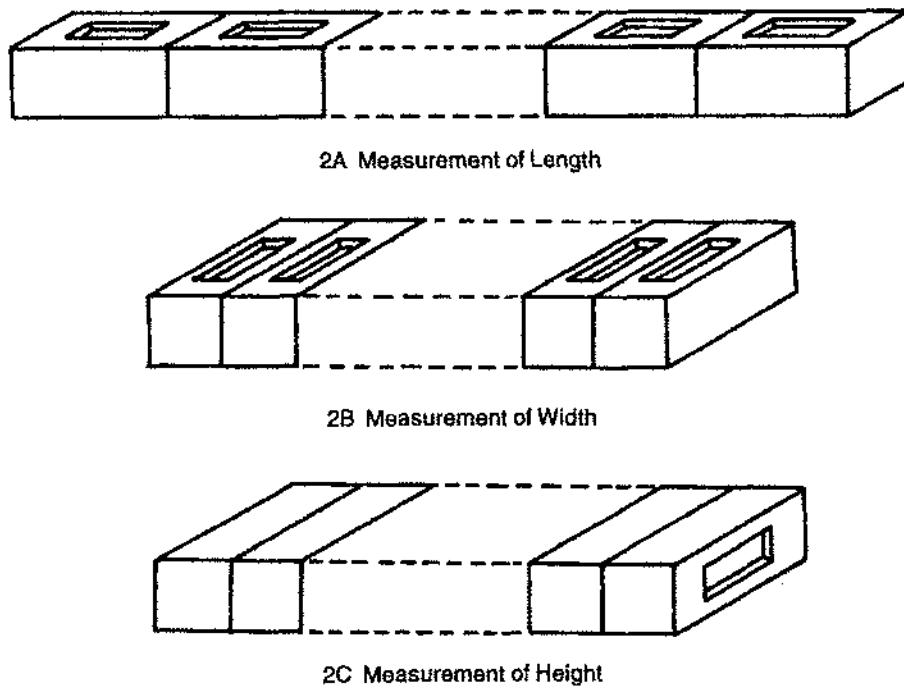


FIG. 2 MEASUREMENT OF TOLERANCES OF COMMON BUILDING BRICKS

6.3 Sand

Deleterious materials, such as clay and silt in sand, shall preferably be less than 5 percent.

6.4 Lime

Lime shall conform to Class C hydrated lime of IS 712.

6.5 Additives

Any suitable additive considered not detrimental to the durability of the bricks such as gypsum, cement, etc, may be used.

7 PHYSICAL CHARACTERISTICS

7.1 Compressive Strength

The minimum average wet compressive strength of pulverized fuel ash-lime bricks shall not be less than the one specified for each class in 4.1 when tested as described in IS 3495 (Part 1). The wet compressive strength of any individual brick shall not fall below the minimum average wet compressive strength specified for the corresponding class of bricks by more than 20 percent.

NOTE — In case any of the test results of wet compressive strength exceed the upper limit for the class, the same shall be limited to the upper limit of the class for the purpose of averaging.

7.2 Drying Shrinkage

The average drying shrinkage of the bricks when tested by the method described in IS 4139, being the average

of three units, shall not exceed 0.15 percent.

7.3 Efflorescence Test

The bricks when tested in accordance with the procedure laid down in IS 3495 (Part 3), shall have the rating of efflorescence not more than 'moderate' up to Class 12.5 and 'slight' for higher classes.

7.4 Water Absorption

The bricks, when tested in accordance with the procedure laid down in IS 3495 (Part 2), after immersion in cold water for 24 h, shall have average water absorption not more than 20 percent by mass up to class 12.5 and 15 percent by mass for higher classes.

8 SAMPLING AND CRITERIA FOR CONFORMITY

8.1 Sampling and criteria for conformity of the bricks shall be as given in IS 5454.

9 MARKING

9.1 Each brick shall be marked in a suitable manner with the manufacturer's identification mark or initials.

9.2 BIS Certification Marking

The bricks may also be marked with the Standard Mark.

9.2.1 The use of the Standard Mark is governed by the provisions of the *Bureau of Indian Standards Act, 1986* and the Rules and Regulations made thereunder. The details of conditions under which the licence for the use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

ANNEX A
(Foreword)

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IS : 9394 1979
(Reaffirmed 2003)

Indian Standard
SPECIFICATION FOR STONE LINTELS

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July 1980

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Indian Standard

SPECIFICATION FOR STONE LINTELS

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(Continued on page 2)

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IS : 9394 - 1979*(Continued from page 1)*

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Indian Standard

SPECIFICATION FOR STONE LINTELS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 20 December 1979, after the draft finalized by the Stones Sectional Committee, had been approved by the Civil Engineering Division Council.

0.2 Lintels are important structural part of a building. Stratified limestones and sandstones which are available more or less in every part of our country, are extensively used for making lintels. The strength of the stone used for lintels, is of considerable importance, and, therefore, due care should be taken while making their selection. This standard has, therefore, been formulated to provide guidance for the selection of suitable stones for the purpose.

0.3 The stone lintels described in this standard are primarily intended for use with doors, windows and ventilators in residential, office and industrial buildings. But their use is not thus restricted.

0.4 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard lays down the requirement for dimensions, physical properties, and workmanship of lintels made out of natural stone.

2. GENERAL REQUIREMENTS

2.1 The stone for the lintels shall be reasonably fine grained, hard and shall have a uniform texture and colour. They shall be free from weathering and decay.

*Rules for rounding off numerical values (revised).

IS : 9394 - 1979

2.2 The stone shall be without any cracks, vents, fissures, clayholes or other similar source of weakness.

2.3 The lintel shall be so cut that when set in the building, the stone is laid on its natural bed or with the bed in the same direction as it was when the test for transverse strength was carried out.

2.4 The stone damaged by blasting, driving edges, heating, etc, shall not be considered as a source of rejection.

3. PHYSICAL PROPERTIES

3.1 The physical properties of the stones used for lintels shall conform to the requirements given in col 3 of Table 1, when tested in accordance with the provisions of Indian Standards given in col 4.

TABLE 1 PHYSICAL PROPERTIES OF THE STONE USED FOR LINTELS

SL No.	CHARACTERISTICS	REQUIREMENTS	METHOD OF TEST (REF TO IS)
(1)	(2)	(3)	(4)
i)	Specific gravity	2.6 <i>Min</i>	IS : 1124-1974*
ii)	Water absorption, percent	1.0 <i>Max</i>	IS : 1124-1974*
iii)	Transverse strength, N/mm ²	11.0 <i>Min</i>	IS : 1121 (Part II)-1974†
iv)	Durability	Shall not develop spalling or cracks	IS : 1126-1974‡

*Method of test for determination of water absorption apparent specific gravity and porosity of natural building stones (*first revision*).

†Method of test for determination of strength properties of natural building stones: Part II Transverse strength.

‡Method of test for determination of durability of natural building stones (*first revision*).

4. DIMENSION AND TOLERANCE

4.1 The stone lintels shall be of rectangular cross-section.

4.2 The width shall be equal to the thickness of the wall and the depth shall not be less than 100 mm. The length shall be limited to a maximum clear span of 2.65 metres.

4.3 A tolerance of ± 1.5 mm shall be allowed on all dimensions of 1.2 m or less and ± 3 mm on all dimensions more than 1.2 m.

4.4 Throating — A 16 x 8 mm throating shall be provided to the soffit of the external lintel as shown in Fig. 1.

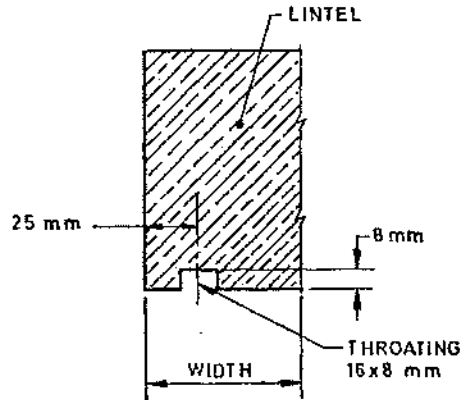


FIG. 1 POSITION AND SIZE OF THROATING

4.5 Lintel Bearing — Stone lintels shall be well bonded into the masonry on either side of the opening. The bearing length on either side shall not be less than the depth of the lintel or half the width of the supporting masonry whichever is more. The bearing length shall be increased for exceptionally heavy loads and for long spans. Bed blocks shall be provided if the clear span exceeds 2m.

5. DESIGN

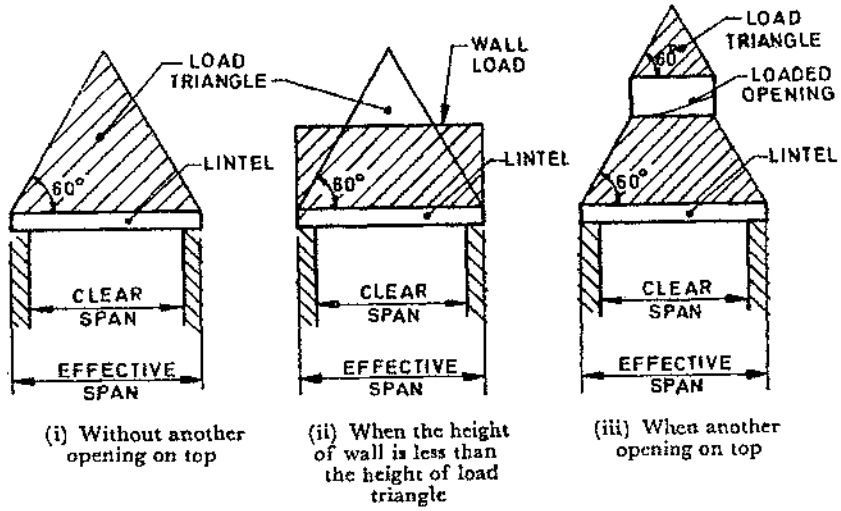
5.1 The stone lintel shall be designed as freely supported at the ends.

5.2 In calculating the required depth of lintels the loading shall be assumed as follows:

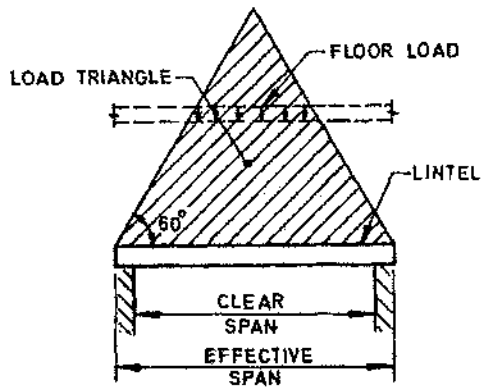
- a) The load of masonry contained in a 60° triangle with the base equal to the effective span as shown in Fig. 2A.
- b) Uniformly distributed floor loads above the equilateral triangle shall be disregarded. However, in case uniformly distributed floor load falls within the triangle, they shall be considered by taking into account only the length of the floor lying inside the triangle as shown in Fig. 2B.
- c) When a concentrated load falls inside the equilateral triangle, the load to be considered is the weight of the triangle as given in (a) or (b) above, plus the concentrated load over the span as shown in Fig. 2C.
- d) When a concentrated load comes over the equilateral triangle, the load to be carried is the weight of the triangle, as given in (a) or (b) above, plus the weight of the concentrated load both acting together as uniformly distributed load over the span as shown in Fig. 2D.

22

IS : 9394 - 1979

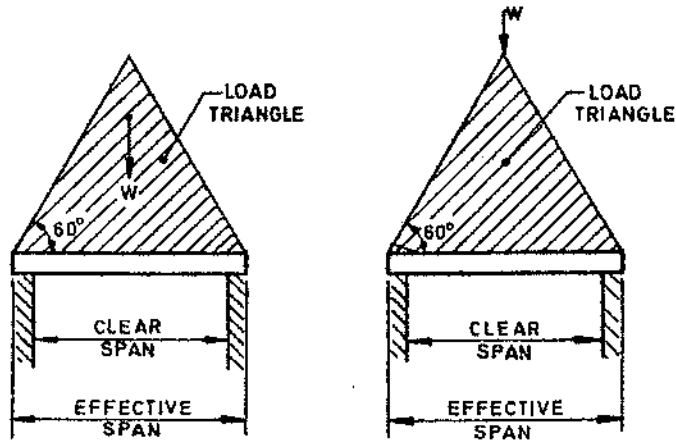


2A When the Floor Load Fall outside the Load Triangle



2B When the Floor Load Fall inside the Load Triangle

FIG. 2 LOADING ON LINTELS (Continued)



2C When a Concentrated Load Falls inside the Load Triangle

$$BM = \left(\frac{WL}{4} + \frac{W_1L}{6} \right)$$

2D When a Concentrated Load comes over the Load Triangle

$$BM = \frac{(W + W_1) L}{6}$$

where

W = Concentrated load

W₁ = Weight due to load triangle

L = Effective span

FIG. 2 LOADING ON LINTELS

6. WORKMANSHIP

6.1 The edges of the stone lintels shall be dressed as per IS : 1129-1972*.

6.2 The exposed surface of the lintel shall be finished as specified.

7. MARKING

7.1 Each stone lintel may be marked in a suitable manner with the manufacturers' identification mark or initials.

8. SAMPLING

8.1 Lot — In any consignment, all the lintels of the same stone group, size and finish shall be grouped together to constitute a lot.

*Recommendation of dressing of natural building stones (first revision).

IS : 9394 - 1979

8.1.1 Samples shall be selected and tested separately for each lot for determining its conformity or otherwise to the requirements of the specification.

8.2 The number of stone lintels to be selected from a lot shall depend upon the size of the lot and shall be in accordance with col 1 and 2 of Table 2.

TABLE 2 SAMPLE SIZE AND CRITERIA FOR CONFORMITY

LOT SIZE	SAMPLE SIZE	PERMISSIBLE NO. OF DEFECTIVES	SUB-SAMPLE SIZE
(1)	(2)	(3)	(4)
Up to 25	3	0	2
26 to 100	5	0	2
101 to 200	8	0	3
201 to 500	13	0	4
501 and above	20	1	5

8.2.1 The lintels in the sample shall be selected at random and in order to ensure the randomness of selection, random number tables may be used (see IS : 4905-1968*).

8.3 All the lintels, selected as per col 2 of Table 2 shall be examined for general requirements (see 2), transverse strength (see 3), dimensions and tolerances (see 4), workmanship (see 6). Any lintel failing in any one or more of the above requirements shall be considered as defective. A lot shall be conforming to these requirements, if the number of defective lintel obtained is not more than the permissible number of defectives given in col 3 of Table 2.

8.4 The lot having been found satisfactory with respect to dimensions, workmanship, general requirements, and transverse strength shall be tested for the remaining physical properties. For this purpose a sub-sample of size given in col 4 of Table 2 shall be selected at random. A lot shall be considered to have satisfied the requirements of the physical properties if none of the lintels tested for these requirements fail in any of these tests.

*Method for random sampling.

IS 13990 : 1994

(Reaffirmed 2005)

भारतीय मानक

पूर्वढली प्रबलित प्लैक एवं जॉईस्ट — विशिष्ट

Indian Standard

**PRECAST REINFORCED CONCRETE PLANKS
AND JOISTS FOR ROOFING AND FLOORING —
SPECIFICATION**

UDC 691.328—413 : 692.4/5

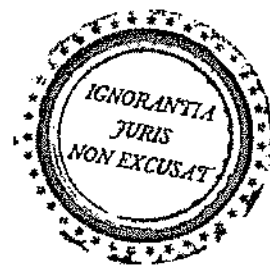
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**BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BHADUR SHAH ZAFAR MARG
NEW DELHI 110002**

August 1994

Price Group 5

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FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Housing Sectional Committee had been approved by the Civil Engineering Division Council.

Considerable shortage of houses in the country, which is also increasing continuously, has led to increasing stress being laid in the development programmes of central and state governments, on facilitating speedy and economical construction of houses. Problem of housing being greatest amongst the lower income groups, both rural and urban, the enormous stress is being laid on housing for these target groups.

This calls for development and standardization of new building materials and construction techniques which are simple and economical, commensurate with structural and hygeinic safety and durability, in order to ensure speedy and economical construction.

This standard is one of the series of standards on new materials and techniques of roof/floor construction which when implemented will result in substantial savings in materials and cost of construction, in addition to achieving speedy construction. The other standards being published in the series are:

- a) Specification for prefabricated brick panel and partially precast concrete joist for flooring and roofing,
- b) Code of practice for design and construction of roofs and floors with prefabricated brick panel,
- c) Specification for precast reinforced concrete channel unit for roofing and flooring,
- d) Code of practice for design and construction of floor and roof with reinforced concrete channel units,
- e) Code of practice for design and construction of floor and roof with reinforced concrete planks and joists,
- f) Specification for precast L-panel units for roofing,
- g) Code of practice for design and construction of roof with L-panel units, and
- h) Code of practice for construction of walls using precast concrete stone masonry blocks.

Precast reinforced concrete planks are partially precast rectangular slab elements which are supported over partially precast RCC joists side by side. These are joined together and also to the joist by pouring *in-situ* concrete over the haunches provided in the planks and the gaps between the planks over the joists. Monolithic action of the slab elements is ensured by leaving stirrups projecting out of joists and providing reinforcement across the joists over haunched portion of planks, tying them together and pouring *in-situ* concrete over it.

Roofs and floor made with precast RC planks are found economical as compared to conventional RC slabs mainly due to the following reasons:

- a) Components used for construction being precast, shuttering is eliminated.
- b) Quality can be controlled better in precast elements.
- c) Moderate size components are used thereby eliminating need for mechanical handling and erection equipment.
- d) Prefabrication leads to substantial reduction in time required for construction.

Considerable assistance has been rendered in the preparation of this standard by the Central Building Research Institute, Roorkee, who has developed this technique.

The Committee responsible for the formulation of this standard is given in Annex B.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (revised)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

PRECAST REINFORCED CONCRETE PLANKS AND JOISTS FOR ROOFING AND FLOORING — SPECIFICATION

1 SCOPE

This standard lays down requirements for precast reinforced concrete planks and joist used for construction of roofs and floors. The planks length up to 1.5 m long only are covered.

2 REFERENCES

The following Indian Standards are necessary adjuncts to this standard:

IS No.	Title
432 (Part 1) : 1982	Mild steel and medium tensile steel bars and hard-drawn steel wire for concrete reinforcement: Part 1 Mild steel and medium tensile steel bars (<i>third revision</i>)
456 : 1978	Code of practice for plain and reinforced concrete (<i>third revision</i>)
4905 : 1968	Methods for random sampling
13994 : 1994	Code of practice for design and construction of floor and roof with precast reinforced concrete planks and joist

3 MATERIALS

3.1 Concrete

Concrete used for making the planks, partially precast joists as also *in-situ* concrete shall conform to grade M15 of IS 456 : 1978. Coarse aggregate used for making concrete shall be well graded with maximum size of 10 mm, while for joist the maximum shall be 20 mm.

3.2 Reinforcement

Steel for reinforcement shall be as recommended in IS 456 : 1978.

4 SHAPES, DIMENSIONS AND TOLERANCES

4.1 Precast Reinforced Concrete Planks

4.1.1 Shape

Shape of the planks shall be rectangular with haunches as shown in Fig. 1. Top surface shall be chequered finish.

4.1.2 Dimensions

4.1.2.1 Width

The width of the planks shall be 300 mm. The dimension of 300 mm has been selected keeping

in view the requirements of modular co-ordination as also to keep the weight of the planks low so as to facilitate manual handling. However to suit to the room size, the width may be suitably changed to up to ± 50 mm.

4.1.2.2 Length

The length of the planks shall be limited to a maximum of 11.5 m. Smaller lengths required for varying room dimensions shall be permitted. However, it is preferable to use lengths in multiple of 300 mm only, keeping in view the requirements of modular co-ordination.

4.1.2.3 Thickness

To achieve monolithicity of roof/floor and to achieve *T*-beam effect with the joists in composite roof/floor made with these planks, the plank shall be made partly 30 mm and partly 60 mm thick as shown in Fig. 1. A 100 mm wide tapered concrete filling shall be provided for strengthening the haunch portion for shear during handling and erection.

Length of the tapered concrete filling at both ends shall be kept 300 mm for all lengths of planks and the length of central 60 mm thick portion shall be decreased for lengths of planks smaller than 1.5 m.

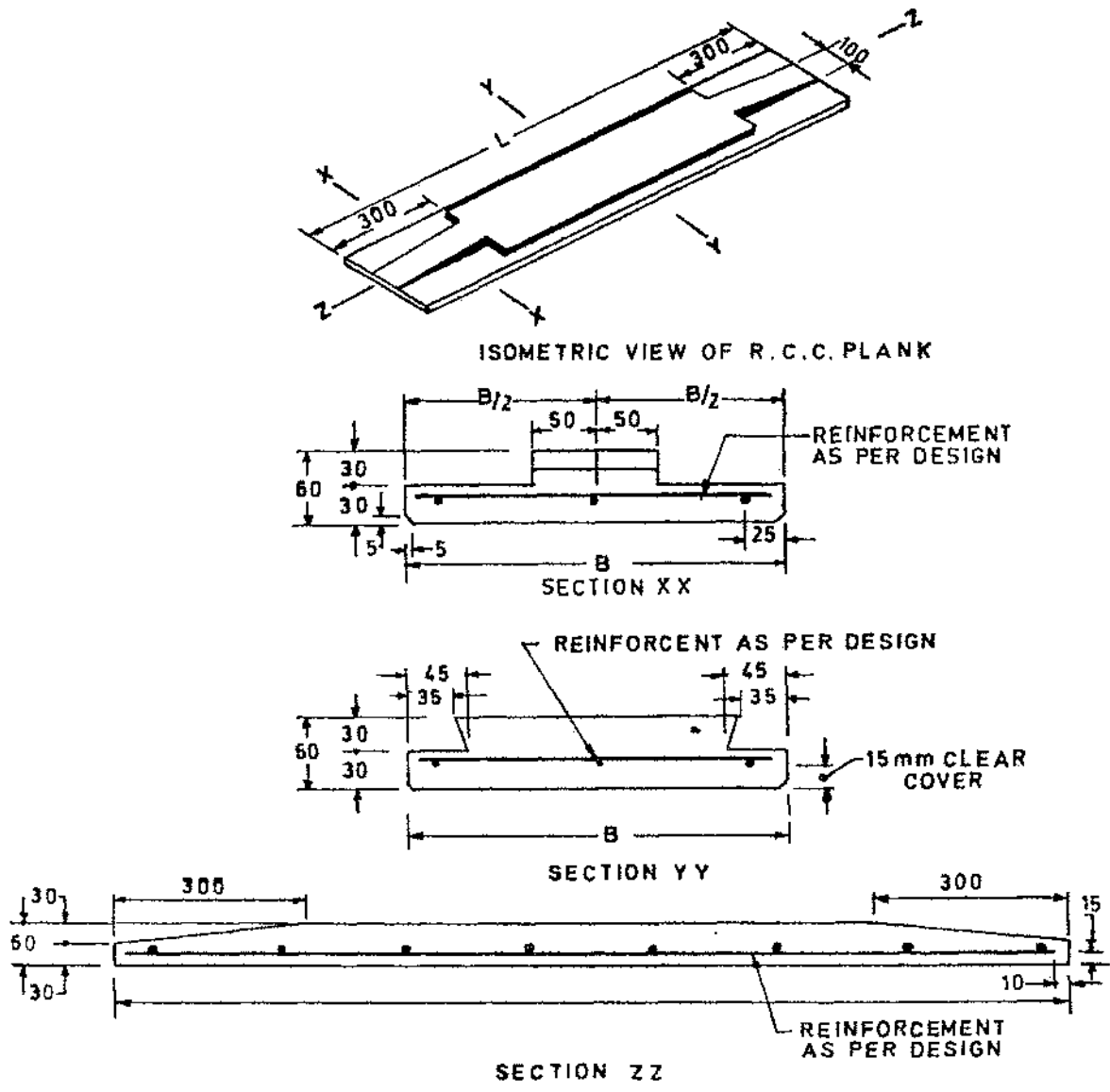
4.2 Partially Precast Joists

The width of precast joists shall be kept equal to required width of web of *T*-beam (*see* IS 13994 : 1994) and the depth shall be kept equal to the required overall depth of *T*-beam less the thickness of flange, that is, the maximum thickness of RC planks (60 mm).

4.3 Tolerances

Casting tolerances on various dimensions of plank shall be as given below:

Dimension	Tolerance
Length	± 5 mm
Width	± 3 mm
Thickness	± 2 mm
Bow (deviation from intended line or plane)	± 2 mm
Twist (distance of any corner from the plane containing other three corners)	1 mm



All dimensions in millimetres.

FIG. 1 PRECAST R.C.C. PLANK

4.3.1 Squareness

The long edge of planks shall be taken as the base line. The shorter side shall not vary in its length from perpendicular distance between long edges by more than 3 mm.

4.3.2 Flatness

The maximum deviation from a 1.5 m straight edge placed in any position on a nominal plane surface shall not exceed 2 mm.

5 DESIGN

5.1 The planks shall be designed as simply supported for self weight including *in-situ* concrete over haunches, and as a continuous slab for a load comprising live load, self weight and dead

load of floor finish and/or water proofing treatment. The design shall be in accordance with the limit state method of IS 456 : 1978.

5.2 Reinforcement

5.2.1 Reinforcement for the planks shall comprise three equally spaced bars of required diameter along the length of planks as main reinforcement. Distribution reinforcement shall be equal to or more than the minimum recommended for slabs in IS 456 : 1978. The main reinforcement shall also fulfil the requirement of maximum permissible spacing given in IS 456 : 1978.

5.2.2 Reinforcement for planks for roofs and floors of residential buildings for spacing of joists at 1.5 m, shall comprise 3 bars of 6 mm of mild steel grade I conforming to IS 432 (Part 1) :

1982 as main reinforcement and 6 mm dia bars, of mild steel grade I conforming to IS 432 (Part 1) : 1982, at 200 mm c/c as transverse reinforcement. In the absence of detailed design same reinforcement may be used for spacing of joist smaller than 1.5 m.

5.2.3 Reinforcement for RCC joist shall be provided as per design (see IS 13994 : 1994).

6 CASTING AND CURING OF PRECAST ELEMENTS

6.1 Precast RC Planks

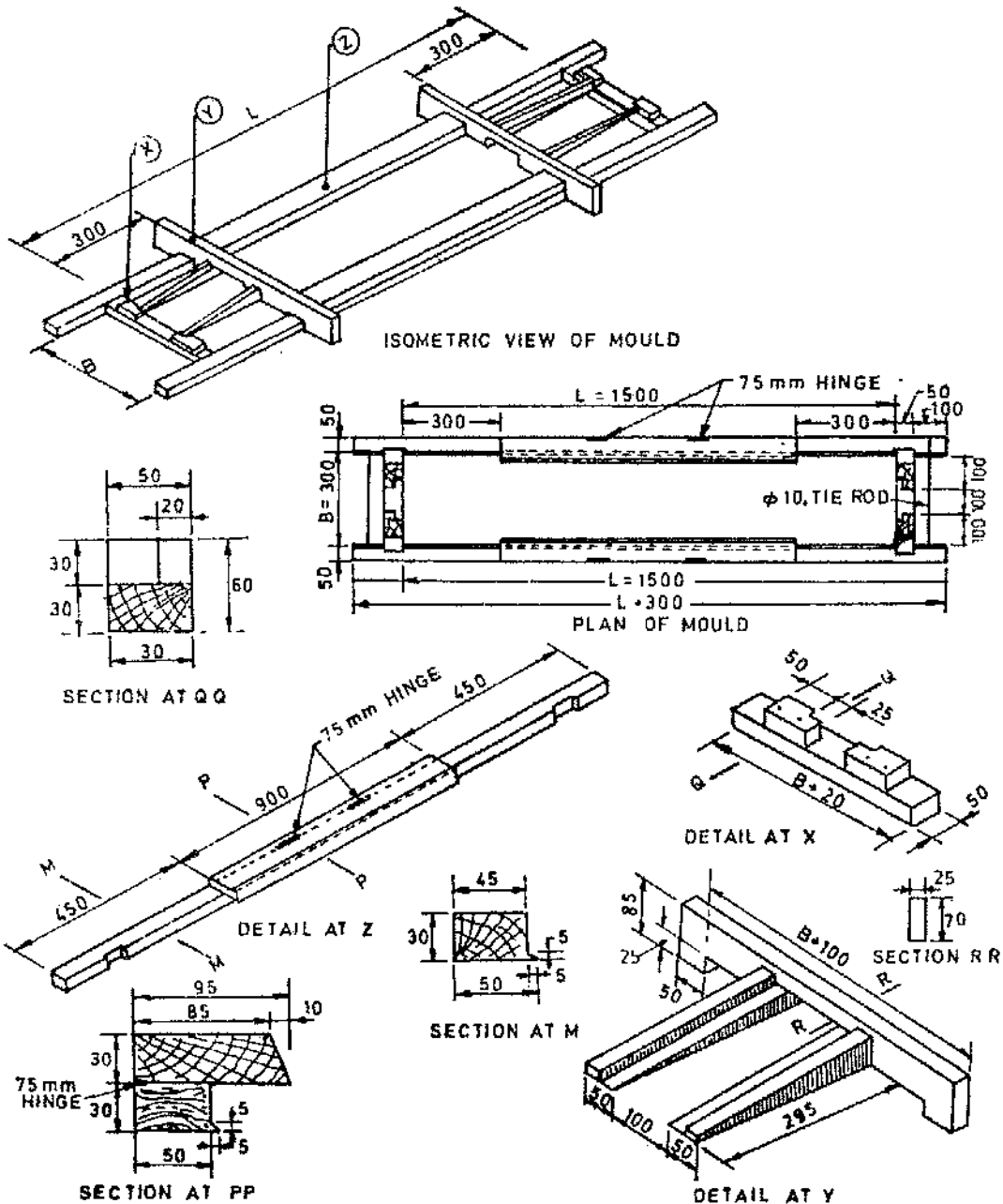
6.1.1 Moulds

Moulds may be generally made from well seasoned

good quality timber or an equivalent wood substitute. However, in case of mass production, steel, plastic or FRP moulds may be used with advantage. Any material used for making moulds shall be rigid, non-absorbant and non-corrodible and shall maintain the dimensions within the specified limits. Typical sketches of timber as well as steel moulds are shown in Fig. 2A and Fig. 2B.

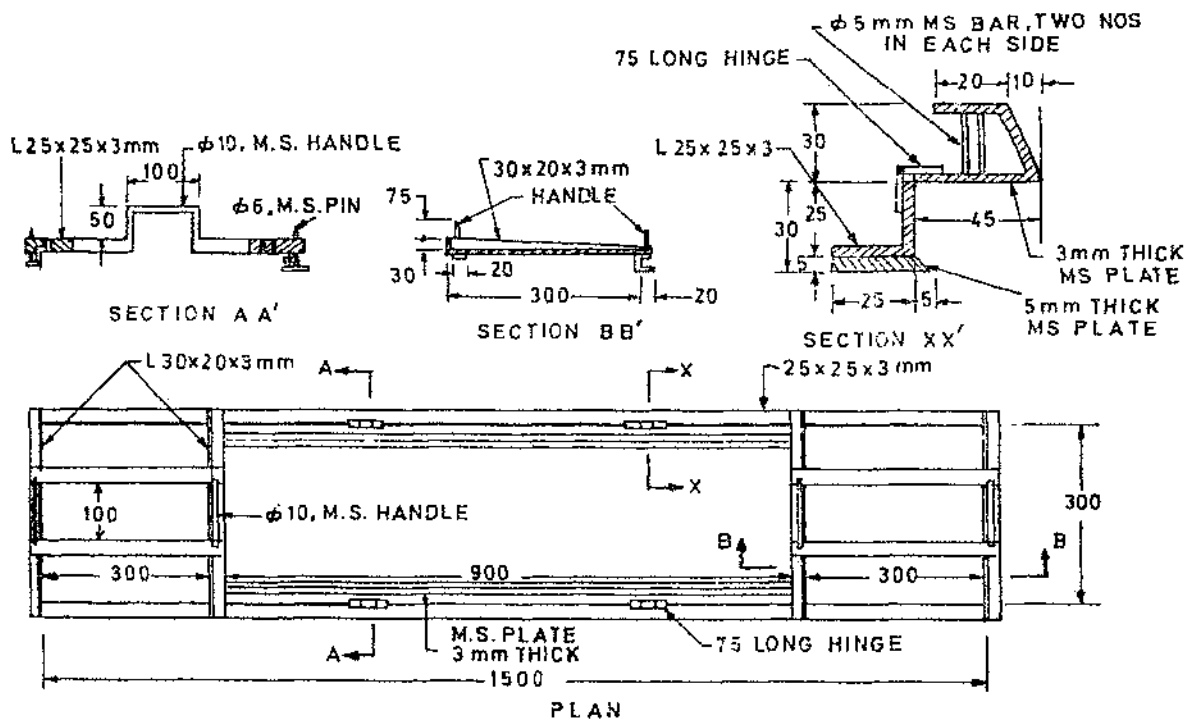
6.1.2 Casting

Inner sides of mould shall be applied with a suitable bond release agent and it shall be kept



All dimensions in millimetres.

FIG. 2A TYPICAL SKETCH OF TIMBER MOULD FOR RC PLANK



All dimensions in millimetres.

FIG. 2B TYPICAL SKETCH OF STEEL MOULD FOR RC PLANK

on a smooth concrete platform coated with the bond release agent. Alternatively wrinkle free old newspaper may be used over the concrete platform. Reinforcement cage shall be placed inside the mould in such a way as to provide a cover of 15 mm. Concrete with well graded aggregate of maximum size 10 mm shall be poured to a depth such that after compaction with a plate vibrator, shall become 30 mm. The upper side of the longitudinal members of the mould and the two tapering members shall be then placed over the mould. Concrete shall then be poured in middle and the sides and compacted with a plate vibrator. Concrete shall be finished level with the mould and the top surface shall be made rough by trowel markings. After about half an hour of casting, the two tapering members may be lifted off. The mould may be stripped off in about 2 hours (depending on the weather). About 24 to 30 hours after casting (depending on the weather), the cast unit shall be first slid by push and then tilted through right angles on long edge. It shall then be transported in vertical position for curing.

6.1.3 Curing

The units shall then be stacked against a vertical support in nearly vertical position and cured for at least two weeks by sprinkling water. It shall further be air-cured for another two weeks before it can be used for construction.

6.2 Partially Precast RC Joists

6.2.1 Moulds

Moulds may be made from the same material as recommended for moulds for planks (see 6.1.1). Typical details of timber and steel moulds are shown in Fig. 3A and 3B.

6.2.1.1 Tolerances on mould dimensions shall be as given below:

Dimension	Tolerance (mm)
Length	± 4 mm
Width	± 2 mm
Depth	± 2 mm

6.2.2 Casting

The mould shall be assembled and bond release agent applied on the inner side. Reinforcement cage with a gap from bottom of 25 mm for cover shall be placed in the mould with the stirrups projecting out as shown in Fig. 4. The top spacer pieces shall be fixed over the mould. Cement concrete with well graded aggregate of 20 mm maximum size shall then be poured in the mould and compacted either with a plate vibrator by placing it on the top of the mould or by inserting a needle

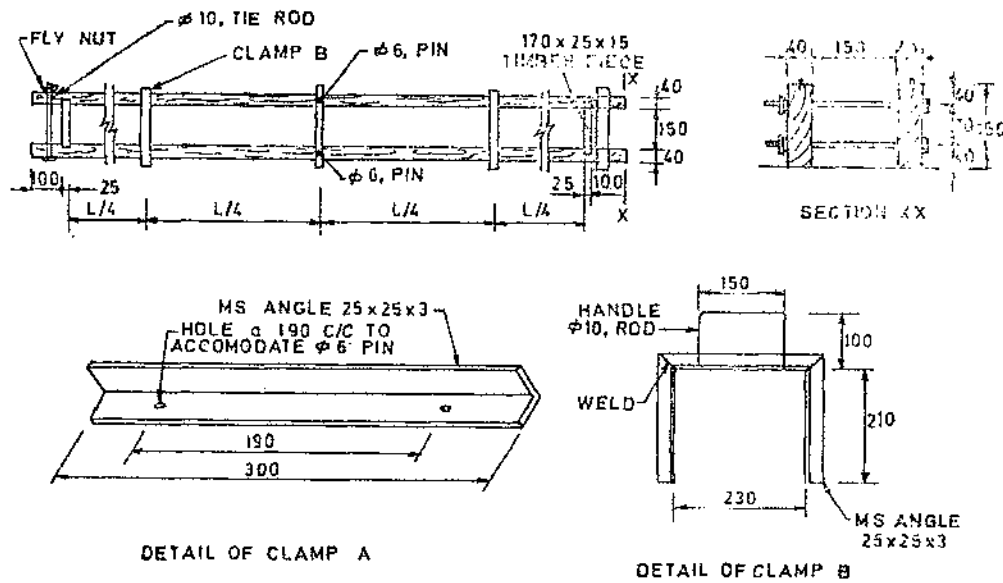


FIG. 3A TYPICAL SKETCH OF TIMBER MOULD FOR PARTIAL PRECAST JOIST

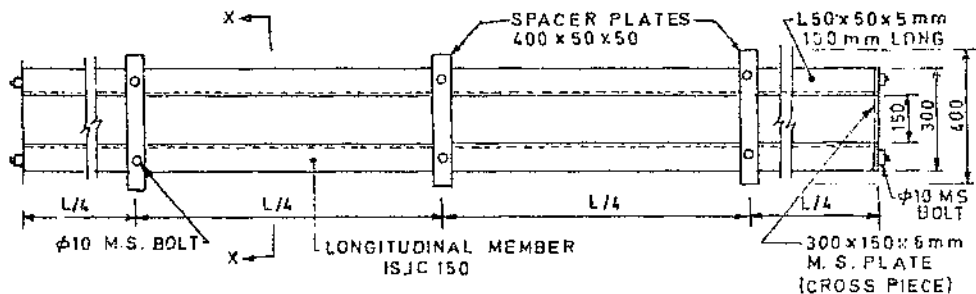
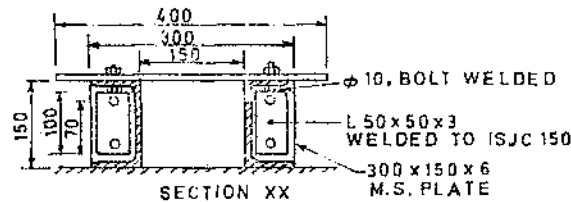


FIG. 3B TYPICAL SKETCH OF STEEL MOULD FOR PRECAST RC JOIST

vibrator. The mould may be stripped after 3 to 4 hours depending on weather. After 48 to 72 hours (depending on weather), the joists shall be first slid by push and then transported to the curing area by holding them near the ends.

6.2.3 Curing

The precast joists shall be water cured for a minimum period of two weeks and air cured further for at least two or more weeks before they can be used for construction.

7 SAMPLING

7.1 All the precast reinforced concrete units of the same size, manufactured from similar condition of productions shall be grouped together to constitute a lot.

7.2 Five units shall be selected at random out of a lot consisting of 300 units or less. For lot bigger than 300 units 5 units shall be selected for every additional 300 units or part thereof. In order to ensure randomness of selection, procedure given in IS 4905 : 1968 may be followed.

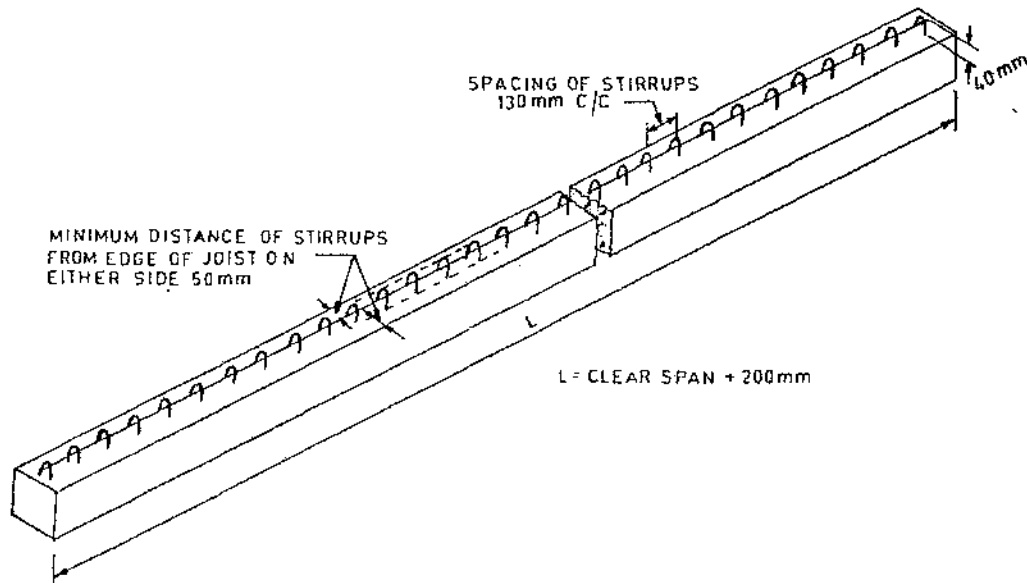


FIG. 4 ILLUSTRATIVE SKETCH OF PARTIALLY PRECAST JOIST

7.3 The samples shall be suitably marked for future identification of the lot it represents.

8 TEST

Tests shall be conducted on samples of the units as given in Annex A.

8.1 Dimensional test and deflection recovery test shall be routine test whereas failure load test shall be a type test. Type test is intended to prove the suitability and performance of a new design and size of a component. Failure load test be applied at the time of design of a component of a particular size or at the time of any change in the design/size.

9 CRITERIA OF CONFORMITY

9.1 If four out of the five samples satisfy the shape and dimensional requirements given in 4, the lot represented by the sample shall be deemed to have passed the dimensional requirements given in 4, otherwise it shall be rejected.

9.2 In the deflection recovery test performed in accordance with Annex A, if the deflection after 24 h of the removal of the imposed load is at least 75 percent of the deflection under the load for 24 h, the units shall be deemed to have passed the test. If the deflection recovery is less than 75 percent the lot represented by the unit shall be rejected. If the maximum deflection in mm, shown during 24 h under load is less than $40 l^2/D$,

where l is the effective span in mm and D , the overall depth of the section in mm, it is not necessary for the deflection recovery to be measured and the recovery provision mentioned in this clause earlier shall not apply

In case of the failure load performed in accordance with Annex A, the unit shall carry a load at least equal to 1.33 times the characteristics load to pass the test. If the load at failure is less than 1.33 times the characteristic load, the lot represented by the sample shall be rejected.

10 MARKING

10.1 Each component shall be legibly and indelibly marked with the following:

- a) Identification of the source of manufacturer, and
- b) Month and year of manufacture.

10.2 BIS Certification Marking

The components may also be marked with Standard Mark.

10.2.1 The use of Standard Mark is governed by the provisions of Bureau of Indian Standards Act, 1986 and the Rules and Regulations made thereunder. The details of conditions under which the licence for the use of Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

ANNEX A
(Clauses 8 and 9)

TEST FOR PRECAST REINFORCED CONCRETE PLANKS AND JOISTS

A-1 AGE OF TESTING

The precast reinforced concrete planks shall be tested at an age of 28 days after *in-situ* concrete has been laid in the haunch portion as mentioned in A-3. Precast joists shall be tested at an age of 28 to 33 days after casting.

A-2 DIMENSIONAL CONFORMITY

5 Samples of planks and joist selected in accordance with 7.2 shall be checked for conformity with the shape and dimensional requirements as given in 4. Length of unit shall be measured with a steel tape at least 5 m long having graduation in mm. Other dimensions shall be measured with 1 m long steel scale having graduation in mm.

A-3 DEFLECTION RECOVERY TEST OF REINFORCED CONCRETE PLANK

A-3.1 One unit selected at random out of the units which have satisfied shape and dimensional requirements shall be subjected to deflection recovery test. The precast units shall be simply supported with a bearing of 50 mm over brickwall finished level and smooth with cement mortar 1 : 4 as shown in Fig. 5. The haunches around the plank shall be filled with M15 concrete using 10 mm and down graded aggregate. The haunch concrete shall be water cured for 14 days. Design dead load other than due to self weight of the unit shall be applied uniformly over the unit through loading blocks or by other means. A dial gauge having least count of 0.02 mm or less and a range of 50 mm or more shall be fixed at mid-span of the units. The dial gauge shall be adjusted to indicate zero reading under self weight of the units and applied dead load.

A-3.2 The plank shall be subjected to a uniformly distributed load equal to 1.25 times the imposed design load, applied through loading blocks of

concrete or steel. Alternatively, uniform load can be applied by hydraulic jacks through a self reacting frame and a set of beam to distribute the load. The load shall be retained for 24 h. After recording deflection at the end of this period, the load shall be removed.

The residual deflection shall be recorded again after twenty-four hours of removal of the load for deflection recovery.

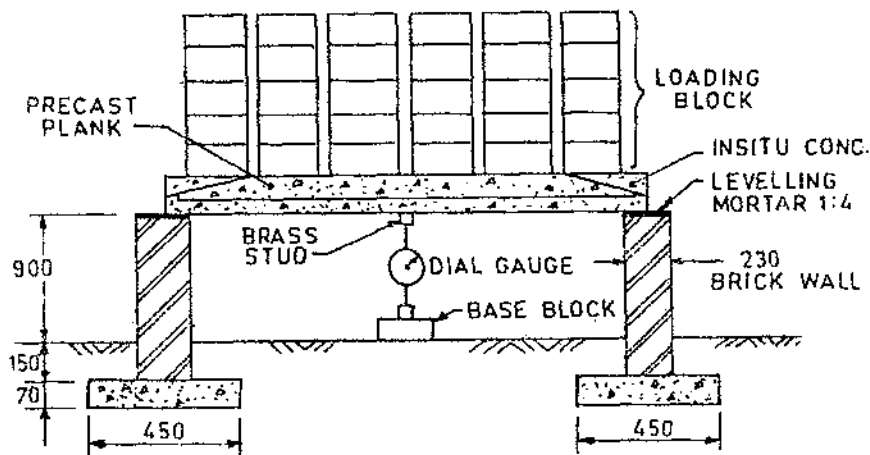
A-4 FAILURE LOAD TEST

A-4.1 The RC plank which has passed the deflection recovery test shall be subjected further to failure load test. Loading shall be done uniformly through loading blocks or through hydraulic jacks and a set of beams to distribute the load. If loading is done through blocks to sufficient gap shall be provided between adjacent tiers of blocks to ensure that they do not touch each other even at the final stages of loading, to prevent transfer of load to supports of units through arch action. Loading shall be preferably done from an independent scaffold as a safety precaution.

A-4.2 The loading shall continue till the plank fails. If no failure occurs by crushing or breaking of the unit, the load causing a deflection equal to 1 in 60 of clear span of the unit shall be considered as the failure load. To check that the limiting deflection is not exceeded, a steel marker shall be fixed below the unit at midspan, leaving a gap of 1 in 60 of clear span before the start of the test.

A-4.3 Load Test for RC Joist

The test shall be done similar to the test for RC planks, except that instead of uniform load, point loads shall be applied at middle third points and the bearing of the joist at each ends shall be 100 mm.



All dimensions in millimetres.

FIG. 5 LOADING TEST

ANNEX B

(Foreword)

COMMITTEE COMPOSITION

Composition of Housing Sectional Committee, CED 51

<i>Chairman</i>	<i>Representing</i>
DR P. S. A. SUNDARAM	Ministry of Urban Development, New Delhi
<i>Members</i>	
SHRI G. R. AMBANI	Municipal Corporation of Delhi, Delhi
SHRI ARUNAR RAY	The Action Research Unit, New Delhi
PROF H. P. BAHARI	School of Planning and Architect, New Delhi
PROF SUBIR SAHA (Alternate)	
SHRI K. K. BHATTANAGAR	Housing and Urban Development Corporation, New Delhi
SHRI M. N. JOGLEKAR (Alternate)	
SHRI H. U. B. JANI	In Personal Capacity (1, Sadhna Enclave, Panchsheel Park, New Delhi 110017)
SHRI S. N. CHATTERJEE	Calcutta Municipal Corporation, Calcutta
CHIEF ARCHITECT	Central Public Works Department, New Delhi
SENIOR ARCHITECT (H & TP) I (Alternate)	
CHIEF ENGINEER, AUTHORITY	Maharashtra Housing and Area Development Authority, Bombay
ARCHITECT, AUTHORITY (Alternate)	
CHIEF ENGINEER (D)	Central Public Works Department, New Delhi
SUPERINTENDING ENGINEER (D) (Alternate)	
ENGINEER MEMBER, DDA	Delhi Development Authority, New Delhi
SHRI Y. K. GARG	National Housing Bank, New Delhi
SHRI CHITAN VAIDYA (Alternate)	
SHRI O. P. GARYALI	National Council for Cement and Building Materials, New Delhi
DR N. K. JAIN (Alternate)	
SHRI T. N. GUPTA	Building Materials and Technology Promotion Council, New Delhi
SHRI HARINDER SINGH	Public Works Department, Government of Rajasthan, Jaipur
SHRI R. N. AGARWAL (Alternate)	
DR K. S. JAGDISH	Centre for Application of Science and Technology to Rural Area (ASTRA), Bangalore
DR B. V. VENKATARAMAN REDDY (Alternate)	
SHRI N. N. JAYDEKAR	CIDCO, Maharashtra
SHRI P. M. DESHPANDE (Alternate)	
SHRI T. P. KALIAPPAN	Tamil Nadu Slum Clearance Board, Madras
SHRI J. BHUVANESHWARAN (Alternate)	
MISS NINA KAPOOR	The Mud Village Society, New Delhi
SHRI A. K. M. KARIM	Housing Department, Government of Meghalaya, Shillong
SHRI K. R. S. KRISHNAN	Department of Science and Technology (DST), New Delhi
SHRI RAJA SINGH	IRCON, New Delhi
SHRI S. SELVANTHAN (Alternate)	
DR A. G. MADHAVA RAO	Structural Engineering Research Centre (CSIR), Madras
SHRI I. K. MANI (Alternate)	
COL D. V. PADMALOKAR	B. G. Shirke and Co, Pune
SHRI T. K. SARA	Engineer-in-Chief's Branch, New Delhi
SHRI R. K. MITTAL (Alternate)	
SHRI J. S. SHARMA	Central Building Research Institute, Roorkee
SHRI B. B. GARG (Alternate)	
SHRI J. VENKATARAMAN,	Director General, BIS (Ex-officio Member)
Director (Civil Engg)	
<i>Member Secretary</i>	
SHRI J. K. PRASAD	
Joint Director (Civil Engg), BIS	

(Continued on page 9)

(Continued from page 8)

Composition of the Panel for Modular Coordination and Prefabrication for Mass Scale Housing, GED 51 : P2

<i>Convener</i>	<i>Representing</i>
SHRI T. N. GUPTA	Ministry of Urban Development, New Delhi
<i>Members</i>	
SHRI Y. K. GARG	National Housing Bank, New Delhi
SHRI SUNIL BERY (Alternate)	Housing and Urban Development Corporation, New Delhi
SHRI M. N. JOGLEKAR	School of Planning and Architects, New Delhi
PROF V. P. RAORI	National Building Construction Corporation, New Delhi
PROF P. K. CHAUDHARY (Alternate)	B. G. Shirke and Co, Pune
SHRI G. S. RAO	Structural Engineering Research Centre, Madras
REPRESENTATIVE	Hindustan Prefab Ltd, New Delhi
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SHRI K. MANI (Alternate)	Central Public Works Department
SHRI S. ROY	
SHRI M. KUNDU (Alternate)	
SHRI J. S. SHARMA	
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(Reaffirmed 2005)

भारतीय मानक

फर्श एवं छत बनाने के लिए पूर्व निर्मित ईंट पैनल एवं आंशिक
पूर्व ढलित जॉइस्ट — विशिष्टि

Indian Standard

**PREFABRICATED BRICK PANEL AND
PARTIALLY PRECAST CONCRETE
JOIST FOR FLOORING AND ROOFING —
SPECIFICATION**

UDC 691'328-413 : 692'4

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**BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002**

November 1994

Price Group 2

Housing Sectional Committee, CED 51

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Housing Sectional Committee had been approved by the Civil Engineering Division Council.

Considerable shortage of houses in the country, which is also increasing continuously, has led to increasing stress being laid in the development programmes of central and state governments, for facilitating speedy and economical construction of houses. Problem of housing being enormous amongst the lower income groups, both rural and urban, the maximum stress is being laid on housing for these target groups.

This standard is one of a series of standards on new materials and techniques of roof/floor construction, which when implemented, is likely to result in substantial savings in material and cost of construction, in addition to achieving speedy construction. The other standards being published in the series are:

- a) Design and construction of roofs and floors with prefabricated brick panel — Code of practice
- b) Precast reinforced concrete channel unit for construction of floors and roofs — Specification
- c) Design and construction of floors and roofs with precast reinforced channel units — Code of practice
- d) Precast reinforced concrete planks and joists for flooring and roofing — Specification
- e) Design and construction of floor and roof with precast reinforced concrete planks — Code of practice
- f) Precast reinforced concrete L-panel for roofing — Specification
- g) Design and construction of roofs using precast reinforced concrete L-panel — Code of practice

The use of reinforced brick roofs had been quite common in Northern parts of India. Its design was based on the crushing strength of brick. The large variation in crushing strength of bricks had, however, inhibited their use and raised doubts about the feasibility and performance of reinforced brick roofing/flooring slab. Further, the corrosion of reinforcement due to contact between mild steel bars and bricks caused reduction in the life of roof. Also, the crushing strength of bricks usually being low, the thickness of slab increases causing an increase in dead load too.

The Central Building Research Institute, Roorkee has developed prefab brick panel system which is a combination of concrete, bricks and reinforcement such that concrete is used in the zone of maximum compressive stresses thereby permitting the use of lower compressive strength bricks and T-beam action develops between partially precast joist and the *in-situ* concrete.

The Committee responsible for the formulation of this standard is given in Annex A.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

PREFABRICATED BRICK PANEL AND PARTIALLY PRECAST CONCRETE JOIST FOR FLOORING AND ROOFING — SPECIFICATION

1 SCOPE

This standard lays down requirements for prefabricated brick panel and partially precast joist for flooring and roofing.

2 REFERENCES

The Indian Standards listed below are necessary adjuncts to this standard:

IS No.	Title
432 (Part 1) : 1982	Specification for mild steel and medium tensile steel bars and hard-drawn steel wire for concrete reinforcement : Part 1 Mild steel and medium tensile steel bars (<i>third revision</i>)
456 : 1978	Code of practice for plain and reinforced concrete (<i>third revision</i>)
1077 : 1991	Specification for common burnt clay building bricks (<i>fifth revision</i>)
2180 : 1988	Specification for heavy duty burnt clay building bricks (<i>third revision</i>)
4905 : 1968	Methods for random sampling
12894 : 1990	Specification for fly ash lime bricks
13757 : 1993	Specification for burnt clay fly ash building bricks
14142 : 1994	Code of practice for design and construction of roofs and floors with prefabricated brick panel

3 MATERIALS

3.1 Concrete

The concrete used for making prefabricated brick panels and joists shall conform to grade M-15 of IS 456 : 1978. Coarse aggregate used for making concrete shall be well graded with maximum size of 12 mm for brick panels and well graded with maximum size of 20 mm for joist.

3.2 Reinforcement

The reinforcing steel as recommended in IS 456 : 1978 shall be used.

3.3 Bricks

Bricks used for making prefabricated panels shall conform to IS 1077 : 1991 or IS 12894 : 1990 or IS 13757 : 1993. Bricks of higher strength conforming to IS 2180 : 1988 may also be used.

4 DIMENSIONS AND TOLERANCES

4.1 Prefabricated Brick Panel (*see Fig. 1*)

4.1.1 Length

Length of panel shall not exceed 1.1 m for bricks having strength less than 40 N/mm². For bricks having strength more than 40 N/mm² conforming to IS 2180 : 1988 the length of panel shall not exceed 1.2 m. From economic point of view, the minimum recommended length of panel is 0.9 m. Thickness of transverse joints may be varied within the range specified in 4.3.2 for varying the length.

4.1.2 Width

Width of the panel shall be 53 cm for panels made of conventional size (230 mm × 110 mm × 75 mm) bricks and 45 cm for panels made of modular size (190 mm × 90 mm × 90 mm) bricks.

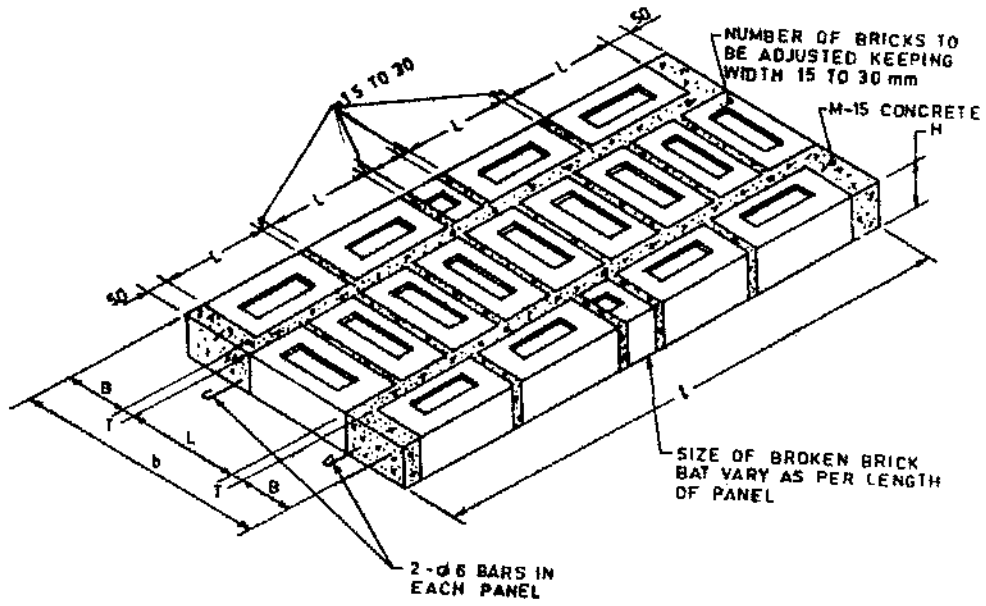
4.1.3 Thickness

Thickness of the panel shall be equal to thickness of a brick, that is, 75 mm for conventional size bricks and 90 mm for modular size bricks.

4.2 Partially Precast Joist

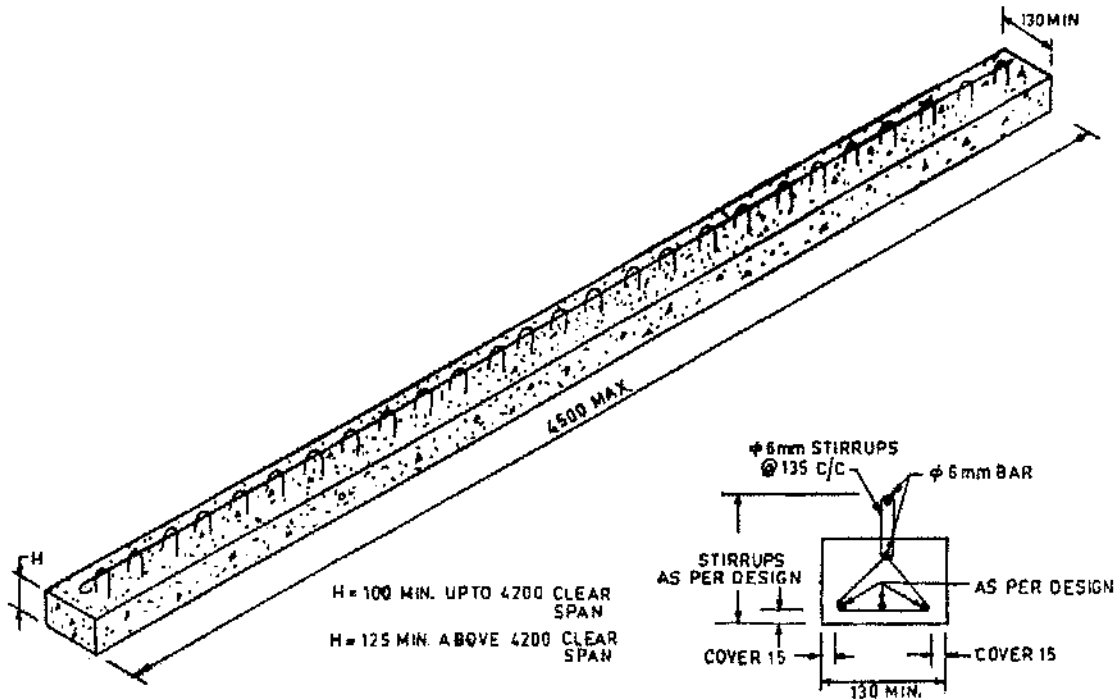
4.2.1 Shape

Partially precast joist shall be rectangular in shape with steel stirrups kept projecting out which shall be tied with reinforcement along the joist to achieve monolithicity with concrete (*see Fig. 2*).



All dimensions in millimetres.

FIG. 1 ISOMETRIC VIEW OF PREFAB BRICK PANEL



All dimensions in millimetres.

FIG. 2 TYPICAL PARTIALLY PRECAST JOIST

4.2.2 Width

Width of partially precast joists shall be sufficient to support two successive spans of brick panels with sufficient bearing, leaving an adequate gap between them. The minimum recommended width is 13 cm, which may be increased if required for structural strength.

4.2.3 Depth

The recommended depth for precast joist, for clear span of joist up to 4.2 m shall be 100 mm for both conventional and modular size bricks. Accordingly overall depth of joist with *in-situ* concrete of 35 mm shall be 210 mm for conventional bricks and 225 mm for modular bricks.

4.3 Thickness of Joints

4.3.1 Longitudinal Joints

Thickness of longitudinal joints shall be 40 mm to accommodate one 6-mm reinforcing bar with adequate cover (see Fig. 1). However, the thickness of joints may vary to compensate for variation in brick dimensions, so that specified panel dimensions remain the same.

4.3.2 Transverse Joints

Thickness of transverse joints shall vary from a minimum of 15 mm to a maximum of 30 mm. However in a single panel unit, this shall be kept uniform for all transverse joints. The range of 15 mm to 30 mm has been permitted to facilitate variation in panel length, using same number of bricks to suit room dimensions.

4.4 Tolerances

Tolerances on various dimensions of the panel shall be as given below:

Dimension	Tolerance
Length of panel	± 10 mm
Width of panel	± 5 mm
Thickness of panel	± 4 mm

NOTE — Recommended dimensions of the panel have been decided so that the panels are light enough to be handled manually and are safe structurally and economical. Dimensions other than those recommended, if required, shall be designed as per 5 and tested as per 8.

5 REINFORCEMENT

5.1 Reinforcement required for brick panel shall be provided as per design along the length. This shall consist of 2 bars of required diameter embedded in the longitudinal joints as shown in Fig. 1.

5.1.1 For span and dimensions of brick panels covered in this standard a reinforcement with two mild steel Grade I bars of 6 mm conforming

to IS 432 (Part 1) : 1982 may be used in residential building without needing calculations.

5.1.2 Reinforcement for RC joist shall be provided as per design (see IS 14142 : 1994).

5.2 Cover to Reinforcement

A minimum clear cover of 15 mm shall be provided to reinforcement in the panel while for the joist the minimum clear cover shall be 25 mm.

6 MANUFACTURE OF PRECAST ELEMENTS

6.1 Prefabricated Brick Panel

6.1.1 Mould

The moulds should generally be made from well-seasoned good quality timber or an equivalent wood substitute. In case of mass production, mild steel or other rigid, non-absorbant and non-corrodible materials such as FRP may be used with advantage.

6.1.2 Casting

The moulds which are open at bottom shall be kept on a levelled ground having thin layer of sand or *pucca* floor or platform. The bricks shall be properly wetted and arranged in the mould with outermost bricks touching the sides of mould and the specified gaps for joints shall be left between bricks. For breaking (staggering) transverse joints, broken brick bats may be used as shown in Fig. 2. The frogs of the bricks shall face upward to provide shear key to deck concrete (*in-situ* concrete). About 15 mm thick layer of concrete or 1 : 3 cement coarse sand mortar shall then be placed in the longitudinal gaps between the bricks and two reinforcing bars shall be placed over it. All the gaps between the bricks shall then be filled with concrete or mortar. The mould may be removed just after casting.

6.1.3 Curing

The panel shall be cured for at least 14 days by sprinkling water and dried for 14 days thereafter, before it is used for construction.

6.2 Partially Precast Joist

6.2.1 Mould

The mould should generally be made of well seasoned good quality timber or an equivalent wood substitute. In case of mass production, use of mild steel or other rigid, non-absorbant, non-corrodible materials such as FRP may be advantageous.

6.2.2 Casting

Mould shall be placed on a smooth and levelled surface and a 25 mm thick layer of concrete shall be laid in the mould. The reinforcement cage shall then be placed in the mould over the concrete layer. The concrete shall be poured in the mould and compacted well by vibration. The mould may be stripped off after about 2 to 3 h (depending upon weather) after casting.

6.3 Tolerances on dimensions of moulds shall be as given below:

<i>Dimension</i>	<i>Tolerance</i>
Length	±8 mm
Width	±3 mm
Depth	±3 mm

6.4 Curing

The panel and joists shall be water-cured for a minimum of 2 weeks followed by air-curing for another 2 weeks before using them in construction.

7 SAMPLING

7.1 All prefabricated brick panels and joists of the same size manufactured from similar materials and under similar conditions of production shall be grouped together to constitute the lot.

7.2 Five units of prefabricated brick panel and joist shall be selected at random out of a lot consisting of 300 units or less. For a lot bigger than 300 units, 5 units shall be selected for every 300 units or part thereof. In order to ensure randomness of selection, procedure given in IS 4905 : 1968 may be followed.

7.3 The samples shall be suitably marked for future identification of the lot it represents.

8 TESTS

Tests shall be conducted on samples of the units as given in Annex B.

8.1 Dimensional test and deflection recovery test shall be routine tests whereas failure load test shall be a type test. Type test is intended to prove the suitability and performance of a new design and size of a component. Failure

load test is applied at the time of any change in the design/size.

9 CRITERIA FOR CONFORMITY

9.1 If four out of five samples satisfy the shape and dimensional requirements given in 4, the lot represented by the sample shall be deemed to have passed the dimensional requirements. If more than one panel fails to satisfy the dimensional requirements given in 4.1.1 to 4.1.3, the lot represented by sample shall be rejected.

9.2 In the deflection recovery test as per Annex B, if the deflection 24 h after the removal of imposed load is at least 75 percent of the deflection under the load for 24 h, the units shall be deemed to have passed the test. If the deflection recovery is less than 75 percent, the lot represented by the unit shall be rejected. If the maximum deflection in mm, shown during 24 h under load is $40 l^2/D$, where l is the effective span in mm and D , the overall depth of the section in mm, it is not necessary for deflection recovery to be measured and the recovery provision mentioned in this clause earlier shall not apply.

9.3 In the case of the failure load performed in accordance with Annex B, the unit shall carry a load at least equal to 1.33 times the characteristic load to pass the test. If the load at failure is less than 1.33 times the characteristic load, the load represented by the sample shall be rejected.

10 MARKING

10.1 Each component shall be legibly and indelibly marked with the following:

- Identification of the source of manufacture, and
- Month and year of manufacture.

10.2 BIS Certification Marking

The product may also be marked with the Standard Mark.

10.2.1 The use of the Standard Mark is governed by the provisions of Bureau of Indian Standards Act, 1986 and the Rules and Regulations made thereunder. The details of the conditions under which the licence for the use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

ANNEX A

(Foreword)

COMMITTEE COMPOSITION

Housing Sectional Committee, CED 51

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Sr ARCHITECT (H & TP-1)	
(<i>Alternate</i>)	
CHIEF ENGINEER, AUTHORITY	Maharashtra Housing and Area Development Authority, Bombay
ARCHITECT, AUTHORITY (<i>Alternate</i>)	
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SUPERINTENDING ENGINEER (D)	
(<i>Alternate</i>)	
ENGINEER MEMBER, DDA	Delhi Development Authority, New Delhi
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SHRI CHETAN VAIDYA (<i>Alternate</i>)	
SHRI O. P. GARYALI	National Council for Cement and Building Materials, New Delhi
DR N. K. JAIN (<i>Alternate</i>)	
SHRI T. N. GUPTA	Building Materials and Technology Promotion Council, New Delhi
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SHRI P. M. DESHPANDE (<i>Alternate</i>)	Tamil Nadu Slum Clearance Board, Government of Tamil Nadu, Madras
SHRI T. P. KALIAPPAN	The Mud Village Society, New Delhi
SHRI J. BHUVANESWARAN (<i>Alternate</i>)	Housing Department, Government of Meghalaya, Shillong
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Director (Civ Engg)	
<i>Member Secretary</i>	
SHRI J. K. PRASAD	
Joint Director (Civ Engg), BIS	

Panel for Modular Coordination and Prefabrication for Mass Scale Housing, CED 51 : P2

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SUPERINTENDING ENGINEER (D)	Central Public Works Department, New Delhi
EXECUTIVE ENGINEER (HQ) (<i>Alternate</i>)	

ANNEX B

(Clauses 8, 9.2 and 9.3)

TESTS FOR PREFABRICATED BRICK PANEL

B-1 AGE OF TESTING

The prefabricated brick panel and joist shall be tested as soon as possible after expiry of 28 days from the time of casting. Precast joist shall be tested at an age of 28 to 33 days after casting.

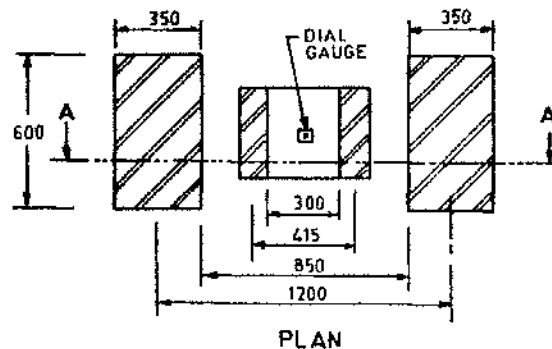
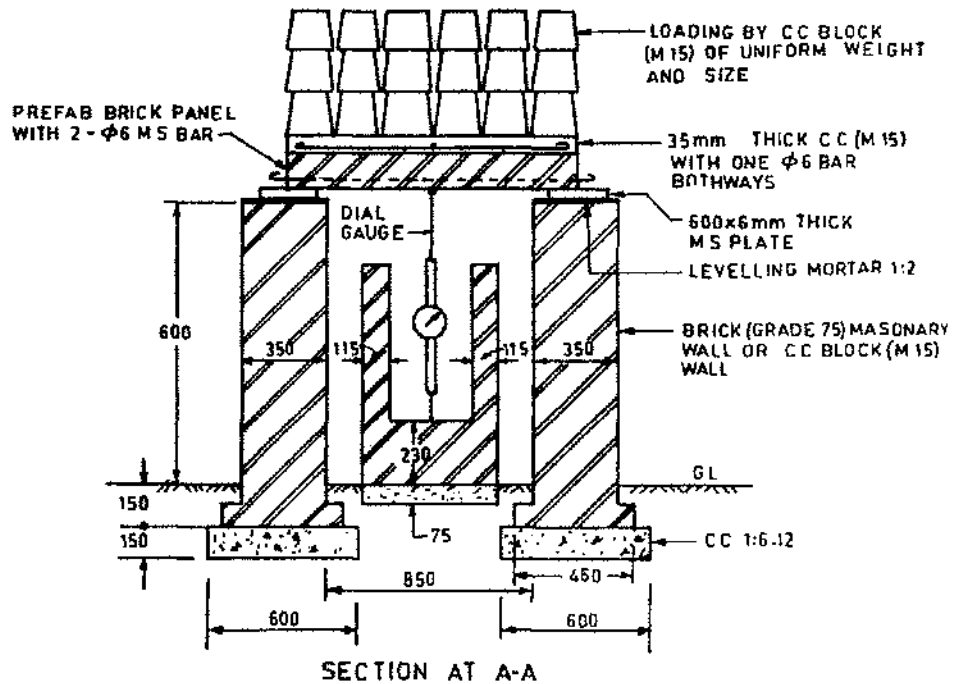
B-2 DIMENSIONAL CONFORMITY

Five samples of prefabricated brick panel and joist selected in accordance with 7.2 shall be checked for conformity with the shape and dimensional requirements as given in 4. Length of the

unit shall be measured with a steel tape at least 5 m long having graduation in mm. Other dimensions shall be measured with 1 m long steel scale having graduation in mm

B-3 DEFLECTION RECOVERY TEST

B-3.1 One panel selected at random out of panels which have satisfied dimensional requirements as per 9.1 shall be subjected to deflection recovery test. The panel shall be simply supported with a bearing of 40 mm on either end of the panel over a concrete/brick walls with 6 mm thick M. S. steel plate fixed in level at top of the walls as shown in Fig. 3.



All dimensions in millimetres.

FIG. 3 A TYPICAL LOAD TEST SETUP

Distribution/temperature reinforcement in the form of one 6-mm mild steel Grade I bar conforming to IS 432 (Part 1) : 1982 shall be laid parallel and perpendicular to the length of the panel. Cement concrete (M 15) 3.5 cm thick shall be laid over the panel and it shall be cured by sprinkling water for 14 days and dried for 14 days thereafter, before testing. A dial gauge having a least count of 0.02 mm or less and a range of 50 mm or more shall be fixed at mid span of the panel. The dial gauge shall be adjusted to indicate zero reading under self weight of the panel and applied dead load. Design dead load other than due to self weight of the unit shall be applied uniformly over the panel through loading blocks or by other means.

B-3.2 The panel shall be subjected to a uniformly distributed load equal to 1.25 times the imposed designed load, applied through loading blocks of concrete or steel. Alternatively uniform load may be applied by hydraulic jacks through a self reacting frame and a set of beams to distribute the load. The load shall be retained for 24 h and after recording deflection at the end of this period, the load shall be removed without disturbing the dial gauge.

The residual deflection shall be recorded again after 24 h of the removal of the load for deflection recovery.

B-4 FAILURE LOAD TEST

B-4.1 The prefabricated brick panel, which has

passed the deflection recovery test shall be further subjected to failure load. Loading shall be done uniformly through loading blocks or through hydraulic jacks and a set of beams to distribute the load.

If loading is done through blocks/bricks, sufficient gap shall be left between adjacent blocks/bricks to ensure that they do not touch each other even at the final stage of loading, to prevent transfer of load to supports of the panels through arch action. The loading shall preferably be done by making an independent scaffolding to provide safety to the labourers.

B-4.2 The loading shall continue till the panel fails. If no failure occurs by crushing or breaking of unit, the load causing a deflection equal to 1/60th of clear span of the panel shall be considered as the failure load. To check that the limiting deflection is not exceeded, a steel marker shall be fixed below the panel at mid span, leaving a gap of 1/60th of clear span, before the start of the test.

B-5 LOAD TEST FOR PARTIALLY PRECAST R. C. JOIST

The test shall be done similar to the test for prefabricated brick panel, except that instead of uniform load, two point loads shall be applied at middle third points.

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Amendments Issued Since Publication

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भारतीय मानक
संरचनात्मक प्रयोजनों के लिए बाँस का संरक्षण — रीति संहिता
(पहला पुनरीक्षण)

Indian Standard

PRESERVATION OF BAMBOO FOR
STRUCTURAL PURPOSES — CODE OF PRACTICE
(*First Revision*)

ICS 71.100.50; 79.020

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April 2006

Price Group 2

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Timber and Timbers Stores Sectional Committee had been approved by the Civil Engineering Division Council.

Bamboo which occupy a prominent place in every day life, is used for structural purposes like posts, pole fencing, scaffoldings, house buildings, etc. Bamboo compares favourably with such timber as 'sal' and 'teak' in strength properties. But bamboo has low natural durability (1 to 3 years) against attacks by fungi and insects. They are very difficult to be treated by normal preservative methods in dry condition since their outer and to some extent inner membranes are impermeable to liquids. The treatment of bamboo is, therefore, best carried out in green condition.

The standard was first published in 1979. This revision is based on experience gained since publication of the standard. In this revision, preservatives such as copper-chrome-zinc-arsenic composition and chromated zinc chloride have been deleted. Copper-chrome-zinc-arsenic (CCZA) composition has been deleted as it is similar to copper-chrome-arsenic (CCA) composition and additional zinc will not have any difference in toxicity. Chromated zinc chloride has been deleted as zinc has a lower toxicity than copper. Zinc chloride being hygroscopic, any unreacted salt in wood causes sweating of treated bamboo products. Further, the recommended practice with regard to preservatives, their concentration, absorption and methods of treatment for various structural uses have also been redefined.

In the formulation of this standard due weightage has been given to international co-ordination among the standards and practices prevailing in different countries in addition to relating it to the practices in the field in this country.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (revised)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

PRESERVATION OF BAMBOO FOR STRUCTURAL PURPOSES — CODE OF PRACTICE

(First Revision)

1 SCOPE

1.1 This standard covers types of preservatives and treatment procedures of bamboos used for structural purposes like post, scaffoldings, house building, walls, trusses, etc. It also includes recommendations on the choice of treatment depending upon the various uses to which the bamboo is put.

1.2 This standard does not cover the treatment of bamboo for non-structural purposes, which is covered in IS 1902.

2 REFERENCES

The following standards contain provisions which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	Title
218 : 1983	Specification for creosote oil for use as wood preservatives (<i>second revision</i>)
401 : 2001	Preservation of timber — Code of practice (<i>fourth revision</i>)
1902 : 2006	Preservation of bamboo and for non-structural purposes — Code of practice (<i>second revision</i>)
10013	Specification for water soluble type wood preservatives:
(Part 1) : 1981	Acid-copper-chrome (ACC) wood preservative
(Part 2) : 1981	Copper-chrome-arsenic (CCA) wood preservative
(Part 3) : 1981	Copper-chrome-boron (CCB) wood preservative

3 RECOMMENDED PRESERVATIVES

The following are the various preservatives recommended for treatment of bamboos (*see also* IS 401)

a) *Coal Tar Creosote* — This is a fraction of

coal tar distillate with a boiling point range above 200°C and is widely used admixed with fuel oil. A creosote fuel oil mixture in the ratio of 50 : 50 is found suitable. The fuel oils ensure stability to creosote against evaporation and bleeding from the treated bamboo. The creosote used shall conform to IS 218.

- b) *Copper-Chrome-Arsenic Composition* — A typical composition of this preservative comprises of copper sulphate ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$), arsenic pentoxide ($\text{As}_2\text{O}_5 \cdot 2\text{H}_2\text{O}$) and sodium or potassium dichromate ($\text{Na}_2\text{Cr}_2\text{O}_7 \cdot 2\text{H}_2\text{O}$ or $\text{K}_2\text{Cr}_2\text{O}_7 \cdot 2\text{H}_2\text{O}$) in proportion of 3 : 1 : 4; conforming to IS 10013 (Part 2).
- c) *Acid-Chromic-Chromate Composition* — A typical composition of this preservative comprises of 1.68 parts chromic acid (Cr_2O_3) (equivalent to 2.5 parts of sodium dichromate), 50 parts of copper sulphate ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$) and 47.5 parts of sodium dichromate ($\text{Na}_2\text{Cr}_2\text{O}_7 \cdot 2\text{H}_2\text{O}$); conforming to IS 10013 (Part 1).
- d) *Copper-Chrome-Boron Composition* — A typical composition of the preservative comprises of boric acid (H_3BO_3), copper sulphate ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$) and sodium or potassium dichromate ($\text{Na}_2\text{Cr}_2\text{O}_7 \cdot 2\text{H}_2\text{O}$ or $\text{K}_2\text{Cr}_2\text{O}_7 \cdot 2\text{H}_2\text{O}$) in the proportion of 1.5 : 3 : 4; conforming to IS 10013 (Part 3).
- e) *Boric-Acid-Borax* — This has been used successfully against lyctus borers. A mixture in ratio of 1 : 1.5 is found more suitable.
- f) *Copper-Zinc-Naphthenate/Abietates* — These are copper and zinc salts of naphthenic/abietic acid.

4 METHODS OF TREATMENT

Details of the method of treatment of bamboo by surface application (brushing, dipping), vacuum/pressure process, hot and cold process, Fast fluctuating pressure (FFP) process and Boucherie process are given in IS 401. In addition to the above, diffusion process, modified Boucherie processes and Steeping or Butt end treatment method as applicable to the treatment of bamboo (non-structural) given in IS 1902 may also be employed.

IS 9096 : 2006

5 CHOICE OF PRESERVATIVE AND METHOD OF TREATMENT

5.1 The choice of preservative and the method of treatment depend upon the use to which the treated material is put.

5.2 The recommended practice with regard to preservative, their concentration, requisite absorption and method of treatment of bamboo are given in Table 1.

6 SAMPLES

6.1 Representative samples for test of preservative shall be cut from the treated bamboos for purpose

of chemical analysis. The weight of the sample shall be about 100 g for every 100 kg of bamboo treated.

6.2 The sample obtained as in 6.1 shall be powdered either by hand file or by means of a suitable powdering machine or converted into small chips (about 10 mm long, 2 mm wide and 1 mm thick) by using a knife. The powder or chips thus prepared shall be thoroughly mixed and a liquid of 10 to 20 g taken for chemical analysis.

7 TESTING OF PRESERVATIVE IN TREATED MATERIAL

Testing of preservative in treated material shall be carried out in accordance with IS1902.

Table 1 Recommended Preservatives, Their Concentration and Absorption and the Method of Treatment of Bamboo for Structural Purposes

(Clause 5.2)

Sl No.	Structural Uses of Bamboo	Recommended Preservatives (see 3)	Concentration of Preservatives percent	Absorption of Preservatives kg/m ³	Method of Treatment
(1)	(2)	(3)	(4)	(5)	(6)
i)	Posts, pole fencing, etc. exposed to weather and in contact with ground:				
	a) Dry bamboo	a	—	80-128	Hot and cold, vacuum/Pressure process
		b	6-8	8-12	Vacuum/Pressure process
		c and d	8-10	10-14	Vacuum/Pressure process
	b) Green bamboo	b	8-10	8-12	Diffusion, Boucherie process
		c and d	8-10	10-14	Modified Boucherie process. Butt end treatment
ii)	Scaffoldings, ladders, bridges, etc. exposed to weather but not in contact with ground:				
	a) Dry bamboo	a	—	48-80	Hot and cold, vacuum/pressure process
		b	5	5-8	Vacuum/Pressure process
		c and d	6-8	6-10	Vacuum/Pressure process
	b) Green bamboo	b	6-8	5-8	Modified Boucherie process for 6 h and diffusion process for 20-25 days, FFP process
		c and d	6-8	6-10	
iii)	Housing, building, walls, rafters, trusses, purlins, etc. under cover:				
	a) Dry bamboo	a		48-80	Hot dipping, hot and cold, vacuum/pressure process
		c and d	5	6	Steeping, hot and cold, vacuum/pressure process
		e	4	5	Steeping, hot and cold, vacuum/pressure process

Table 1 (concluded)

Sl No.	Structural Uses of Bamboo	Recommended Preservatives (see 3)	Concentration of Preservatives percent	Absorption of Preservatives kg/m ³	Method of Treatment
(1)	(2)	(3)	(4)	(5)	(6)
		f	5 percent as copper (for Copper Napthanate/ Abietates)	0.4 as Cu	Dipping, brushing
			6 percent as Zinc (for Zinc Napthanate/ Abietates)	0.6 as Zn	Dipping, brushing
	b) Green bamboo	c, d and e	5	5-6	Diffusion process, Modified Boucherie process, FFP process
iv)	Ceiling, door and door panelling:				
	a) Dry bamboo	c, d	3	4	Steeping, hot and cold, vacuum/ pressure process
		e	4	5	Steeping, hot and cold, vacuum/ pressure process
		f	4 percent as copper (for Copper Napthanate/ Abietates)	0.4 as Cu	Dipping, brushing
			5 percent as Zinc (for Zinc Napthanate/ Abietates)	0.6 as Zn	Dipping, brushing
	b) Green bamboo	c, d, e	5	4	Diffusion process, Boucherie process, FFP process

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Standards and Specifications

1 General

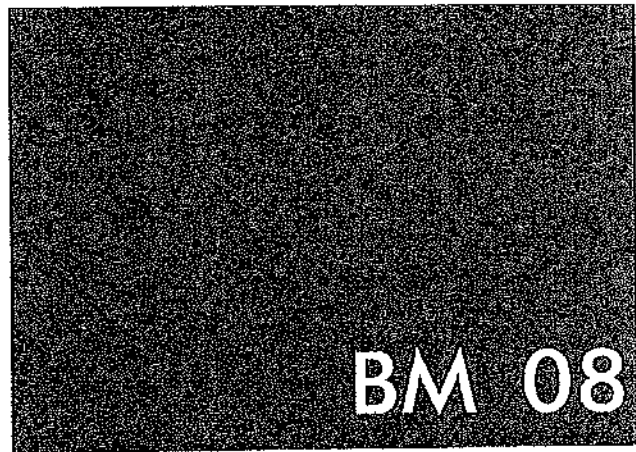
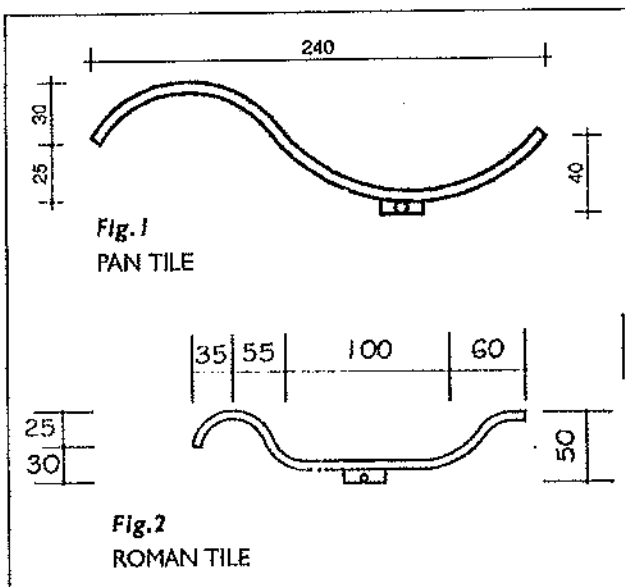
- 1.1 Micro Concrete Roofing (MCR) tiles are precast tiles made out of a mix of micro chips (4mm down), coarse sand and cement. These are made on a table vibrator. Tiles thus made are strong, durable and economical.
- 1.2 MCR tiles are energy efficient, eco-friendly and low cost roofing elements made from a carefully controlled mix of cement, sand fine stone aggregate and water. The MCR tiles can be made in two distinctive profiles namely Pan and Roman. They are designed to meet high quality standards in strength, shape and colour and are therefore, acceptable to both the rural and urban markets. MCR is suitable in all places where a need for reliable, affordable and aesthetic roofing material exists. MCR roofing is similar to roofing materials like clay tiles or sheets.
- 1.3 The MCR technology provides an inexpensive and reliable roof covering and is specially suited for the needs of developing countries.

2 Shape, Dimensions and Tolerances

- 2.1 Shape of the Pan and Roman tile shall be as given in Fig. 1 and Fig.2. The nominal dimensions of the tile shall be as given in Table 1.

Table 1

	Pan Tile	Roman Tile
Clear length	488 mm	480 mm
Clear width	240 mm	240 mm
Thickness	8 mm or 10 mm	8 mm to 10 mm
Corrugation depth	55 mm	55 mm



Specifications for Micro Concrete Roofing Tiles

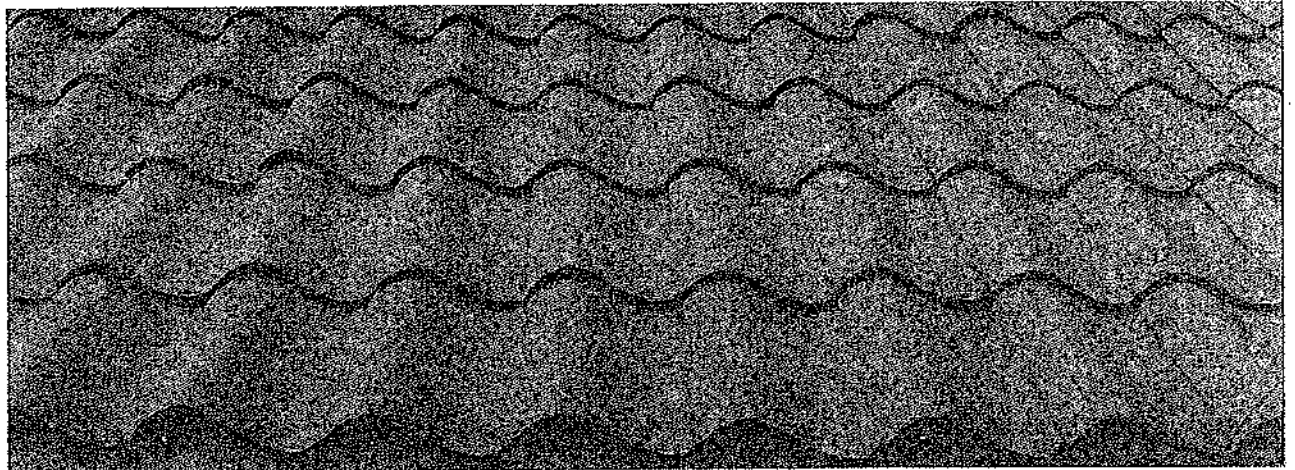
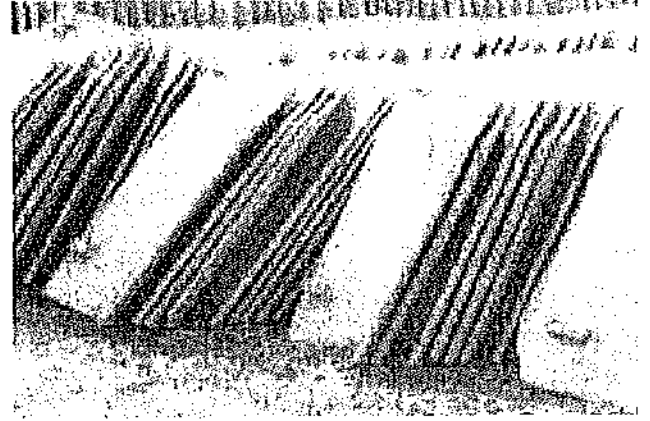
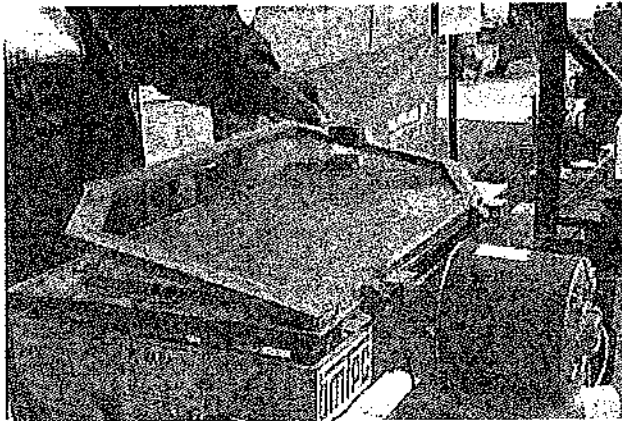
- 2.2 **Tolerances** – The permissible tolerances shall be as under:-
- 2.2.1 **Length and Width** – The average dimensions of the tile when measured to the nearest 0.1 mm, shall not vary more than ± 0.5 mm.
- 2.2.2 **Thickness** – The average thickness of the tile when measured to the nearest 0.1 mm, shall not vary more than ± 0.5 mm from the nominal dimensions.

3 Physical Characteristics

- 3.1 **Physical characteristics of the Tiles shall be as given below:**

Standard Size	: Pan Tile – 240mm X 488mm
	Roman Tile – 240mm X 480mm
Thickness	: 8mm or 10mm
Weight (Min.)	: 2.25kg (8mm) 2.75kg (10mm)
Loading capacity (Min.)	: 60kg/m ² (8mm) 80kg/m ² (10mm)
- 3.2 **Strength** - When stuck by coin the tile shall give a uniform ringing sound.
- 3.2.1 **Transverse bending strength** - When tested in accordance with IS 654, transverse bending strength shall not be less than 60 kg weight for 8 mm thick tile and 80 kg

- weight for 10 mm thick tile.
- 3.2.2 **Bearing capacity** of the nib shall not be less than 20 kg weight.
- 3.3 **Water Tightness** - Not more than 50 percent of the underside of the tile shall have signs of dampness if topside is made to be a water pool for 24 h. Underside shall be free from water droplets.
- 3.4 **Water Absorption** - Average percentage of water absorption after soaking tiles in water at normal temperature and humidity for 24 h., shall not be more than 10 percent.
- 3.5 **Pores and Cracks** - Pores, if any, shall not be deeper than 2mm, wider than 5mm and more than six in number with dia more than 2mm. The cracks shall not be longer than 5 mm.
- 4 **Finish**
- 4.1 Tiles shall have smooth finish on the top side, un-coloured and unplgmented tile shall be of uniform grey colour:
- 5 **Manufacturing**
- 5.1 **Raw Materials specification**
- Cement: Shall conform to IS 81 12.



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Fine Aggregate: Sand or crusher dust passing through 4.75mm sieve shall be free from clay and silt.

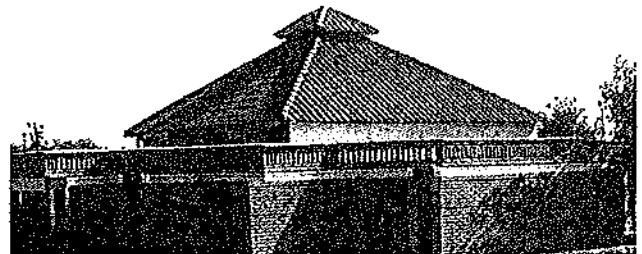
Sand: Should conform to the following grading:

Stieve size	Percent passing through
10mm	100
4.75mm	90-100
2.36mm	75-100
1.18mm	55-70
600microns	35-59
300microns	8-30
150microns	0-10

Water: Potable, free from organic matter Chlorides & sulphates should not exceed permissible limits specified in IS 456.

Water Cement Ratio : 0.5 - 0.6

- 5.2 **Material preparation** - Generally, proportions of cement, sand and aggregate used shall be 1:2:1 by volume. Proper mix ratio is necessary for optimising the materials use and for achieving high strength tile without fine cracks & air bubbles and with low water absorption. With any change of raw material proportion shall be reviewed to get proper result.
- 5.3 **Casting of tiles** - The tiles shall be casted on a Tile Making Machine after placing plastic sheet in position on vibrating plate. The operation should not take more than 30 - 35 seconds. After casting of tile Nib shall be casted. The casted tile shall be placed carefully on the mould to take the shape.
- 5.4 **Mould curing** - The curing shall start immediately after the product has been cast. The tiles shall be stacked in an airtight manner or covered within 5 minutes after casting. Tiles shall be cured in a horizontal position while still on the mould, by covering their surface with plastic sheets or stacking with moulds that guarantee airtight and damp proof stacking. The mould shall be placed on a flat surface with fresh tile lying flat on it. Second mould shall be placed careful enough on the first mould without damaging the edges of tile in the mould underneath. Make sure moulds fit with each other airtight. All the moulds shall be placed in stacks upto 1m high for the first day curing. Care shall be taken to cover the uppermost tile with cover. The moulds shall be kept in the same position for 24 h.
- 5.5 **Demoulding** - Demoulding of tiles shall be done after 24 h of casting.
- 5.6 Moulds and polythene sheets shall be thoroughly cleaned after each use.
- 5.7 **Water Tank Curing** - After the tiles have been cured for 24 h in a horizontal position, they shall be carefully moved to the curing tank, where they shall be kept completely under water in a vertical position for atleast 5 days.
- 5.8 Depending upon the choice of customer/end user, the tile shall be painted by standard procedure.
- 6 Sampling and Testing**
- 6.1 1 percent or more tiles from the daily production stock shall be tested regularly.
- 6.2 **Test**
- 6.2.1 **Pores and Cracks** - Every tile shall be visually checked for pores and cracks as mentioned in 3.5.
- 6.2.2 **Ring Test** - Every tile shall be tested. The test is done by taping the tile with a coin or a stone. A clear ringing sound shall be heard. If there is a dull sound, the tile is probably cracked and shall be rejected.
- 6.2.3 **Water Tightness Test** - 1 percent of the tile shall be tested. It shall be as per 3.3.
- 6.2.4 **Bending Test** - The strength of tile shall be as per 3.2.1.
- 6.2.5 **Weight Test** - Take 4 randomly chosen tile from each week's production. Store them and dry for 24 h and weight them. The weight of the tile shall not differ more than 10 percent from the weight as mentioned in 3.1.
- 6.2.6 **Nib Tensile Test** - 1 percent of the tile shall be tested by suspending a 20 kg weight on the loop of the nib. The nib should bear a 20 kg weight without cracking.
- 6.2.7 If any of the tiles in the sample fails to comply with the requirements of any of the tests, another sample shall be similarly drawn and tested. If any of the tiles in the second sample also fails to comply with requirements of any of the tests, then the whole lot, from where the samples were taken shall be rejected.
- 7 Marking**
- 7.1 Before putting tile in water tank for curing, each tile shall be legibly or indelibly marked or stamped with identification of source of manufacture, year of manufacture and batch number.



Handwritten notes and symbols along the right margin, including a vertical line of small marks and some illegible characters.

IS : 6523 - 1983
(Reaffirmed 2007)

Indian Standard

SPECIFICATION FOR PRECAST REINFORCED
CONCRETE DOOR AND WINDOW FRAMES

(First Revision)

Third Reprint JANUARY 1999

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MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 5

November 1983

Indian Standard

**SPECIFICATION FOR PRECAST REINFORCED
CONCRETE DOOR AND WINDOW FRAMES**

(First Revision)

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IS : 6523 - 1983

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(Continued on page 19)

**AMENDMENT NO. 1 JUNE 2005
TO
IS 6523 : 1983 SPECIFICATION FOR
PRECAST REINFORCED CONCRETE DOOR AND
WINDOW FRAMES**

(*First Revision*)

(*Page 3, clause 0.2, first sentence*) — Substitute the following for the existing

'The increasing scarcity and high cost of good timber has considerably increased the utility of precast reinforced cement concrete door and window frames, which are not only durable and termite proof but also appreciably economical and easy to manufacture.'

(*Page 3, clause 0.4*) — Insert the following new para after 0.4.

'0.5 A scheme for labelling environment friendly products known as ECO Mark has been introduced at the instance of the Ministry of Environment and Forests (MEF), Government of India. The ECO Mark would be administered by the Bureau of Indian Standards (BIS) under the BIS Act, 1986 as per the Resolution No 85 (E) dated 21 February 1991 and No 589 (E) dated 10 June 1992 published in the Gazette of the Government of India. For a product to be eligible for marking with ECO logo, it shall also carry the ISI Mark of BIS besides meeting additional optional environment friendly requirements. For this purpose, the Standard Mark of BIS would be a single mark being a combination of the ISI Mark and the ECO logo. Requirements to be satisfied for a product to qualify for the BIS Standard Mark for ECO friendliness will be optional, manufacturing units will be free to opt for the ISI Mark alone also.'

This amendment is based on the Gazette Notification No 170 dated 18 May 1996 for substitutes for Wood Building Materials as environment friendly products published in the Gazette of the Government of India.'

(*Page 3, clause 0.5*) — Renumber clause '0.5' as '0.6'

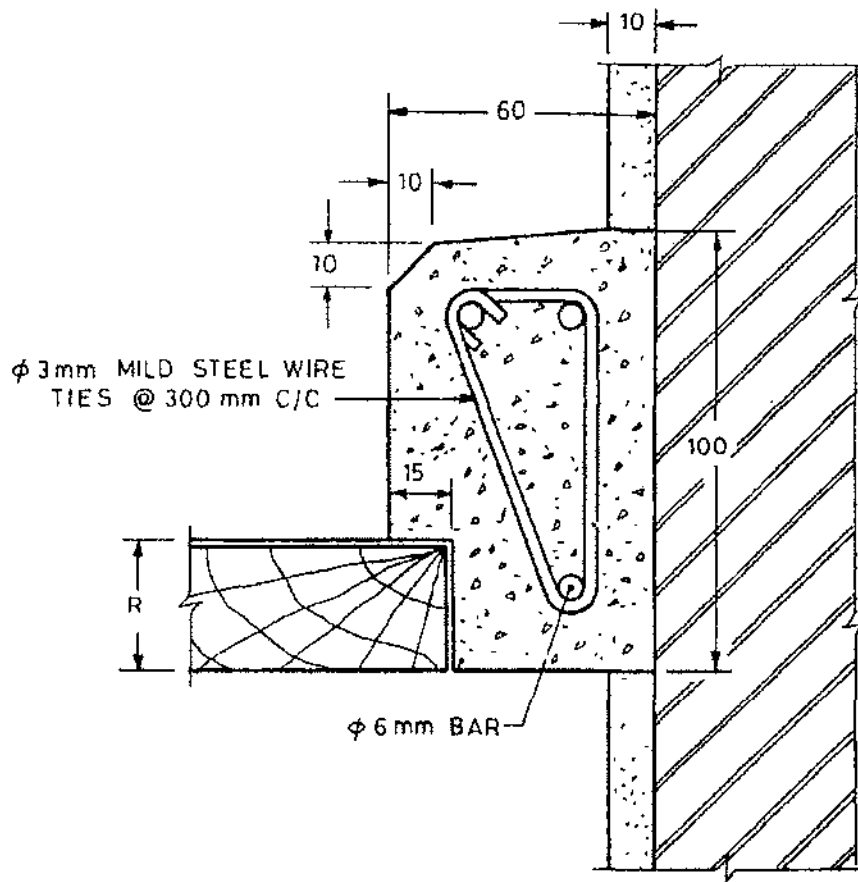
(*Page 4, clause 2.1*) — Add the following Note

NOTE 3 — A slight slope for ease in demoulding may be provided in frame cross section as shown in Fig. 1A and 1B.'

Amend No. 1 to IS 6523 : 1983

(Page 4, clause 3.3, line 3) — Substitute 'M 25' for M 20'

(Pages 6 and 7, Fig 1A and 1B) — Substitute the following Fig. 1A and 1B for the existing

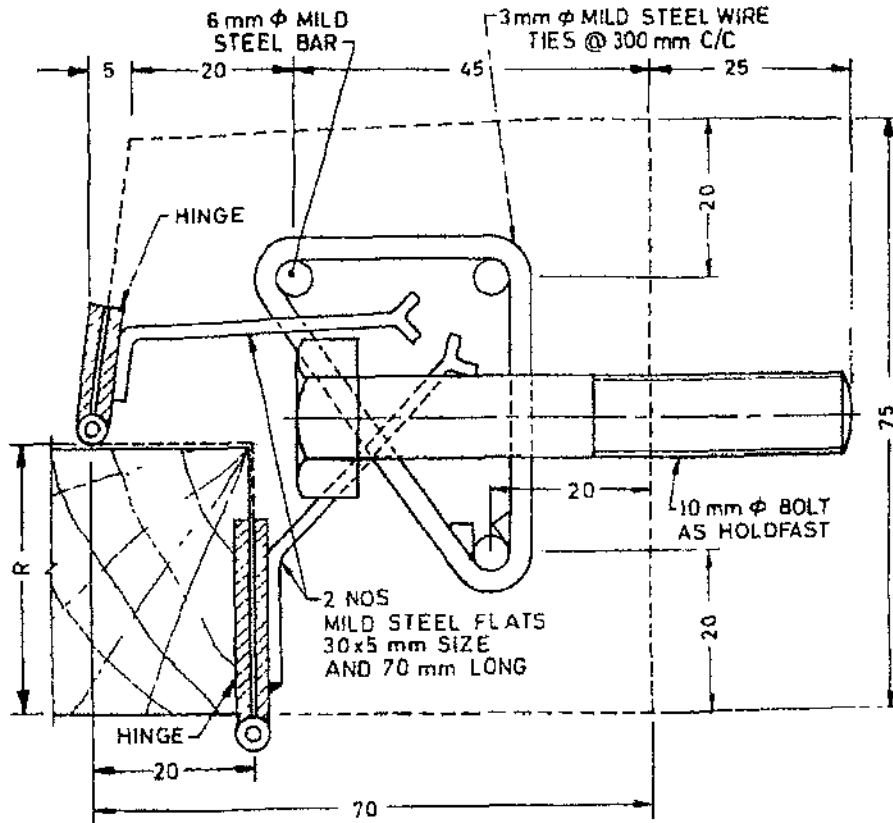


$R = 30, 35$ or 40 mm depending upon the thickness of shutter

1A Typical Cross Section of Precast Reinforced Concrete Door and Window Frame Showing Reinforcement

FIG. 1 REINFORCED CONCRETE DOOR AND WINDOW FRAME — Contd

Amend No. 1 to IS 6523 : 1983



$R = 30, 35$ or 40 mm depending upon the thickness of shutter

NOTE — Instead of bolts for holdfast, mild steel rod 10 mm dia may be embedded in concrete and the projected pieces may be bent after casting

1B Alternative Details of Precast Reinforced Concrete, Door and Window Frame Showing Arrangement for Reinforcement, Holdfasts and Hinges

All dimensions in millimetres

FIG 1 REINFORCED CONCRETE DOOR AND WINDOW FRAME

Amend No. 1 to IS 6523 : 1983

(Page 8, clause 4.2.1, line 2) — Substitute '15 mm' for '12 mm'

(Page 14, clause 7.3) -- Insert the following matter after 7.3 and renumber the subsequent clauses

8 OPTIONAL REQUIREMENTS FOR ECO MARK

8.1 General Requirements

8.1.1 The products shall conform to the requirements for quality and performance as specified in the standard

8.1.2 The product manufacturer must produce the consent clearance from the concerned State Pollution Control Board as per the provisions of *Water (Prevention and Control of Pollution) Act, 1974* and *Air (Prevention and Control of Pollution) Act, 1981* and *Water (Prevention and Control of Pollution) Cess Act, 1977* along with the authorization, if required under *Environment (Protection) Act, 1986* and the Rules made thereunder to BIS while applying for ECO Mark appropriate with enforced Rules and Regulations of the Forest Department

8.1.3 The product or product packaging may display in brief the criteria based on which the product has been labelled environment friendly.

8.1.4 The material used for product packing (if any) shall be recyclable, reusable or biodegradable

8.2 Specific Requirements

8.2.1 Door and window frames used for buildings shall be made from reinforced cement concrete

NOTE — The manufacturer shall provide documentary evidence by way of certificate or declaration to this effect to BIS while applying for ECO Mark

[Page 16, clause 10.1(c)] — Add the following after 10.1(c)

'd) The criteria for which the product has been labelled with ECO Mark (if ECO marked)'

(CED 53)

**AMENDMENT NO. 2 MARCH 2007
TO
IS 6523 : 1983 SPECIFICATION FOR PRECAST
REINFORCED CONCRETE DOOR AND
WINDOW FRAMES**

(First Revision)

*[Page 14, clause 8, Title (see also Amendment No 1)] — Substitute
'ADDITIONAL' for 'OPTIONAL'.*

(CED 53)

Indian Standard

**SPECIFICATION FOR PRECAST REINFORCED
CONCRETE DOOR AND WINDOW FRAMES**

(First Revision)

0. FOREWORD

0.1 This Indian Standard (First Revision) was adopted by the Indian Standards Institution on 28 February 1983, after the draft finalized by the Cement and Concrete Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 The increasing scarcity and high cost of good timber has considerably increased the utility of precast reinforced cement concrete door and window frames, which are not only durable but also appreciably economical and easy to manufacture. Precast reinforced concrete frames for doors and windows will be found specially useful where provisions for such frames have to be made on a mass scale as in the case of large residential housing colonies.

0.3 This standard was first published in 1972 to provide guidance in the manufacture and supply of precast reinforced concrete door and window frames of suitable finish and quality and with reliable fixing arrangements for door and window shutters.

0.3.1 This revision has been prepared with a view to modifying some of the requirements in the light of experience gained in the use of this standard both by the manufacturers and the users. The major modifications in this revision include covering an additional method of fixing hinges to frames, specifying tolerances for the cross-section of the frames and giving reference to latest Indian Standards in the related provisions.

0.4 The use of precast reinforced concrete door and window frames is recommended to be restricted to a maximum opening width of 2.25 m.

0.5 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with

IS : 6523 - 1983

IS : 2-1960* The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard covers the requirements for precast reinforced concrete door and window frames.

2. SHAPE AND DIMENSIONS

2.1 Precast reinforced concrete door and window frames shall be 60 × 100 mm or 70 × 75 mm in cross-section for single shutter door and 60 × 120 mm for double shutter door, the cross-section being generally in accordance with Fig 1 and 3. The overall sizes (width and height) of the frames shall conform to the requirements of IS : 4021-1976†

NOTE 1 — Suitable adjustment in cross-sectional shape may be made by agreement between the purchaser and the supplier to provide suitable groove for wall plaster, etc, provided the overall dimensional requirements given above are not affected.

NOTE 2 — For overall dimensions of the frame, the width of the frame shall be the total length of the horizontal piece measured out-to-out, the height of the frame shall be the total height measured from the lowest end of the vertical piece (in case of three member frame or the outer edge of the lower horizontal member in case of four member frame) to the outer edge of the top horizontal piece (see Fig 2).

2.1.1 Tolerances — A tolerance of ±2 mm shall be permitted on the cross-sectional dimensions of the frames.

3. MATERIALS

3.1 The materials used for the manufacture of precast reinforced concrete door and window frames shall comply with the requirements given in Table 1.

3.2 Aggregates — The aggregates used shall consist of well-graded mixture of clean coarse and fine aggregates. The nominal maximum size of coarse aggregates shall not exceed 10 mm.

3.2.1 Where specified, a sample of the aggregates shall be submitted to the purchaser for approval.

3.3 Concrete — The mix proportion of the concrete shall be determined by the manufacturer and shall be such as to produce a dense concrete not weaker than grade M 20 (see IS : 456-1978‡).

*Rules for rounding off numerical values (revised)

†Specification for timber door, window and ventilator frames (first revision).

‡Code of practice for plain and reinforced concrete (third revision).

3.4 Reinforcement — Steel reinforcement shall be minimum of 3 bars of 6 mm dia or equivalent of about 1.5 percent of the sectional area of the concrete member (see Fig. 1).

3.4.1 Reinforcement shall be clean and free from loose millscale, loose rust, mud, oil, grease or any other coating which may reduce the bond between the concrete and steel. A slight film of rust may not be regarded as harmful but the steel shall not be visibly pitted by rust.

4 MANUFACTURE

4.1 Construction and Finish

4.1.1 Each frame shall be made of concrete proportioned, mixed, placed and compacted by vibration/pressing to give a dense concrete free from voids and honeycombing.

NOTE—Compaction by vibration may be done using a vibrating table or a shutter vibrator.

4.1.2 Each member of the frame shall have a dense surface finish showing no coarse aggregate and shall have no crevices likely to assist in the disintegration of concrete or rusting of steel by the action of natural agencies.

TABLE 1 REQUIREMENTS FOR MATERIALS

(Clause 3.1)

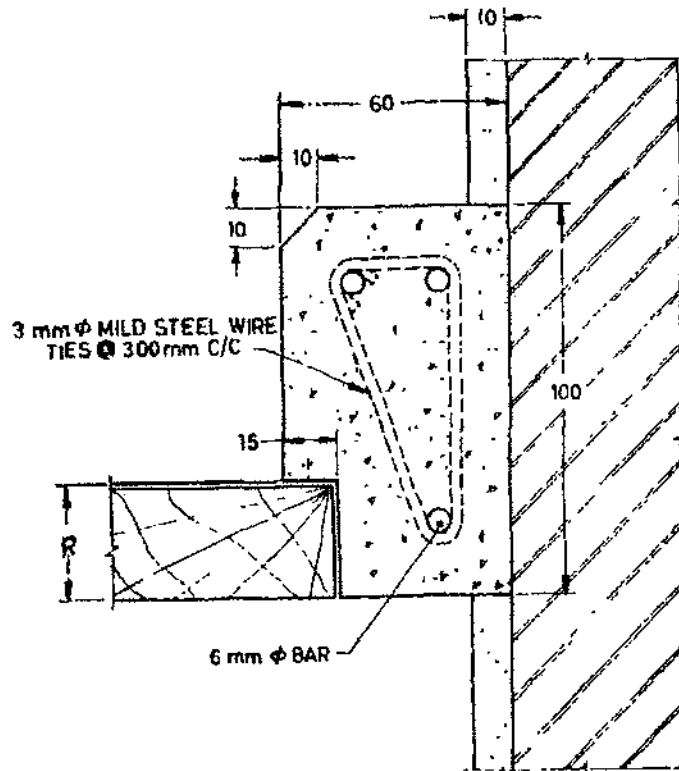
Sl No.	MATERIAL	REF TO INDIAN STANDARD*
i)	Cement shall be ordinary Portland cement or Portland slag cement or Portland pozzolana cement or rapid-hardening Portland cement or high strength ordinary Portland cement	IS : 269-1976, IS : 455-1976, IS : 1489-1976, IS : 8041-1978 and IS 8112-1976
n)	Water	IS : 456-1978
ii)	Concrete aggregate	IS : 383-1970 and IS : 456-1978
iv)	Concrete	IS : 456-1978, IS : 516-1959 and IS : 1199-1959
v)	Reinforcement	IS : 432 (Part I)-1966, IS : 1139-1966 and IS : 1786-1979
vi)	Mild steel wire	IS : 280-1978

*For titles of Indian Standards, see Appendix A.

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4.1.3 While a good finish may generally be obtained by using smooth surface moulds and proper vibration of concrete, any small defects remaining may be removed by rubbing with carborundum stone before erection of the frame. Plastering or touching shall not be done under any circumstances

4.1.4 By mutual agreement between the purchaser and the supplier decorative treatment, such as painting or terrazzo finish may be given to the three exposed surfaces of the frame, the terrazzo finish shall be given while casting the frame

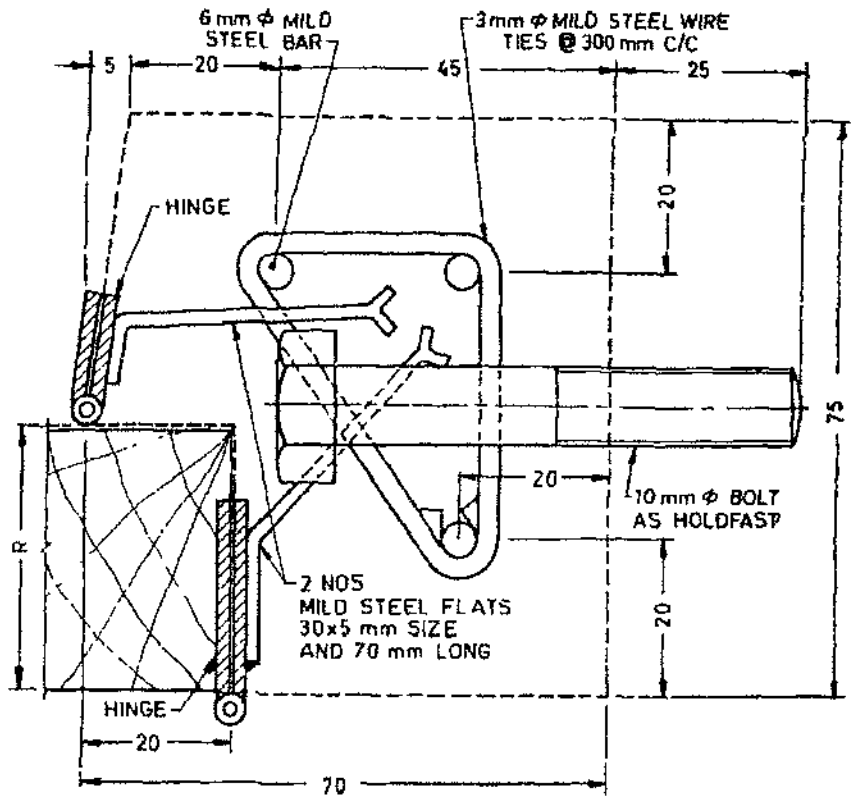


$R = 30, 35$ or 40 mm depending upon the thickness of shutter

1A Typical Cross Section of Precast Reinforced Concrete Door and Window Frame Showing Reinforcement

FIG. 1 REINFORCED CONCRETE DOOR AND WINDOW FRAME — *Contd*

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R = 30, 35 or 40 mm depending upon the thickness of shutter.

NOTE — Instead of bolts for holdfast, mild steel rod 10 mm dia may be embedded in concrete and the projected pieces may be bent after casting.

1B Alternative Details of Precast Reinforced Concrete Door and Window Frame Showing Arrangement for Reinforcement, Holdfasts and Hinges

All dimensions in millimetres

FIG. 1 REINFORCED CONCRETE DOOR AND WINDOW FRAME

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4.2 Positioning of Reinforcement — The vertical as well as the horizontal members of the frame shall be reinforced with longitudinal bars as in 3.4. The longitudinal reinforcement for each of the vertical or horizontal member shall be in one piece. The longitudinal bar shall be firmly held by means of at least 3 mm dia steel ties spaced at not more than 300 mm centre to centre.

4.2.1 Cover — The longitudinal reinforcement shall have a minimum clear cover of 12 mm or twice the diameter of the main bar, whichever is more.

4.3 Casting

4.3.1 The entire frame may be cast complete in one piece or each of the vertical and horizontal members of the frame may be cast separately to be assembled into the complete frame at site. The former method has the advantage of reducing the work at site but introduces difficulties in fabrication of the moulds, and also in transporting and handling of the complete frame; there is likelihood of damage to the frame during transit. Since damage to even one member will result in the rejection of the whole frame, the latter method is relatively simple and economical.

4.3.1.1 When the frame is cast in separate parts (see Fig. 2), one of the reinforcing bars of the vertical members of the frame shall be kept projecting so as to tennon into the corresponding holes in the horizontal member. The hole 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 bar. After assembly at site the holes shall be grouted with cement slurry 1:1½ (cement : sand).

4.3.2 Mould — The mould for casting shall be of steel or of good quality timber suitably lined with iron sheet or of any other suitable material which shall ensure adequate surface finish of the cast frame. Provision shall be made in the mould to accommodate fixing devices for hinges and the holdfasts. If required, suitable rebate may also be provided to act as plaster groove.

4.4 Curing — After placing, the concrete shall be adequately protected, during setting and in the first stages of hardening, from shocks, running or surface water and the harmful effects of sunshine, drying winds and cold. The concrete shall be cured for at least 7 days unless special curing methods are adopted. Steam curing of concrete may be adopted if so desired by the manufacturer, provided the requirements of pressure or non-pressure steam curing are fulfilled.

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NOTE — For non-pressure steam curing, the frames shall be subjected to the action of saturated steam at a temperature of 60 to 80°C for a period of 16 to 18 h; or for such additional time as may be necessary to enable the frame to meet the strength requirements. When a curing chamber is not available, frames shall be placed in an enclosure of canvas or other closely woven material and subjected to saturated steam at the temperature and for the time specified above. The enclosure shall be so erected as to allow full circulation of steam around the entire frame. The interior surface of the curing room or canvas jacket and the surface of the frames shall be entirely moist at all times.

4.4.1 Maturing — From the date of casting, the frames shall be matured for the following period (including the period of curing) depending on the type of cement used for manufacture of the frames before testing or despatch:

Ordinary Portland cement or Portland slag cement or Portland pozzolana cement	28 days
Rapid-hardening Portland cement or high-strength ordinary Portland cement	14 days

4.4.2 Minimum Strength of Concrete for Handling of Frames — The concrete shall have sufficient strength to prevent damage to units when first handled.

5. ARRANGEMENTS FOR FIXING OF HINGES TO FRAMES

5.1 Suitable arrangements for fixing of hinges shall be provided in the frame by any one of the methods described in 5.2 to 5.6 or any other equally suitable method approved by the purchaser. If so required by the purchaser, the frames supplied shall be complete with the required number of hinges fixed in position.

5.1.1 All the exposed area of hinges, holdfast and other steel fixtures shall be painted with anti-corrosive paint, before casting, to prevent rusting.

5.2 Fixtures for Hinges

5.2.1 Aluminium Tube Fixture — Aluminium tube sleeve having internal threading and length to suit 5 mm machine screw (see IS : 1365-1978*) shall be taken and the rear end of the tube sleeve shall be pressed flat. Threading in the tube may be done by holding the tube in a vice. A number of such sleeves shall be made, one sleeve for each screw hole of the hinge (see Fig. 2). The sleeves shall be inserted in the moulds from the inner side and the flattened ends of adjacent tubes shall be kept facing in different directions for better bond. Screws shall be inserted in the tubes from outside of the mould to keep the fitting in position during pouring of concrete and also to prevent concrete from getting into the tube. After

*Specification for slotted countersunk head screws (third revision).

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completion of casting, curing and maturing of the frame, the screws shall be withdrawn from the frame, the hinges placed in position and screws tightened in position to fix the hinges (see Fig. 3A).

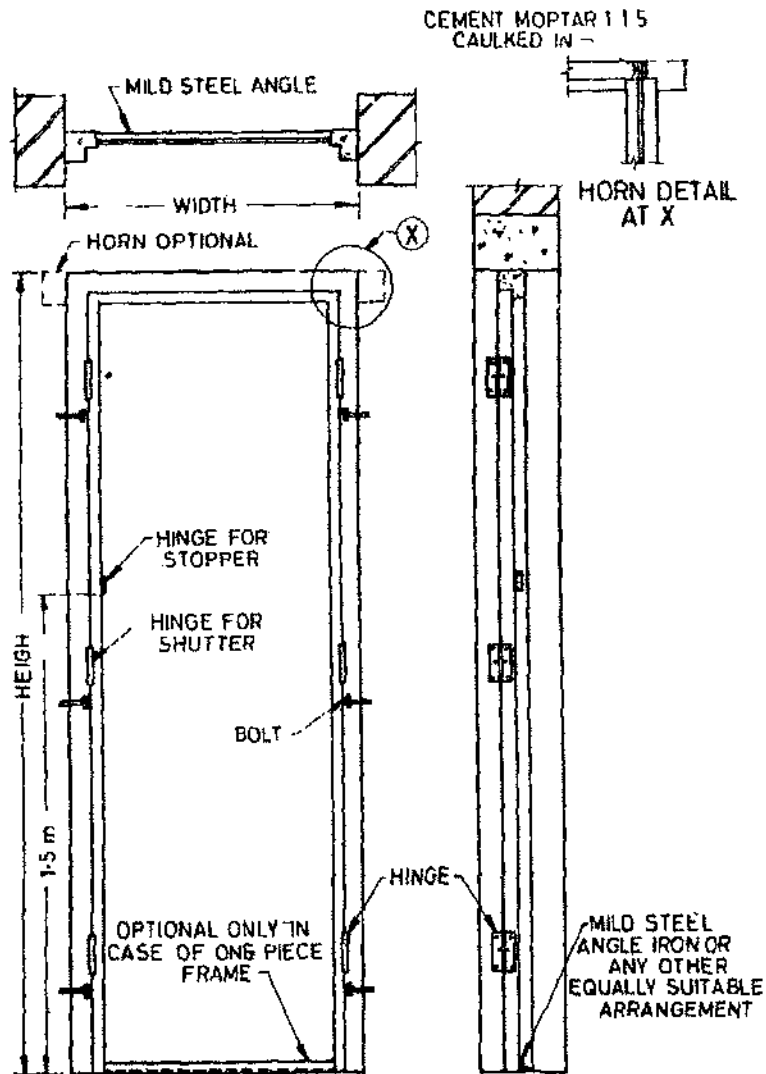
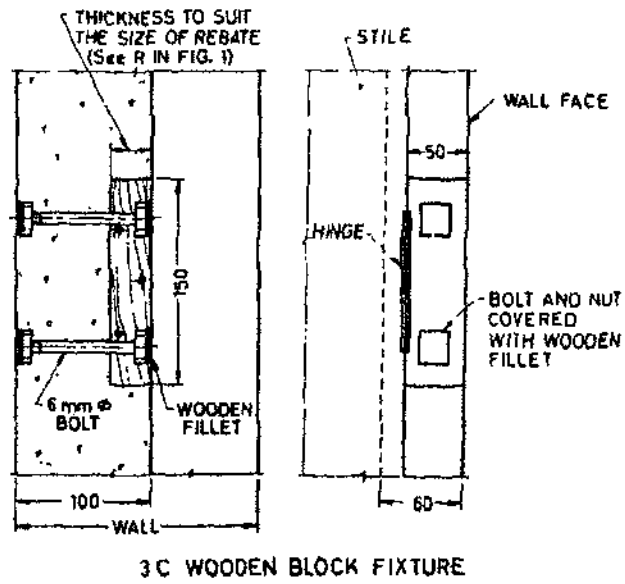
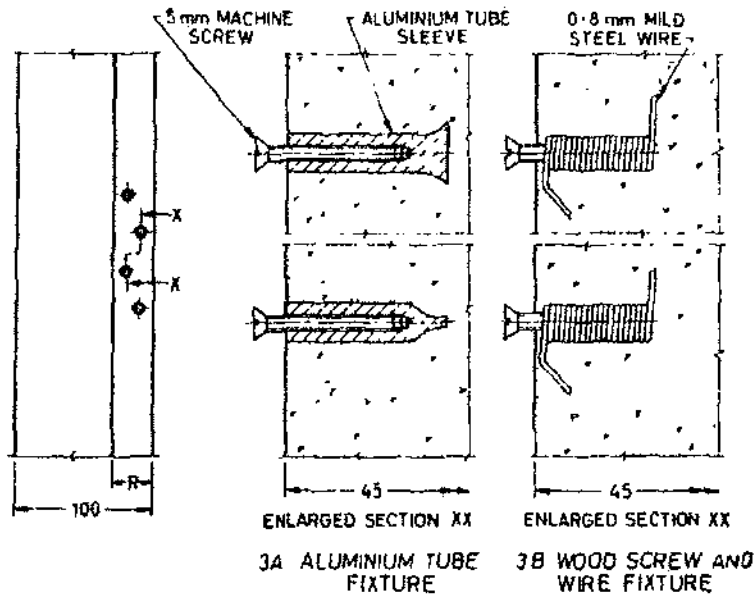


FIG. 2 OVERALL DIMENSIONS OF PRECAST REINFORCED CONCRETE DOOR FRAME

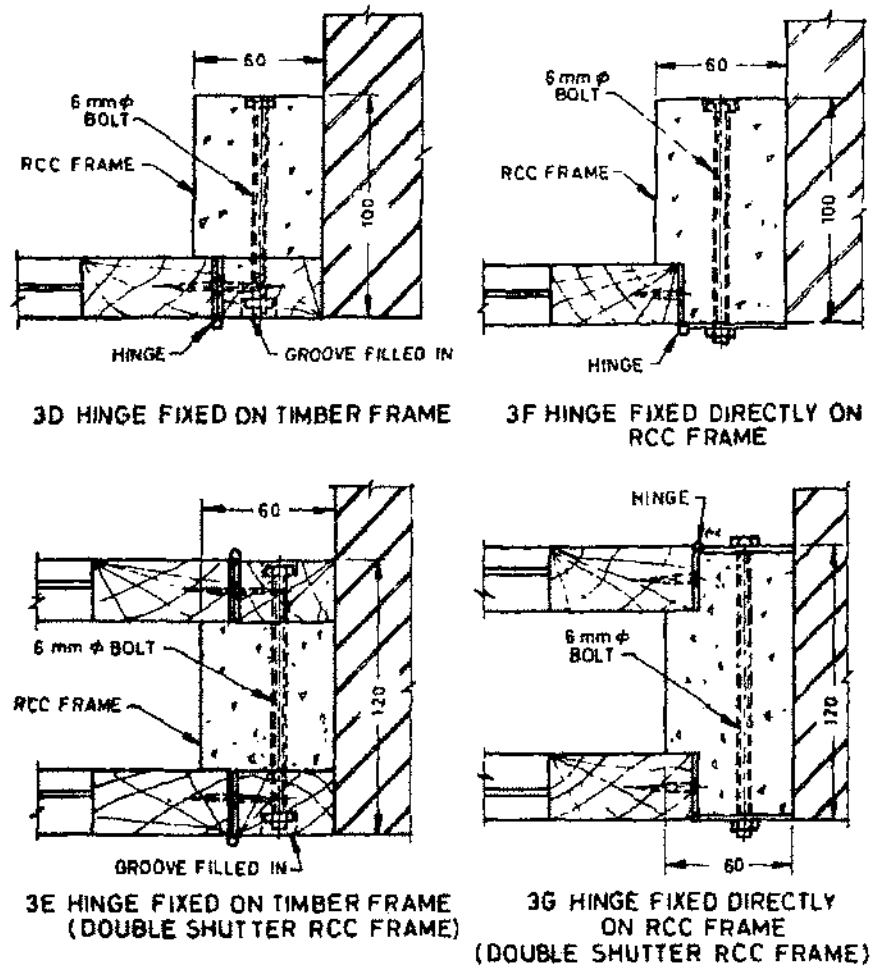
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All dimensions in millimetres.

FIG. 3 ARRANGEMENTS FOR FIXING HINGES TO PRECAST REINFORCED CONCRETE DOOR AND WINDOW FRAMES — Contd

IS : 6523 - 1983



All dimensions in millimetres

FIG. 3 ARRANGEMENTS FOR FIXING HINGES TO PRECAST REINFORCED CONCRETE DOOR AND WINDOW FRAMES

5.2.2 For facilitating proper and easy fixing of hinges, the hinges may be supplied by the manufacturer alongwith the frame.

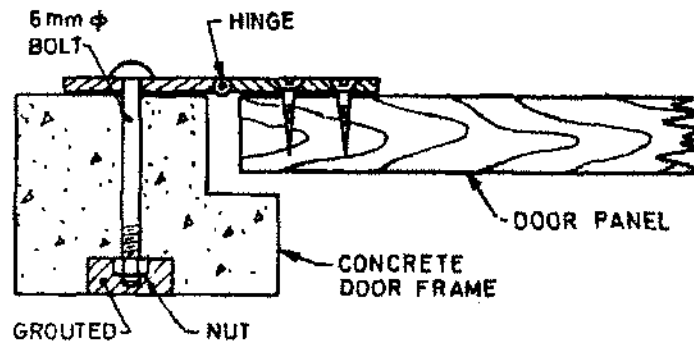
5.3 Wire Fixture — Mild steel wire conforming to IS : 280-1978* and of thickness 0.8 mm shall be helically wound on a wood screw, the size of the wood screw being selected to suit the hinges (see IS : 1341-1976† and

*Specification for mild steel wire for general engineering purposes (third revision)
†Specification for steel butt hinges (third revision).

IS : 451-1972*) For this purpose, the screw shall be held in a vice and the wire wound around it till the wire covers the screw and trails out by about 15 mm on either end of the screw. The wire along with the screw (one fixture for each screw hole of the hinge) shall be left in position in the mould at the place where hinges are to be fixed to the frame (see 5.2.1). After completion of casting, curing and maturing of the frame, the screws shall be withdrawn from the frame, the hinges placed in position and screws tightened in position to fix the hinges (see Fig. 3B).

5.4 Hardwood Block Fixture — Hardwood blocks of suitable timber such as well seasoned teak wood 150 mm long, 45 or 50 mm × 30 to 40 mm in cross-sections with suitable holes to allow for insertion of two 6 mm mild steel bolts shall be used. Suitable spacers shall be kept in the mould while casting the frame so that one block for each of the hinge can 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 nuts shall be suitably covered with hard wood fillets, finished flush with concrete surfaces of the frame (see Fig. 3C). Alternative arrangement of wooden framing as shown in Fig. 3D and 3E may be adopted.

5.5 Hinge Directly Attached to Frame — L type flap hinge may be attached directly to the reinforced cement concrete frame with the help of 6 mm ϕ mild steel bolt (see Fig. 3F, 3G and 3H).



3H HINGE FIXED DIRECTLY ON
RCC FRAME

All dimensions in millimetres.

FIG. 3 ARRANGEMENTS FOR FIXING HINGES TO PRECAST REINFORCED CONCRETE DOOR AND WINDOW FRAMES

*Specification for technical supply conditions for wood screws (second revision).

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5.6 Hinge Welded to Frame — The hinge may be welded to 2 numbers mild steel flat 30 x 5 mm size and 70 mm long, embedded in the reinforced concrete frame (see Fig. 1B). Gas welding is recommended in the case of welding of hinges to the mild steel plates

6. ARRANGEMENTS FOR DOOR AND WINDOW FIXTURES

6.1 Suitable arrangements shall be provided in the frame for receiving tower bolts, sliding bolts and other door and window fixtures, one such arrangement is shown in Fig. 4

7. ERECTION

7.1 When a three-piece frame is used, the vertical members shall be held in position as in case of timber frames and they shall be plumbed and aligned, and firmly supported till the concrete around the holdfasts in the masonry has properly set and hardened. The concrete frames being heavier require little extra care in handling; the joints are liable to give way, if not handled carefully

7.1.1 Alternatively, the vertical members may be held in position and the top member placed over the vertical members. The whole frame is plumbed and aligned, and supported temporarily till the concrete around holdfasts has properly set and hardened

7.2 Where a four-piece frame as in the case of window frames or door frames having sills, is used, the bottom members shall be first placed in position and the others erected on this base.

7.3 Cement slurry 1:1½ (cement : sand) shall be used in grouting the joints between the vertical and horizontal members of door frame (see Fig 2). Alternatively, chemical bonding agents such as epoxy resins may be used.

8. SAMPLING AND INSPECTION

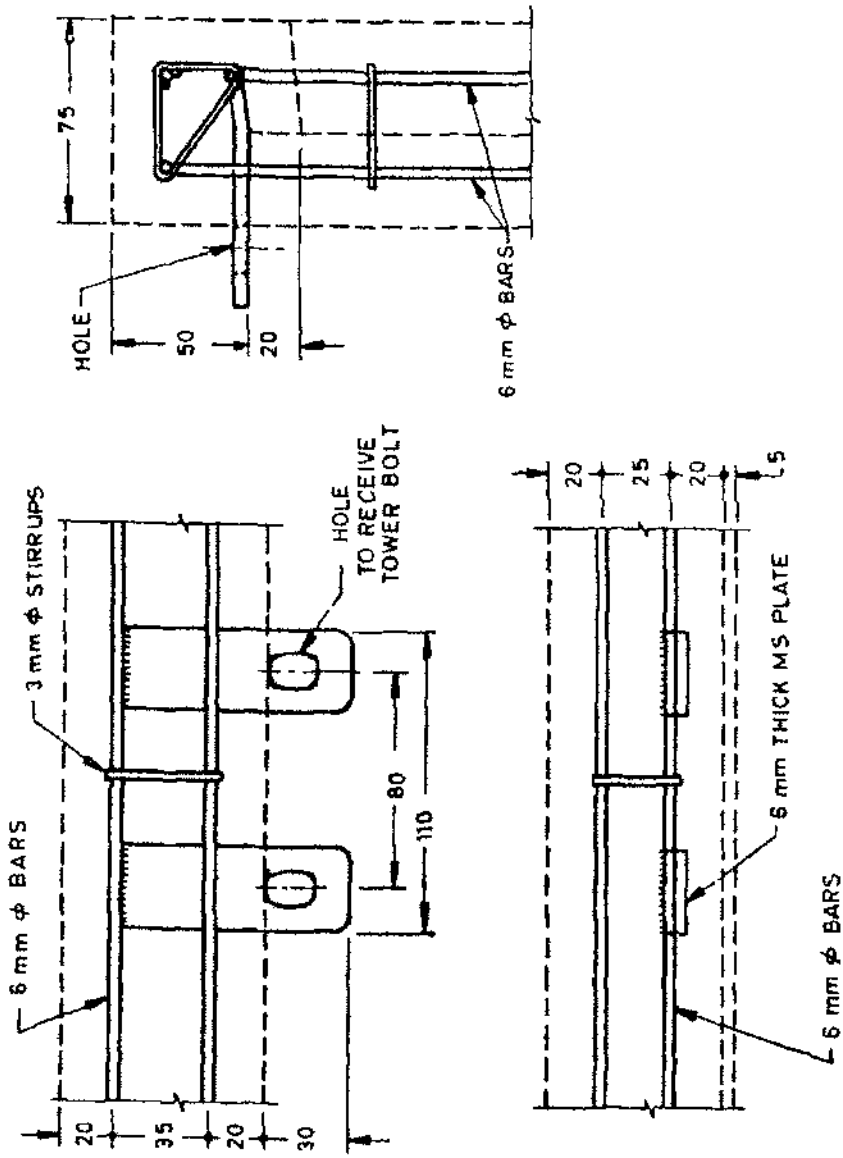
8.1 The method of drawing representative samples and the criteria for conformity shall be as described in Appendix B.

9. MANUFACTURER'S CERTIFICATE

9.1 The manufacturer shall satisfy himself that the frames conform to the requirements of this specification and if requested, shall supply a certificate to this effect to the purchaser or his representative.

10. MARKING

10.1 The frame shall be clearly and indelibly marked with the following information on the face of the frame coming in contact with the masonry:



All dimensions in millimeters
Fig 4 METHOD OF LINING TOWER BOLTS TO RCC FRAMES

IS : 6523 - 1983

- a) Manufacturer's name or trade-mark,
- b) Year of manufacture, and
- c) Overall height and width of frame.

10.1.1 Each frame may also be marked with the Standard Mark.

NOTE - The use of the Standard Mark is governed by the provisions of the Bureau of Indian Standards Act, 1986 and the Rules and Regulations made thereunder. The Standard Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well defined system of inspection, testing and quality control which is devised and supervised by BIS and operated by the producer. Standard marked products are also continuously checked by BIS for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

APPENDIX A

(Table 1)

TITLES OF INDIAN STANDARDS

- IS : 269-1976 Specification for ordinary and low heat Portland cement (*third revision*)
- IS : 280-1978 Specification for mild steel wire for general engineering purposes (*third revision*)
- IS : 383-1970 Specification for coarse and fine aggregates from natural sources for concrete (*second revision*)
- IS : 432 (Part I)-1966 Specification for mild steel and medium tensile steel bars and hard-drawn steel wire for concrete reinforcement : Part I Mild steel and medium tensile steel bars (*second revision*)
- IS : 455-1976 Specification for Portland slag cement (*third revision*)
- IS : 456-1978 Code of practice for plain and reinforced concrete (*third revision*)
- IS : 516-1959 Methods of test for strength of concrete
- IS : 1199-1966 Specification for hot rolled mild steel, medium tensile steel and high yield strength steel deformed bars for concrete reinforcement (*revised*)
- IS : 1199-1959 Methods of sampling and analysis of concrete

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- IS : 1489-1976 Specification for Portland-pozzolana cement (*second revision*)
- IS : 1786-1979 Specification for cold-worked steel high strength deformed bars for concrete reinforcement (*second revision*)
- IS : 8041-1978 Specification for rapid hardening Portland cement (*first revision*)
- IS : 8112-1976 Specification for high strength ordinary Portland cement

APPENDIX B

(*Clause 8.1*)

SAMPLING AND CRITERIA FOR CONFORMITY

B-1. SCALE OF SAMPLING

B-1.1 Lot — In any batch, all frames of the same type and same dimensions shall be grouped together to constitute a lot.

B-1.1.1 Sub-lot — If the number of frames in a lot exceed 500, the lot shall be divided into a suitable number of sub-lots such that the number of frames in any sub-lot shall not exceed 500. The acceptance or otherwise of a sub-lot shall be determined on the basis of sample selected from it.

B-1.1.2 The number of frames to be selected from a lot or a sub-lot shall depend upon its size and shall, be in accordance with col 1 and 2 of Table 2.

B-1.1.3 The frames shall be selected at random. In order to ensure randomness, all the frames in the lot or the sub-lot may be arranged in a serial order and starting from any frame, every r th frame may be included in the sample, r being the integral part of N/n , where N is the size of the lot or the sub-lot and n the sample size.

B-2. NUMBER OF TESTS

B-2.1 All the frames as selected in **B-1.1.2** shall be tested for overall length, cross-section and uprightness.

B-3. CRITERIA FOR CONFORMITY

B-3.1 A lot or a sub-lot shall be considered as conforming to this specification if the conditions under **B-3.2** are satisfied.

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B-3.2 The number of frames which do not satisfy the requirements of overall length, cross-section and uprightness shall not exceed the corresponding number given in col 3 of Table 2. If the number of such frames exceed the corresponding number; all frames in the lot or sub-lot shall be tested for these requirements and those not satisfying the requirements shall be rejected.

TABLE 2 SAMPLE SIZE AND CRITERIA FOR CONFORMITY
(*Clauses B-1.1.2 and B-3.2*)

SIZE OF LOT OR SUB-LOT <i>N</i> (1)	DIMENSIONAL REQUIREMENTS	
	Sample Size <i>n</i> (2)	Permissible No. of Defects (3)
Up to 100	10	1
101 to 200	15	1
201 to 300	20	2
301 to 500	30	3

'RAT-TRAP BOND' BRICK MASONRY

Introduction:

The Rat-trap bond is a masonry technique, where the bricks are used in a way which creates a cavity within the wall, while maintaining the same wall thickness as for a conventional 1 brick thick masonry wall. In a conventional English bond or Flemish bond, bricks are laid flat, whereas in a Rat-trap bond, they are placed on edge forming the inner and outer face of the wall, with cross bricks bridging the two faces (figure-1, 2). The main advantage of Rat-trap bond is reduction in the number of bricks and mortar required as compared to English/ Flemish bond because of the cavity formed in the wall. The cavity also makes the wall more thermally efficient. It is suitable for use, wherever one-brick thick wall is required. Rat-trap bond masonry has been extensively used in different category of building from large institutional complexes, community buildings, Government offices, village panchayats, individual houses for high income and middle income and in government supported EWS housing programmes.

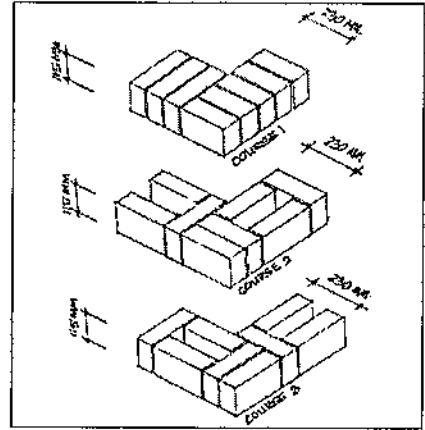
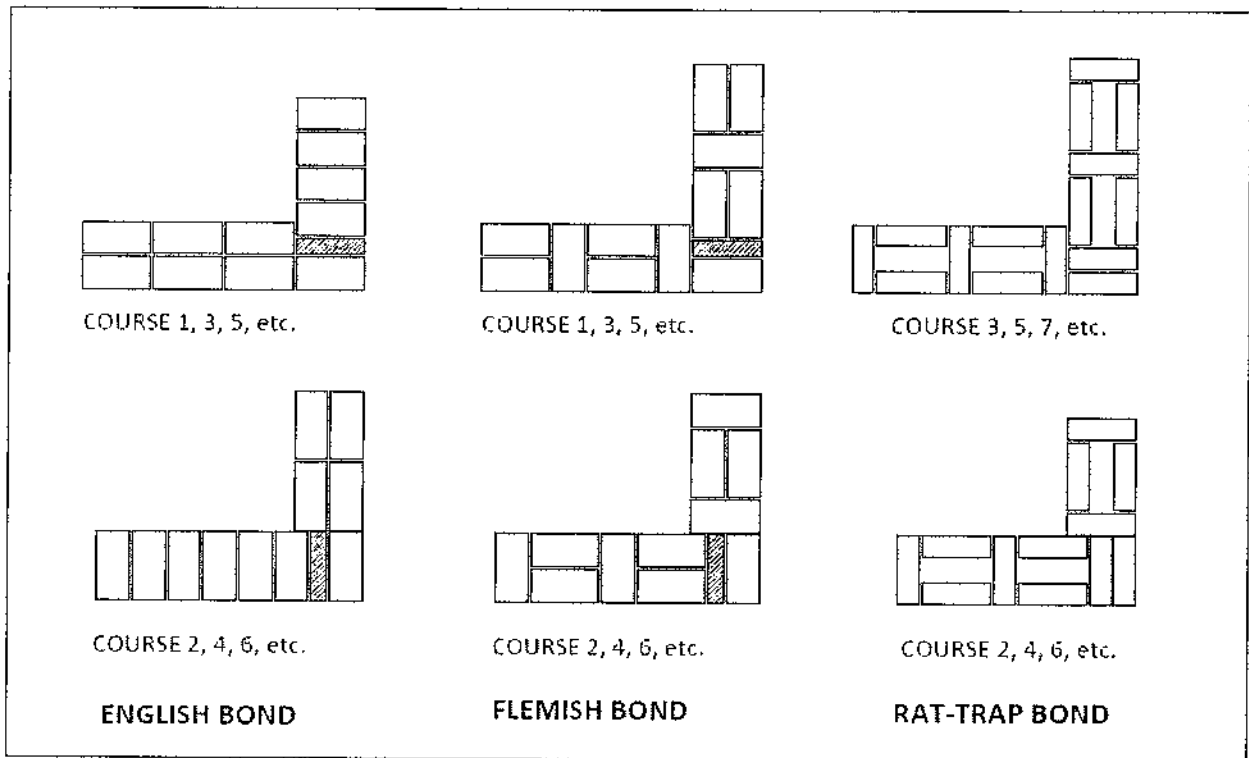


Figure 1: Rat-Trap Masonry



* 1st course in Rat-trap bond is solid masonry.

Figure 2: English bond, Flemish bond and Rat-trap bond

Performance Validation:

- Rat-trap bond Technology has been promoted by national organizations BMTPC & HUDCO.
- The technique has been validated by the Department of Civil Engineering, Anna University, Chennai.
- Rat trap bond can be very easily adapted for earthquake/ seismic strengthening i.e. provision of horizontal tie bands and vertical reinforcement in the brickwork cavity.
- Rat trap bonded brick masonry has been widely used in all parts of the country. Its excellent weathering over the past 30 years is the best performance guarantee.

Design and Construction:

The principal requirement for rat-trap brickwork is the availability of good quality bricks. The following can be taken as guiding principle for strength of bricks for Rat-trap brickwork:

Type of building construction (Span not exceeding 4.2 meters, Roof/ floor loads as per IS 875)	Recommended compressive strength of brick	
	Best Practice	Minimum allowable
Load bearing, double storied	More than 50 kg/cm ²	40 kg/cm ²
Load bearing, single storied	More than 40 kg/cm ²	35 kg/cm ²
Infill masonry in frame structure, no restriction on number of stories	Minimum 35 kg/cm ²	

- All other properties of bricks shall confirm to IS 1905-1987.

Modular design

To ensure maximum advantage of the technique, it is preferable that the masonry is designed in a modular pattern at the design stage itself, after the prevailing brick size available for use has been ascertained. For best Rat-trap brickwork, there should be no half bricks/ quarter bricks used in brickwork, unlike their common use in conventional brickwork. This will disturb the staggering of joints in rat-trap brickwork and affect the integrity of brickwork. For a brick size of 230x115x75mm and mortar thickness of 10mm, a typical module length will be 325mm (Figure-3).

The length of the masonry and the location and size of openings can be determined in multiples of this typical module length, keeping in mind the solid brickwork at wall corners and the 2 ends of door and window openings (Figure-4).

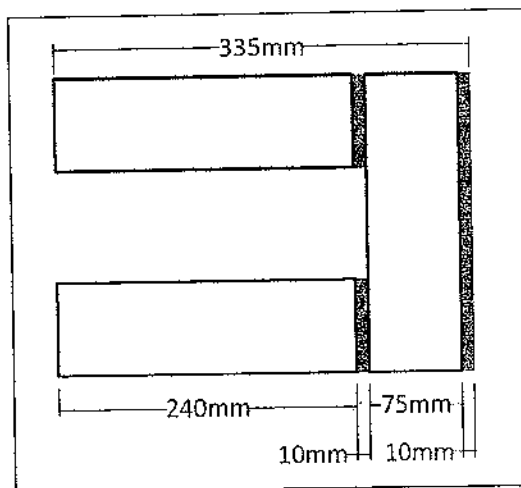


Figure 3: One Module of Rat-trap masonry using a brick of size 230mm X 115mm X 75mm

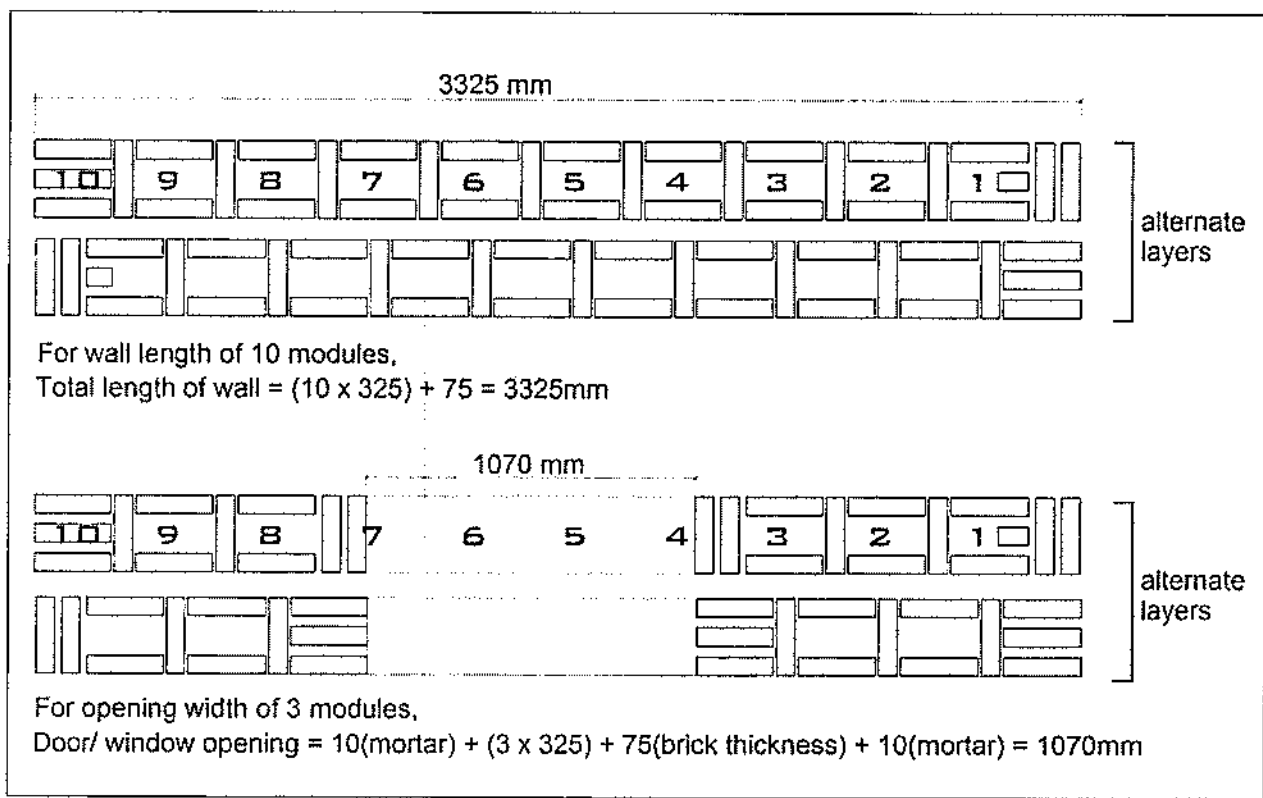


Figure 4: Modular design of masonry and openings in Rat-trap bond

Building up the masonry:

- Before a brick is placed for masonry work, it should be thoroughly soaked in water. This is needed so that any dust/ dirt on the surface of brick is washed away and that the brick is wet enough to not soak the water from freshly laid cement mortar, thus weakening the mortar. Ensure that the bricks being handed to the mason have been immersed in water for at least one hour. It is not good enough to dip the brick in water just before placing it in the wall.
- For mortar, the cement-sand proportion depends on the quality of the brick and the building design which determines the load on the masonry. Mortar with 1:6 (cement: sand) is generally preferred for this masonry.
- The first course is always laid solid. Fill all cavities in the first course by filling them with bricks. Then build up the masonry, ensuring line and plumb, similar to the process followed in conventional masonry.

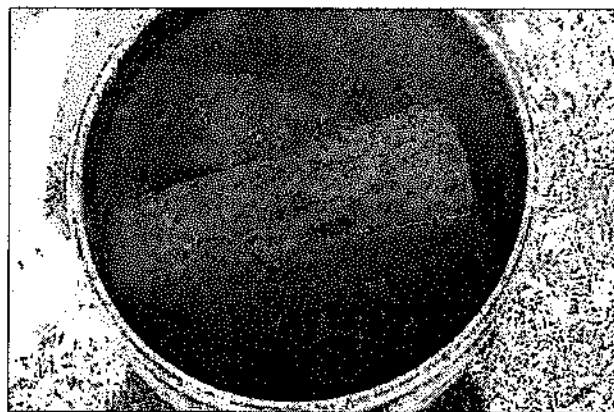


Image 1: Soaking of bricks

- A thickness of 12mm is recommended for the mortar joints, however, a slight reduction in the thickness of vertical joints is allowable because the contact area is much smaller at the side of the brick than at the bottom and top. Care must be taken to ensure that the entire vertical joint is filled with mortar; otherwise the brick masonry wall will be prone to leakages.
- As per design principles of conventional masonry, the corners and the openings represent the weak areas in masonry and should be designed for adequate strength, depending on factors like building design and the seismic strengthening requirements. Therefore, all masonry corners and ends of openings in rat-trap brickwork are constructed solid, without any cavity.
- The maximum Rat Trap Bond brick wall height per day should not exceed more than 8 layers. The added weight by each new course of brickwork is carried by the mortar which should get sufficient time to harden and to be able to carry the load of brick course without developing cracks under the load of courses above it.



Image 2: Wooden tool while laying mortar

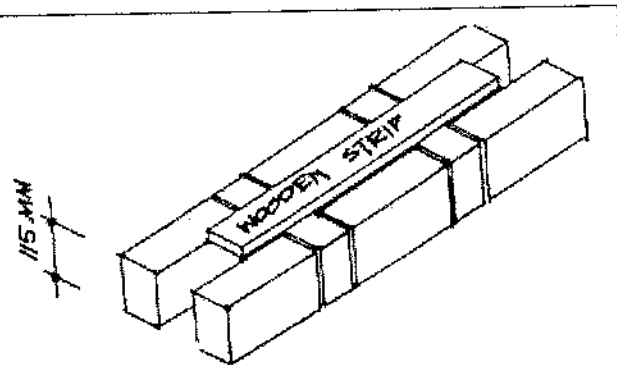
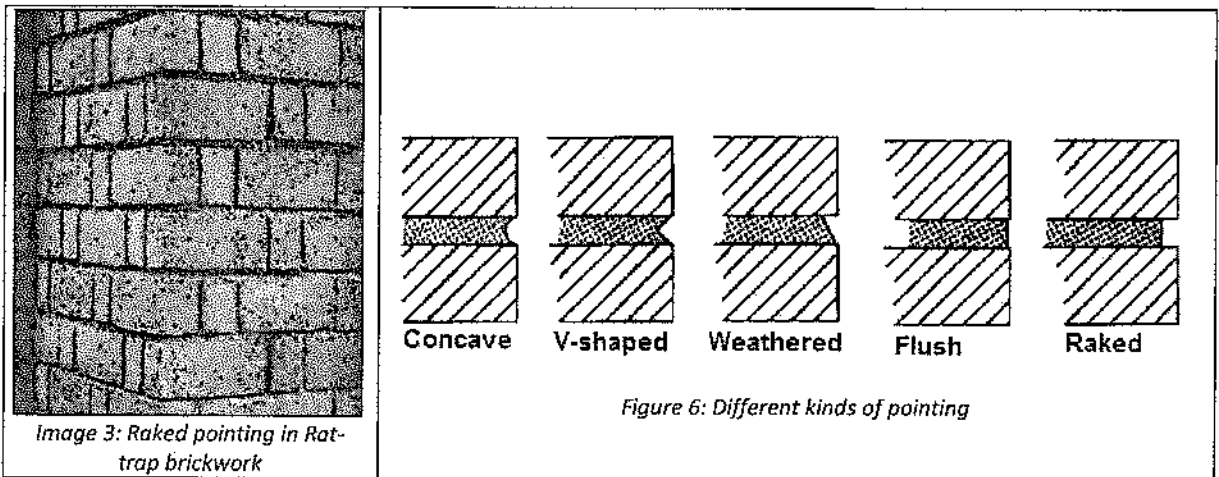


Figure 5: Wooden strip while laying mortar

- It is important to use a tool/ wooden strip of length around 1m and width slightly less than the size of the cavity, for laying mortar in rat-trap brickwork so that the horizontal mortar bed can be laid swiftly without mortar falling inside the cavity of brickwork. (Image-2, Figure-5)
- **Sill level masonry:** Ensure that the window opening fits in the rat-trap brickwork modules. The brick course at the sill level is to be laid solid so that it can subsequently be finished with as per the given detail. It is good practice to project the sill beyond the wall, this allows for both better protection from rain water by finishing it in an outward slope and also improves the aesthetic appearance of the wall.
- **Lintel level masonry:** Similar to the sill level masonry, the brickwork at the lintel level is also constructed solid in the form of a band of solid brickwork around the perimeter of the building. In case a sunshade is to be provided, different details can be developed for integrating it with the lintel level brickwork. For instance, corbelling of brickwork can be done to provide the base for the sunshade.
- **Top of wall/ Roof level masonry:** The topmost course of masonry should also be constructed solid, to provide adequate bearing for the roof slab or for precast roofing elements. Alternatively,

depending on the desired roof level detail the topmost solid course can also be provided by placing the brick in conventional way and not necessarily with brick on edge. Ideally, another band of corbelled brickwork can be provided on the topmost course to mark the roof level.

- **Pointing:** Generally, Rat-trap masonry is finished neatly and left unplastered because of its aesthetical appearance and saving on plastering. Therefore, pointing is important in Rat-trap bond masonry to increase resistance of mortar joints to water penetration and to enhance aesthetic appearance of unplastered wall.



Pointing can be of different types (figure-6) and should preferably be carried out as brickwork proceeds, after every 3rd or 4th course. The same mortar which is used for brickwork can be used for pointing. In case of raked/ recessed pointing, it is important to make the mortar joint more water tight. After the joint is raked out to a depth of 1 to 1.5cm, it is brushed, washed and finished with a rich cement mortar of ratio 1:2.

Another method is to finish the masonry work first and then make the pointing work with a 1:2 cement mortar later. This is suitable only for Flush pointing because it is not practical to rake out the mortar joint after it has hardened.

Curing:

The walls are mostly exposed to wind and sunshine which will dry out the moisture in the mortar joints and will prevent it from hardening adequately. To avoid this, all brick masonry needs regular curing for at least 7 days.

Construction details:

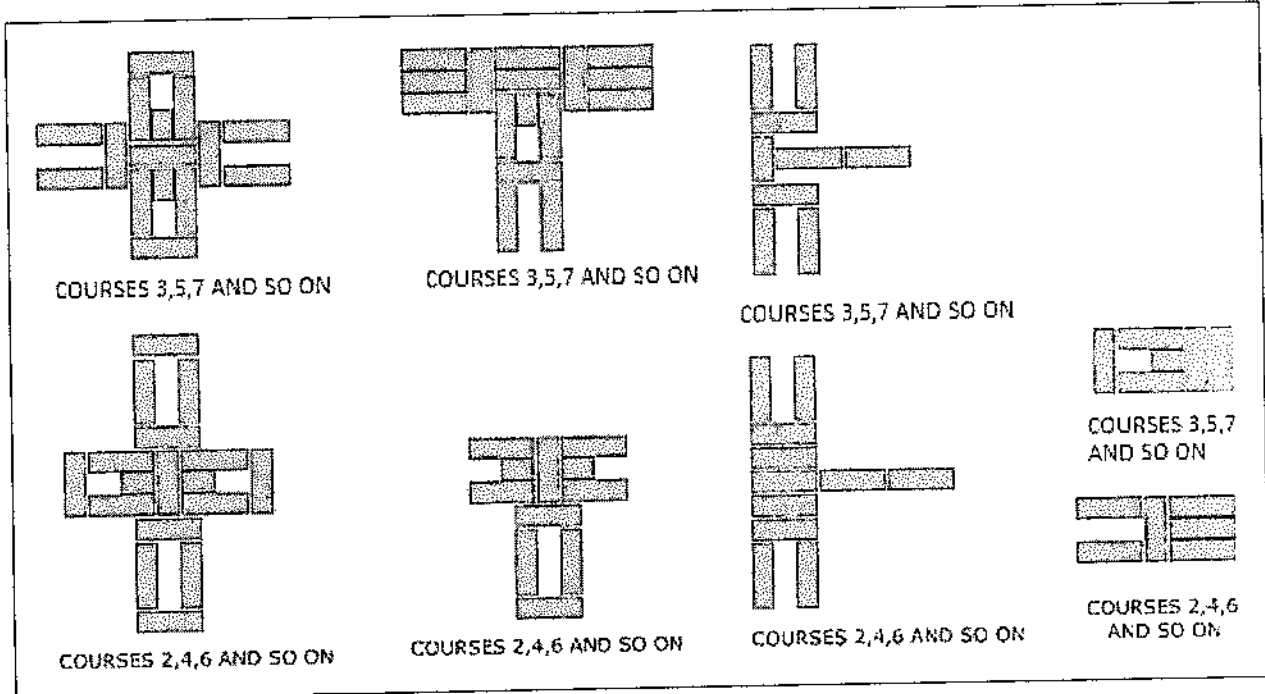
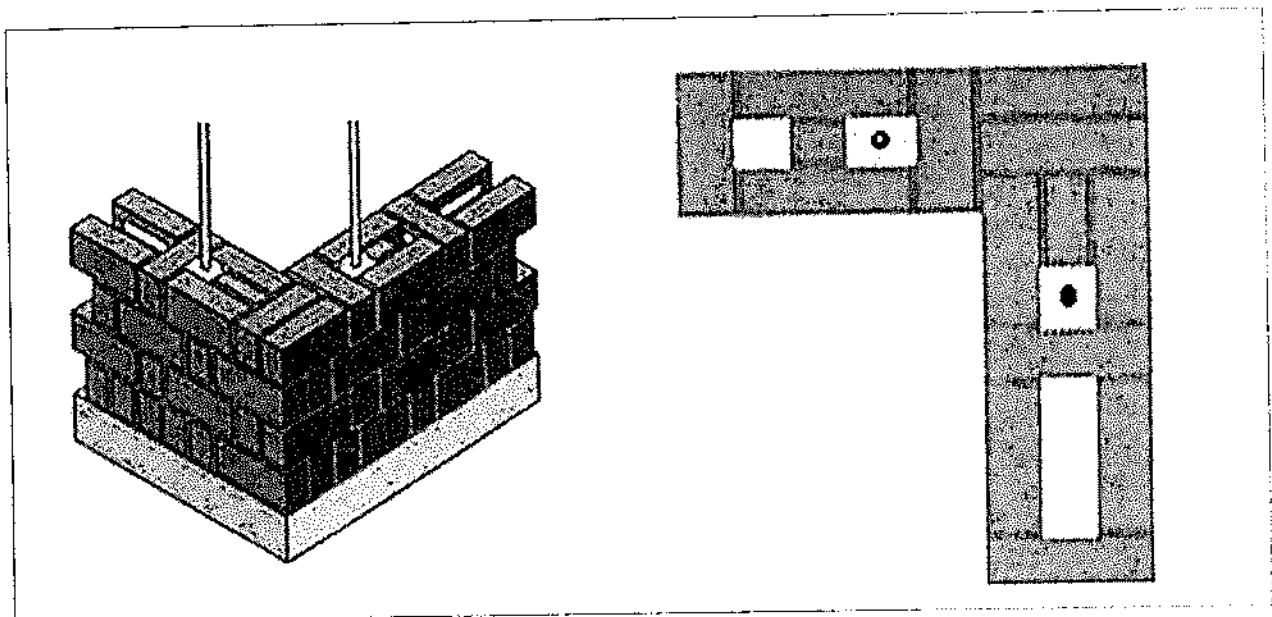


Figure 7: Typical junction details in rat-trap bond brickworks

To improve earthquake resistance, the Rat-trap masonry walls can be reinforced with steel bars at all corners (Figure-8), around openings (door and windows), T-junctions (Figure-9) and filled with a M20 concrete. The diameter of reinforcement depends on number of stories, storey height, seismic zone, importance of building and soil type. It should not be less than 12mm.



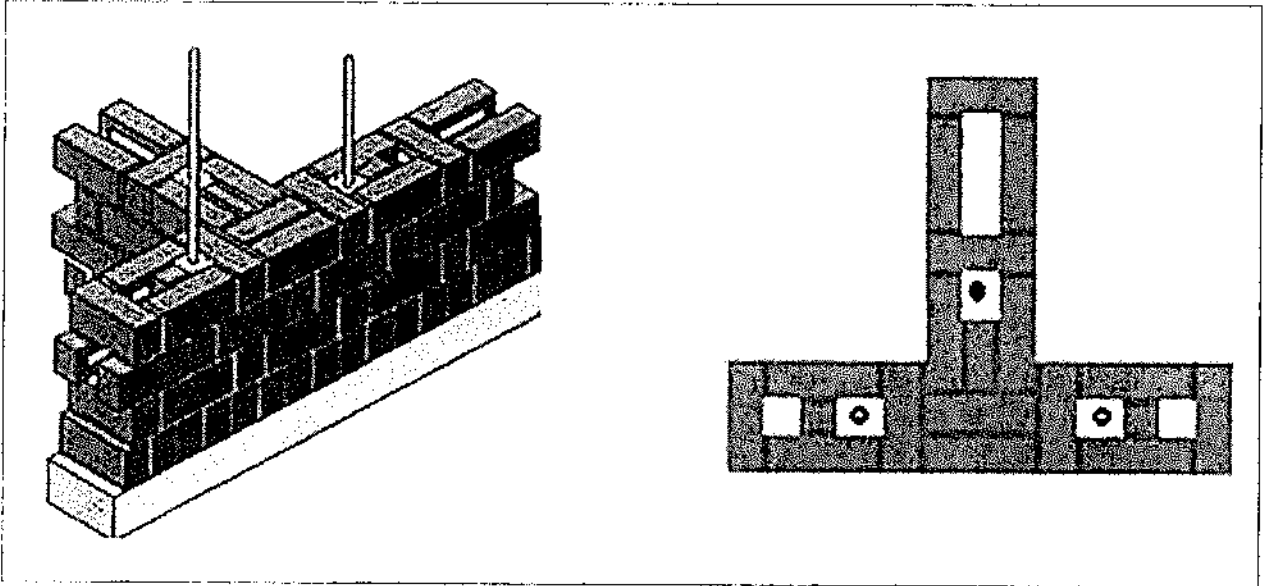


Figure 9: Reinforced T-junction in Rat-trap brickwork

In addition to vertical reinforcement, reinforced concrete bands can be provided at three levels – sill, lintel and roof level. These bands, typically with 2 bars of 8mm dia, can be provided like an open or a concealed element to tie the structure together with vertical reinforced masonry for earthquake resistance (Image-4, 5).

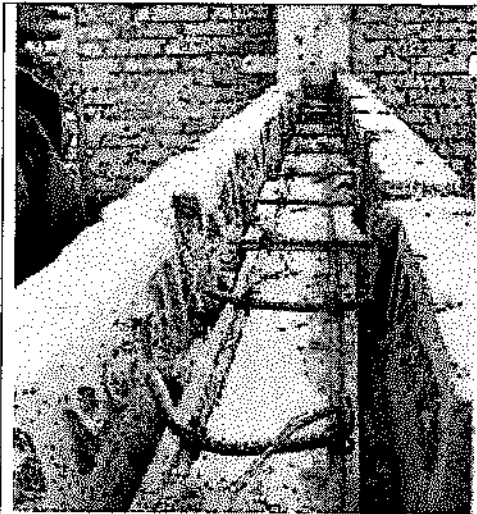


Image 4: Concealed RCC band under progress

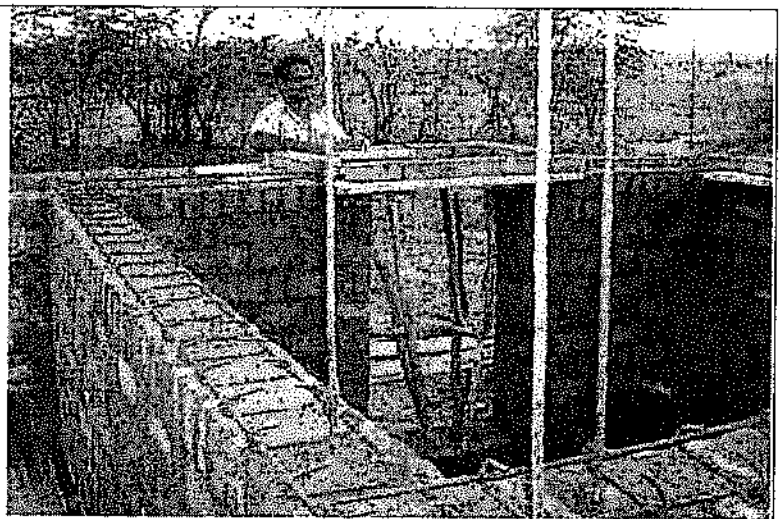


Image 5: Open RCC band under progress

Electrical and Sanitary installation:

Generally the vertical installation of any type of concealed material (GI pipe, electro pipe, PVC pipe etc.) poses the challenge of pre-planning. It is not possible to chase the rat-trap brickwork like conventional masonry. Therefore, solid masonry can be planned and provided at locations which need to support the external conduiting. For concealed work, the cavity of the wall can be used to install the required

electrical/ sanitary pipes up to 75mm in diameter. Exit holes for the conduits must already be made during the construction of the wall and once the pipe installation is completed closed in such a way that the rat-trap brick bond is maintained

The installation of horizontally concealed pipes can be at times quite challenging. Good planning for horizontal installation is required. Bricks can be gently chiseled at the spot where the pipe will be placed (Image-6).

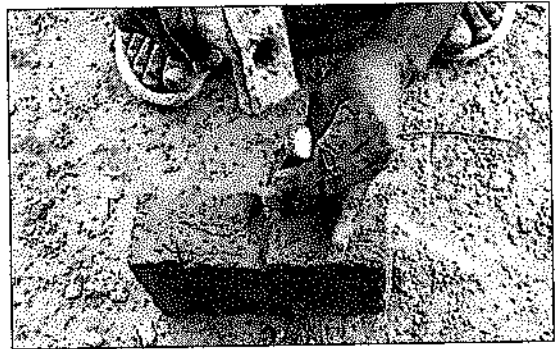


Image 6: Chiseling of brick

Dos and Don'ts:

- Ensure that good quality bricks with neat and straight edges are available for brickwork – do not use bricks of poor quality or non-uniform dimensions for rat-trap brickwork.
- Rat-trap brickwork is modular in nature. Follow a modular design for length of walls and sizes of door-window openings – the module size depends on the available bricks. If this is done, then there is no need for any half or quarter bricks in rat-trap masonry
- Always lay the first 2 courses of brickwork in a dry run (without mortar) to ensure the exact location and size of openings as per the rat-trap module and to ensure that joints in the remaining courses will be properly staggered with the first 2 courses.
- A solid course of brickwork should be laid at plinth, door and window sill/lintel level and roof level.
- In case of exposed brick masonry, pointing should be done, with the mortar joints finished with rich cement mortar.
- Pre-plan the placement of electrical/ sanitary conduits – Do not chase rat-trap masonry because there is risk of damaging the brickwork because of the cavity in the wall.

Advantages of Rat-trap bond:

- Economy in use of bricks- generally, as compared to 500 bricks per Cubic meter of brick wall for English bond masonry wall, 400 bricks are needed in Rat-trap bond masonry. This also results in saving in quantity of cement and sand because lesser mortar is needed.
- Provides better thermal comfort because of the air cavity in the brickwork - the building interior remains cooler in summer and warmer in winter.
- As good quality bricks are required for Rat-trap bond masonry, plastering is not required.

Limitations:

- It is most suited where good quality bricks with straight and sharp edges are available - better avoided when good quality and uniform size bricks are not available
- If the mason is not skilled enough, cement mortar can get wasted by falling into the wall cavity.

- Needs pre-planning in case of concealed electrical conduiting because chasing brickwork, like in conventional practice, is not possible. However, this can be taken care of by identifying location of wiring and plumbing in the design and planning stage.

Data for Rat-trap bond:

- Brick masonry in CM (1:6) using 2nd class bricks (230mm X 110mm X 75mm), having compressive strength not less than 35kg/ cm² With Rat trap bond of 230mm thick.
- Output: 1 cum.

Material description	Unit	Quantity	Labour description	Unit	Quantity
Bricks	No.	400	Skilled	Man days	1.56
Cement	kg	36	Unskilled	Man days	3.95
Coarse sand	cum	0.15	Curing Labour	Man days	0.50
Scaffolding	sqm	4.35			

Reference:

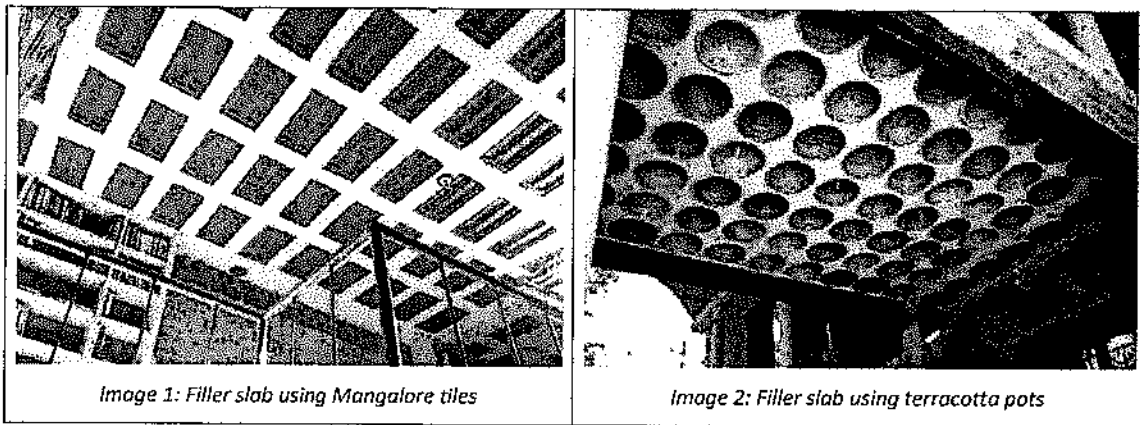
- Rural Housing Knowledge Network (<http://www.ruralhousingnetwork.in/>), MoRD
- Vidyalayam- Cost effective technologies for primary school construction, Govt. of Andhra Pradesh
- The Centre of Science and Technology for Rural Development (COSTFORD)



'FILLER SLAB' ROOFING

Introduction:

Filler slab is a variation of conventional reinforced cement concrete slab in which part of the concrete is replaced with a filler material which can be a waste material to ensure economical advantage over an RCC slab. The filler materials commonly used are burnt clay tiles (such as Mangalore tiles), bricks, coconut shells, thermocol, terracotta pots, Compressed Stabilized Earth filler blocks, etc. The filler slab was first popularized by architect Laurie Baker in India in the late 1970s and subsequently promoted by HUDCO through its national network of building centers. It has been successfully tested for structural performance by the Research and Development laboratory by the Civil engineering department of Anna University, Chennai.



Design principle:

In simply supported RCC slab, Concrete above the neutral axis takes care of compressive forces and steel below the neutral axis takes care of tensile forces. Concrete in the bottom half do not satisfy any structural purpose, instead it increases dead load on the RCC slab. In a filler slab this unnecessary concrete is replaced with filler material which is cheaper and also lighter than the equivalent concrete. In addition to replacing concrete with a cheaper material, the dead weight of the slab can also thus be reduced which in turn reduces the quantity of reinforcement.

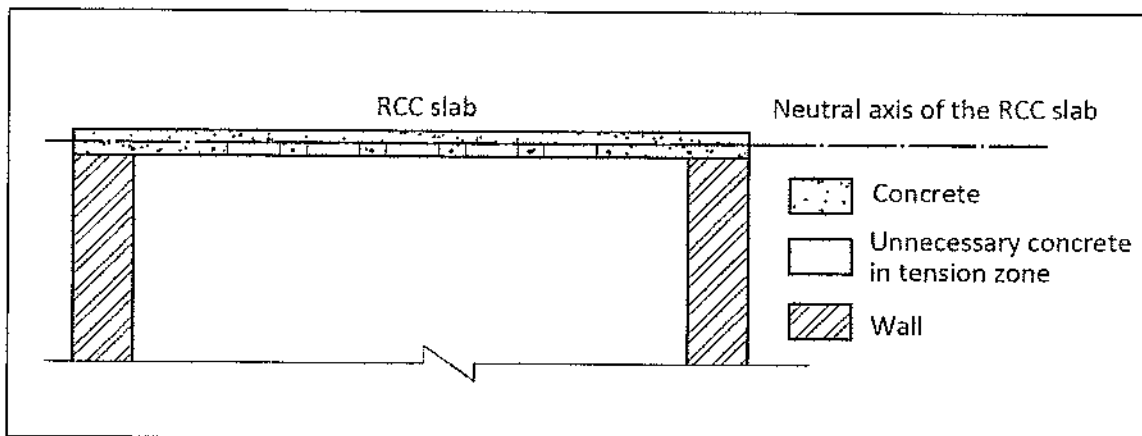


Figure 1: Unwanted tension concrete in RCC slab

Design parameters:

- The filler slab can be designed like a conventional RCC slab as per IS 456-2000 design guidelines, after taking into account the dead load reduction due to the filler material and the spacing of reinforcement as per the size of the filler material. There can be a conflict between filler size and the minimum spacing of reinforcement as per the code, which needs attention while selecting the filler material.
- The size and shape of the filler material are governed by factors like code guidelines for slab thickness, local availability of the filler material, desired ceiling finish, etc. and must be carefully selected.
- Quantity of concrete in the tension zone of the slab that can be replaced by a filler material depends on the shape of the filler material available and the thickness of the solid slab.

Sr. No.	Type of filler material	Size of portion of slab using filler material		
		Length (mm)	Breadth (mm)	Thickness (mm)
1	Mangalore tile (double- one on top of another)	410	260	65-70
2	Stabilized mud block (single)	230	190	50-100
3	Burnt clay brick (double)	230	200	75

Construction:

- The first step is to identify the filler material to be used in slab construction, as prescribe above.
- The shuttering for the slab is erected, just like for a conventional RCC slab
- After erecting the shuttering, the designed reinforcement is laid with a minimum bottom cover of 15mm. This forms a grid and the filler material is placed centrally in each space of the grid. No filler material is provided in bands of concrete along the edge of the slab. The width of this band depends on the actual slab dimensions, thickness of slab and the edge conditions and is normally minimum 300mm. The reinforcement spacing in these bands is smaller than spacing around the filler materials.
- After all the filler materials have been placed, any conduits, such as for concealed electrical work, should be placed in the spaces between the filler material and not on top of them.
- After the filler material has been completely laid, concrete using the given mix is placed to completely fill in the spaces between filler materials and on top of the filler material to achieve the slab thickness.
- In most cases, it is not advisable to use the concrete vibrator to compact the concrete in the bottom portion of the slab which contains the filler material. This may disturb the placement of the filler materials. Therefore, special care must be taken to compact this concrete manually with tamping rods. The concrete on top of the filler materials is compacted with plate vibrator and finished.

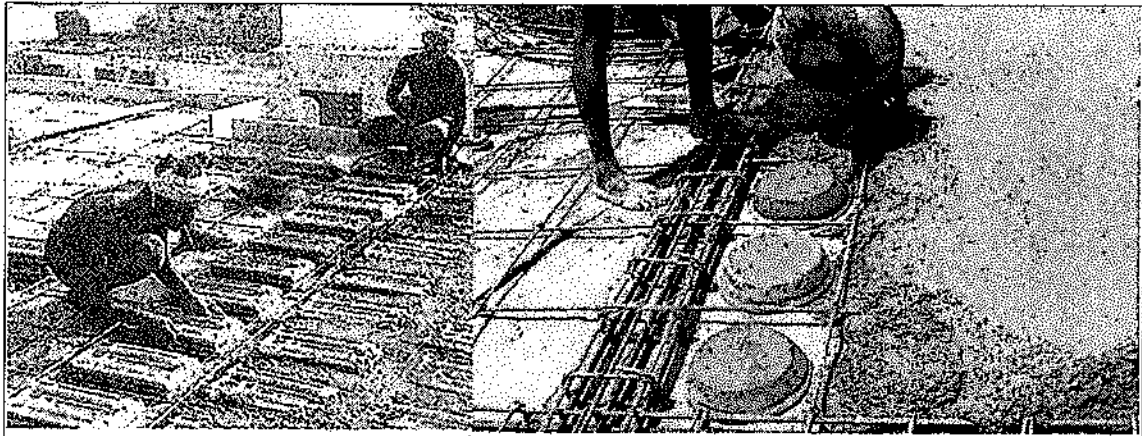


Image 3: Filler slab casting with Mangalore tiles as filler material

Image 4: Filler slab casting with terracotta pots as filler material

- Typical reinforcement layout for filler slab with Compressed Stabilised Earth Filler block (230mm X 190mm X 50mm) as a filler material is given below (Figure-2)

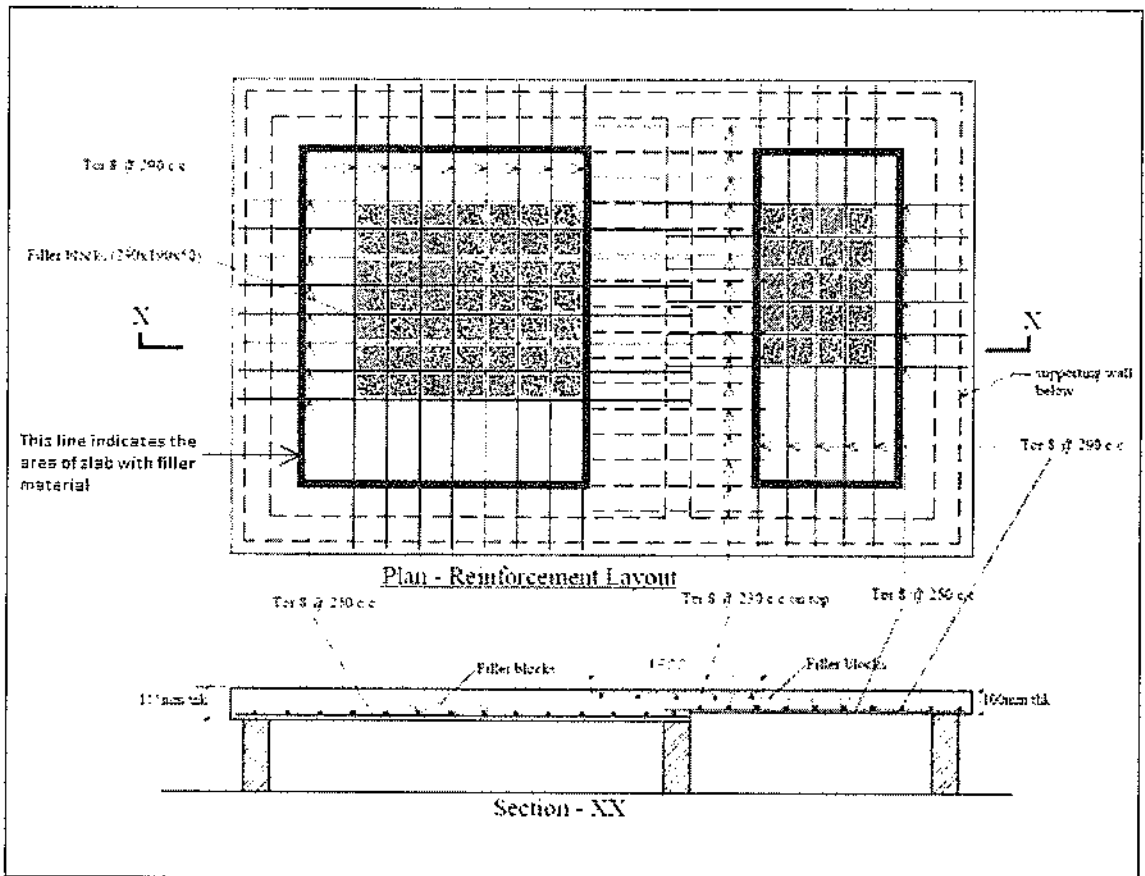


Figure 2: Reinforcement layout for a filler slab using filler blocks

- Typical cross section of filler slab:

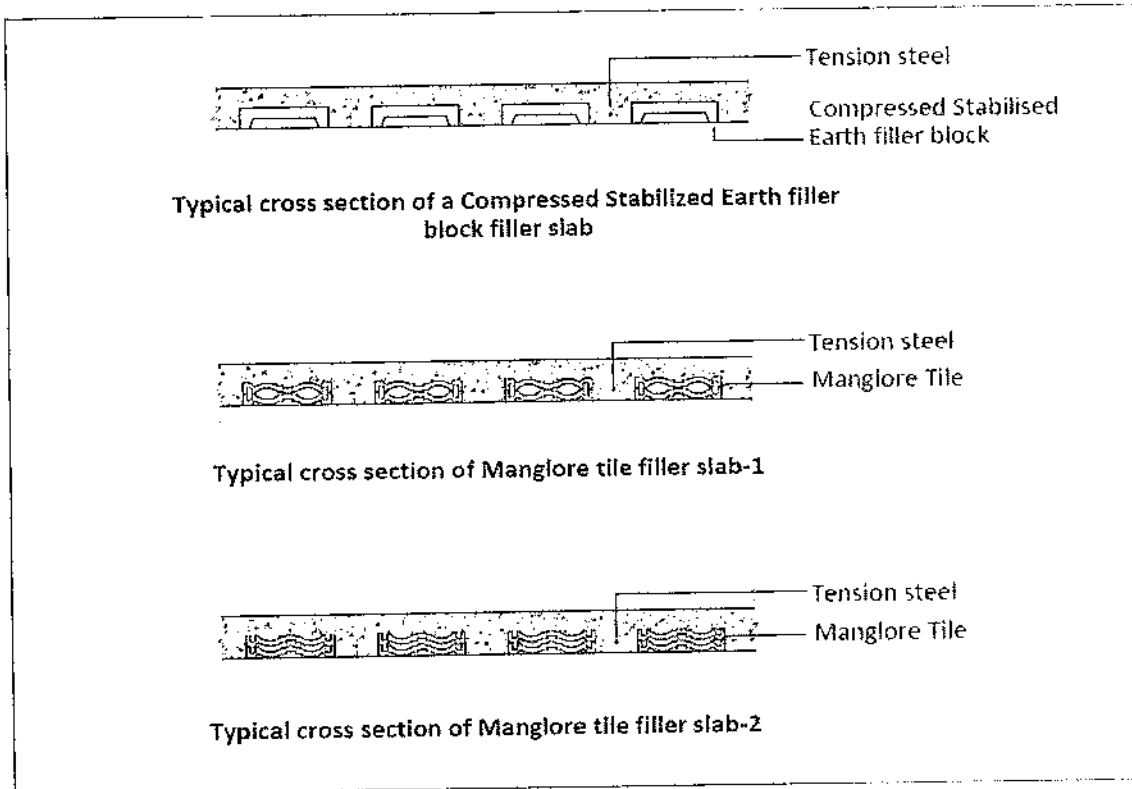


Figure 3: Typical cross sections of filler slab with Compressed Stabilised Earth Filler Blocks and Manglore tiles as filler material

Dos and Don'ts:

- General precautions and quality control measures for filler slab construction are similar to conventional RCC slab.
- While concreting, care should be taken not to displace the filler material.
- Proper cover to the reinforcement should be ensured by placing pieces of aggregate or cover blocks below the reinforcement before concreting.

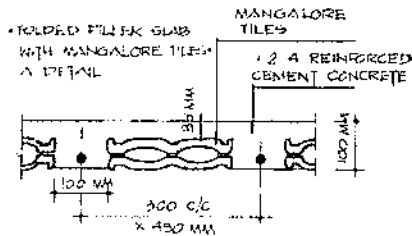
Advantages of Filler slab:

- It enhances the thermal comfort inside the building due to heat resistant qualities of the filler materials used. In the case of waste roofing tiles as filler, the air gap in between the tiles makes it a good heat insulator.
- Reduction (20%) in the use of concrete results in saving in the cost of cement and aggregate compared to cost of cheaper filler material.
- Ceiling of this slab can be given an attractive appearance with the filler material and therefore, a ceiling plaster is not needed
- Masons who are familiar with conventional RCC slab construction can easily adapt to filler slab construction
- Filler slabs can be used wherever RCC is used, for e.g. as floor slabs for multi-storied buildings, for sloping roofs, etc.

Limitations:

- Since vibrators cannot be used in spaces between the filler materials, extra care is needed to manually compact the concrete in this space.

Data for Filler slab:



1.00 Cubic meter of filler slab with 1:2:4 R.C.C. and Mangalore tiles, with slab thickness 100mm.

Material description	Unit	Quantity	Labour description	Unit	Quantity
Cement	kg	331.2	Skilled Mason	Nos	167
Sand	cum	0.46	Unskilled labour	Nos	3.72
Aggregate 20mm size	cum	0.61	Curing labour	Nos	1.22
Aggregate 10mm size	cum	0.31	Bar bender	Nos	0.82
Mangalore tiles	Nos	105			
Binding wire	kg	0.5			
Steel	kg	33.33			

*Depending upon tile size, the number of tiles and reinforcement spacing will vary.

*Data is exclusive of centering and shuttering charges.

Reference:

- Rural Housing Knowledge Network (<http://www.ruralhousingnetwork.in/>), MoRD
- Vidyalayam- Cost effective technologies for primary school construction, Govt. of Andhra Pradesh
- The Centre of Science and Technology for Rural Development (COSTFORD)
- K.S. Jagdish, Alternative Building Materials and technologies, 2013

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CT 08

Specifications for Reinforced Brick and Reinforced Brick Concrete Slabs for Floors / Roofs



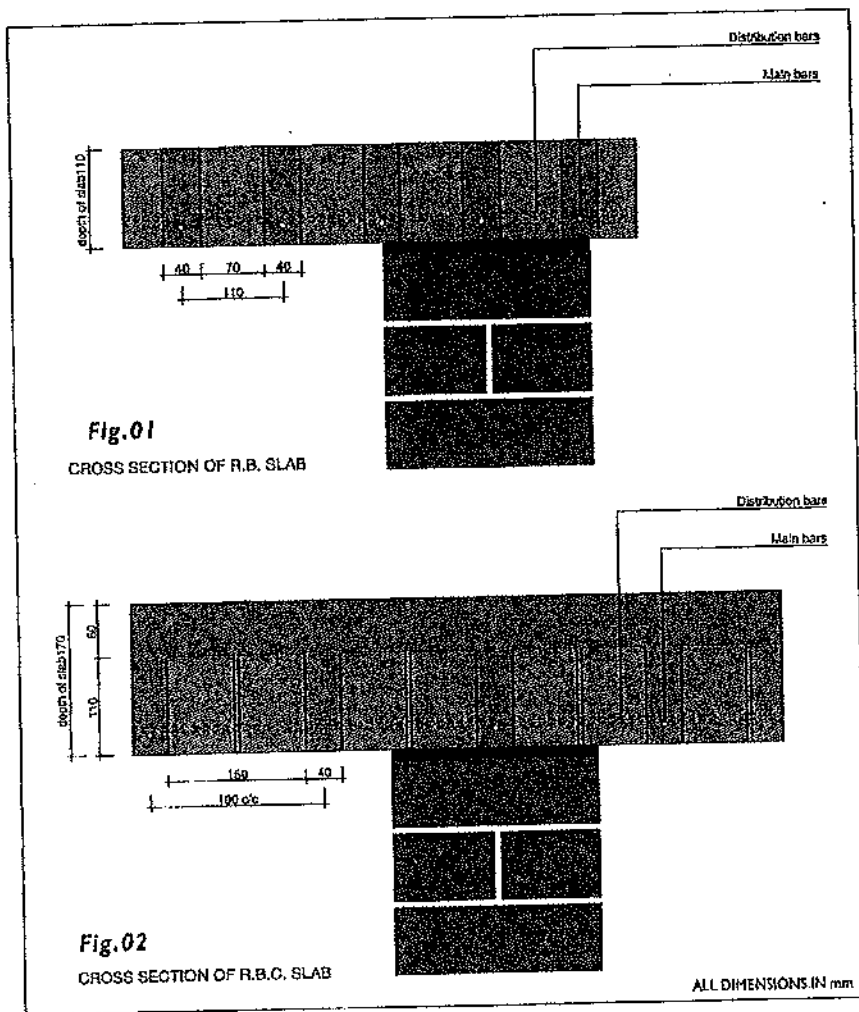
1 General

- 1.1 Reinforced brick slab consist of bricks, steel and mortar while reinforced brick concrete slab comprise of bricks, steel and concrete. In case of Reinforced Brick (RB), the compression is taken by brick while in Reinforced Brick Concrete (RBC), the compression is taken by cement concrete, thus in RB, good quality bricks are required. In later case, the slab can be laid even with low strength bricks. In both cases bricks can be placed either flat or on-edge. RB slab can be constructed with two layers of bricks depending upon the load and span.
- 1.2 Reinforced brick work (Fig.1) is practically the same as reinforced concrete in all its essential features except that brick work in cement mortar is substituted for cement concrete.

2 Dimensions and Tolerances

- 2.1 **Reinforced Brick Slab**
 - 2.1.1 Reinforced brick floor/roof shall consist of good quality bricks placed each brick on-edge with keeping 8mm to 10mm dia. MS bars in joints width of 30 mm in both direction filled up with cement mortar. Normally span shall vary from 2.4 m to 3.6 m. The reinforcement spacing shall form grid of 190mm x 260 mm.
 - 2.1.2 The thickness of floor/roof shall also vary 110mm to 150mm (Fig. 1).

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(011)



- 2.2 **Reinforced Brick Concrete Slab**
- 2.2.1 In reinforced brick concrete construction cement concrete M-20 shall be used in conjunction with bricks (Fig.2). Normally two bricks-on-edge shall form reinforcement grid of 260 mm. The cement concrete, joints thickness shall be 40 mm. On top of the bricks 30 mm to 50mm cement concrete M-20 shall be laid along the joints. The compression zone shall be made up of concrete alone. Bricks shall be considered as fillers.
- 2.2.2 Normally, span shall vary from 2.4 m to 3.9 m with reinforcement of

- 10 mm or 12 mm MS bars.
- 2.2.3 The thickness shall be 150 mm, having top concrete of minimum 40 mm.
- 2.3 **Tolerances** – On joints and thickness of slab shall be ± 3 mm.
- 3 **Materials**
- 3.1 **Bricks** - These shall be of atleast Class 75 for RB and Class 35 for RBC construction and conforming to IS 1077. Overburnt bricks having vitrified surface shall not be used.
- 3.2 **Cement Concrete** - Cement concrete used in filling the interstices in reinforced brick slabs and for providing top decking of

reinforced brick concrete slabs shall be of grade not less than M-20 and shall conform to IS 456. It shall contain just enough water to flow freely without segregation of the aggregates. The size of the aggregates may be suitably selected to suit the construction.

- 3.3 **Reinforcement** - It shall conform to IS 432 (Part 1) or IS 1786. Reinforcement shall be free from rust scale or other coating.
- 3.4 **Centering and Formwork** - The formwork shall consist of timber or steel possessing sufficient strength so as to carry the superimposed load. Unless otherwise specified formwork shall consist of platforms composed of planks or sheets supported on runners or beams. The props and bracings supporting the platforms shall have sufficient lateral stability.

4 **Structural Design**

- 4.1 **Reinforced Brick Slab**
- 4.1.1 The behaviour of reinforced brick slab is similar to that of reinforced concrete. Within the range of practical applications of reinforced brick slabs, failures are generally by yielding of tensile reinforcement. R.B. slabs may be designed by the same methods as followed in R.C.C.
- 4.2 **Reinforced Brick Concrete Slab**
- 4.2.1 RBC slabs may also be designed like R.C.C. slab, both by working load as well as limit state methods given in IS 456.
- 4.2.2 A continuous RBC slab is to be designed at the support like R.B. slab. The bottom reinforcement is to be continued over the support and advantage of this reinforcement taken in resisting the compression.

- Reinforcement for taking negative moment over the support is to be provided in the top concrete.
- 4.3 Reinforcement**
- 4.3.1 Design** - The reinforcement in RB and RBC slabs shall be designed according to the provision of IS 456 taking the spacing of bricks into consideration. The reinforcement in either direction shall, however, not be less than 0.20 percent of the cross sectional area of the slab where plain steel bars are used and not less than 0.16 percent where high strength deformed bars are used.
- 4.3.2 Spacing** - The horizontal distance between two parallel main reinforcement shall not be more than three times the effective depth of the slab or 450 mm whichever is smaller. The pitch of the distribution bars shall not be more than five times the effective depth or 450 mm whichever is smaller.
- 4.3.3 Protection Against Corrosion** - Reinforcements shall be so placed that they do not touch bricks at any point. A minimum cover of 25 mm shall be provided all round the reinforcement. Further measures for preventing corrosion of reinforcements shall be taken as recommended in IS 9077. In general, two bars shall not be used in the same joint.
- 5 Method of Construction**
- 5.1** Medium absorption bricks (about 15 percent) should be preferred since these develop comparatively high bond strength with mortar.
- 5.2** Bricks should be thoroughly wetted and preferably soaked in water before use but at the time of laying it should be ensured that they are skin-dry.
- 5.3 Erection of Centering and Formwork** - Centering shall be erected to support the RB floor or roof from below. The centering shall be smooth, clean and to correct alignment. The top surface of formwork shall be given an upward camber of 1 mm for every 150 mm of span subject to a maximum of 30 mm to allow for initial settlement. Before laying the slab, the formwork and the supports shall be checked to prevent undue sag and to ensure overall safety and stability of the formwork.
- 5.4 Detailing of Reinforcement** - All main and distribution reinforcement shall be placed in the position shown in Fig. 1 & 2 and shall be completely embedded in concrete. They shall be rigidly secured against any displacement and arrangement shall be made to ensure proper cover to the reinforcements. Splices in adjacent bars, if needed shall be staggered.
- 5.5 Spacing of Bricks** - The bricks prepared shall be laid as show in Fig. 1 and 2 with cement mortar 1:3. Preferably a minimum spacing of 60 mm in between the bricks should be maintained for preventing corrosion.
- 5.6 Laying of Bricks and Reinforcement** - The bricks for single brick thickness of floor or roof shall be laid directly on the forms without bedding of any kind. After one row of bricks has been laid the next row is similarly laid providing the gap for concrete joint. Concrete shall be then poured in the gaps to fill the bottom of the joint to a uniform thickness equal to the clear bottom cover to the reinforcing bars. Concrete should be poured into the joints after the placement of reinforcement. Concrete shall be fluid enough to run freely around the reinforcing bars and fill the joints completely. The joints shall be puddled sufficiently with a trowel or a sharp ended 16 mm diameter rod to aid the flow of concrete to every corner and to fill any void space left in the joint due to entrapping of air or otherwise. A typical cross section of RB and RBC floor or roof is show in Fig. 1 & 2. If a slab of two courses of brick is laid, a fresh layer of concrete shall be spaced over the first course to make the middle horizontal joints and screeded properly to the desired thickness of the joint. The top course of brick is then laid in the same manner as in the first course.
- 5.7 Curling** - The brick work shall be kept wet by means of wet straw or wet sand or merely by sprinkling water gently over the surface for about 24 h after finishing. The slab shall then be watered profusely and allowed to set for a period of atleast 10 days.
- 5.8 Removal of Formwork** - The formwork for the RB and RBC floor or roof shall not be removed before 14 days after laying.
- 5.9 Finishing** - The completed floor or roof shall be further finished with a waterproofing course of lime concrete (IS 3036) or Mud Phuska with tiles (IS 2115). The ceiling shall be rendered or plastered after drying with cement mortar (1:3) or lime mortar (1:2) as specified. The plaster may be in a single coat of 12 mm thick, and shall be done in accordance with IS 1661. The finished surface of the floor or roof shall be cured with water for a period of not less than 3 weeks.



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IS 13994 : 1994
(Reaffirmed 2005)

भारतीय मानक

पूर्वढली प्रबलित प्लैक एवं जॉइस्ट से बनी फर्श एवं छत की
डिजाइन एवं निर्माण — रीति संहिता

Indian Standard

DESIGN AND CONSTRUCTION OF FLOOR
AND ROOF WITH PRECAST REINFORCED
CONCRETE PLANKS AND JOISTS —
CODE OF PRACTICE

UDC 691.328—413 : 692.4/5

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

September 1994

Price Group 4

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Housing Sectional Committee had been approved by the Civil Engineering Division Council.

Considerable shortage of houses in the country, which is also increasing continuously, has led to increasing stress being laid in the development programmes of central and state governments, on facilitating speedy and economical construction of houses. Problem of housing being greatest amongst the lower income groups, both rural and urban, the greatest stress is being laid on housing for these target groups.

This calls for development and standardization of new building materials and construction techniques which are simple and economical, commensurate with structural and hygienic safety and durability, in order to ensure speedy and economical construction.

This standard is one of a series of standards being published by BIS on new materials and techniques of roof/floor construction which when implemented will result in substantial savings in materials and cost of construction, in addition to achieving speedy construction. The other standards to be published in the series are:

- a) Precast reinforced concrete planks and joists for flooring and roofing — Specification
- b) Prefabricated brick panel and partially precast concrete joist for flooring and roofing — Specification
- c) Design and construction of roofs and floors with prefabricated brick panel — Code of Practice
- d) Precast reinforced concrete channel units for construction of floors and roofs — Specification
- e) Design and construction of floor and roof with precast reinforced channel units — Code of practice
- f) Precast reinforced concrete L-panels for construction of roofs — Specification
- g) Design and construction of roofs using precast reinforced concrete L-panels — Code of practice
- h) Construction of walls with precast concrete stone masonry blocks — Code of practice

Precast reinforced concrete planks are partially precast rectangular slab elements which are supported over partially precast RCC joists side by side and then joined together and also to the joist by pouring *in-situ* concrete over the haunches provided in the planks and the gaps between the planks over the joists. Monolithic action of the slab elements is ensured by leaving stirrups projecting out of joists and providing reinforcement across the joists over haunched portion of planks, tying them together and pouring *in-situ* concrete over it.

Roofs and floors made with precast RC planks are found economical as compared to conventional RC slabs mainly due to the following reasons:

- a) Components used for construction being precast, shuttering is eliminated.
- b) Quality can be controlled better in precast elements.
- c) Moderate size components are used thereby eliminating need for mechanical handling and erection equipment.
- d) Prefabrication leads to substantial reduction in time required for construction.

Considerable assistance has been rendered in the preparation of this standard by the Central Building Research Institute, Roorkee, who have developed these techniques.

The composition of the technical committee responsible for the formulation of this standard is given in Annex B.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

DESIGN AND CONSTRUCTION OF FLOOR AND ROOF WITH PRECAST REINFORCED CONCRETE PLANKS AND JOISTS — CODE OF PRACTICE

1 SCOPE

This standard lays down recommendations for design and construction of floors and roofs with precast reinforced concrete planks and joist. Planks up to a length of 1.5 m are covered.

2 REFERENCES

The Indian Standards listed in Annex A are necessary adjuncts to this standard.

3 MATERIALS/ELEMENTS OF ROOF/FLOOR

3.1 Precast RC Planks and Joist

The precast RC planks and joist used for construction of floor/roof shall conform to IS 13990 : 1994.

3.2 Concrete

In-situ concrete shall conform to grade M 15 of IS 456 : 1978.

4 DESIGN REQUIREMENTS

4.1 Loads

Design load on various components of the flooring/roofing shall comprise self weight, imposed load in accordance with IS 875 (Part 2) : 1987 and dead load due to floor finish in case of intermediate floors and dead load due to roof treatment in case of roofs in accordance with IS 875 (Part 1) : 1987.

4.2 Structural Design of Roof/Floor

4.2.1 Precast RC Planks

The plank shall be designed as simply supported for self weight including *in-situ* concrete over haunches, and as a continuous slab for a load comprising live load, self weight and dead load of floor finish and/or water proofing treatment. The design shall be in accordance with the limit state method of IS 456 : 1978.

4.2.2 Partially Precast Joists

4.2.2.1 The joists shall be designed as simply supported or continuous T-beam with 60 mm flange thickness (equal to full thickness of flange

with *in-situ* concrete) depending upon whether the joists are having single span or continuous over adjacent span. Reinforcement shall be determined in accordance with IS 456 : 1978 for the required spacing and span of the joists.

4.2.2.2 For large spans requiring high moment of resistance, either the depth of joist can be increased, or if depth can not be increased due to headroom requirements, the joist shall be designed as doubly reinforced beam at the support. In the latter case, the bottom reinforcement of the joist shall be kept projecting out by about 20 mm and the bottom reinforcements of joists covering adjacent spans shall be welded together for continuity. The top reinforcement to resist negative moment shall also be provided in the joists up to a distance from supports as specified in IS 456 : 1978. This shall be embedded in *in-situ* concrete (see Fig. 1). The moments and shears at various sections shall be determined either theoretically or the co-efficients given in IS 456 : 1978 may be used, wherever applicable. Moment of resistance of T-beam with different reinforcement based on limit state methods are given in Table 1 for reference.

4.2.3 Cover to Reinforcement

A minimum clear cover of 15 mm for planks and 25 mm for joists shall be provided.

4.3 When precast units are used for the construction of building in high seismic zones, the roofs/floors shall be strengthened in accordance with the provision of IS 4326 : 1993.

5. ERECTION OF FLOOR/ROOF

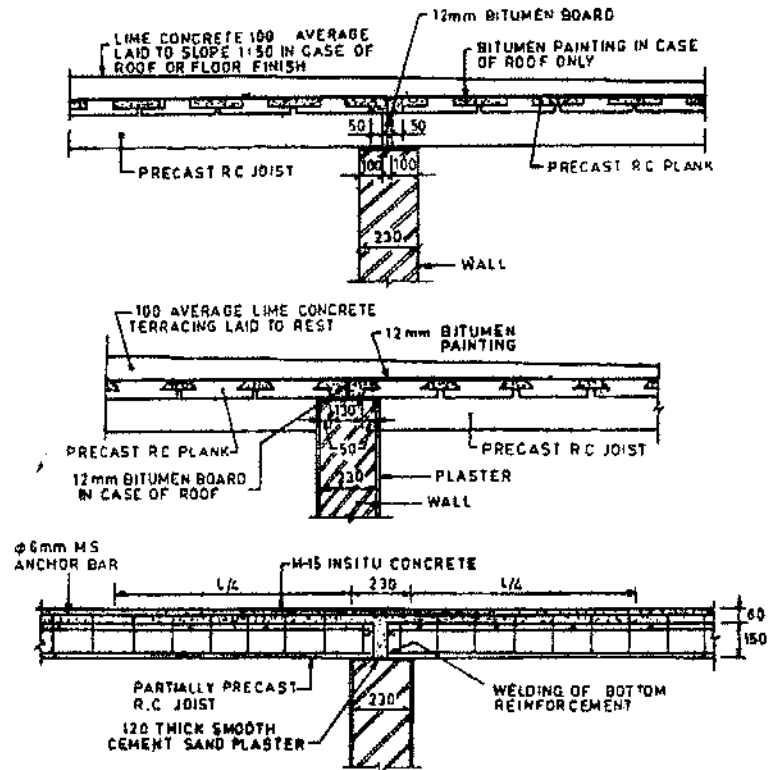
5.1 Cement concrete bed blocks of 300 mm × 230 mm × 75 mm size for joist with proportions of 1 : 3 : 6 (cement : fine aggregate : coarse aggregate) shall be laid on wall in a thickness of 75 mm. The top of the blocks shall be finished smooth.

5.2 Partially precast joists shall then be aligned over these blocks. The joists shall be propped at centre of span, immediately after putting them, with a prop having a timber plank of minimum dimensions of 350 mm × width of joist, of 30 mm thickness at bearing level (see Fig. 2). The minimum bearing of joists over the walls should be 100 mm.

Table 1 +V₀ Moment of Resistance with Different Reinforcement for Partially Precast Joist (Width 150 mm, Depth of Precast Portion 150 mm and Overall Depth with In-Situ Concrete 210 mm)
(Clause 4.2.2.2)

A. M. S. bars,									
Moment of resistance (kgm)	898	1 030	1 157	1 286	1 355	1 609	1 774	1 894	2 206
Area of reinforcement (cm ²)	2.356	2.702	3.047	3.393	3.58	4.27	4.806	5.452	6.032
Reinforcement	3-10 mm	2-10 mm + 1-12 mm	2-12 mm + 1-10 mm	3-12 mm	2-10 mm + 1-16 mm	2-12 mm + 1-16 mm	2-16 mm + 1-10 mm	2-16 mm + 1-12 mm	3-16 mm
B. Deformed bars,									
Moment of resistance (kgm)	994	1 304	1 420	1 477	1 686	1 895	2 103	2 433	2 580
Area of reinforcement (cm ²)	1.57	2.073	2.263	2.356	2.702	3.047	3.393	4.02	4.273
Reinforcement	2-10 mm	2-10 mm + 1-8 mm	2-12 mm	3-10 mm	2-10 mm + 1-12 mm	2-12 mm + 1-10 mm	3-12 mm	2-16 mm + 1-16 mm	2-12 mm + 1-16 mm

NOTE — Mild steel conforming to IS 432 (Part 1) : 1982 and cold twisted bars conforming to IS 1786 : 1985 shall be used as reinforcement.



- 1 A Typical Sketch of Details for Simply Supported Joist at Support.
- 1 B Typical Sketch of Details for Plank Bearing at Roof to Avoid Leakage
- 1 C Typical Sketch of Detail for Continuity of Joist at Support in Intermediate Floors

All dimensions in millimetres.

FIG. 1 DETAILS OF IN-SITU CONCRETE

5.3 Top surface of the walls/beams where planks have to bear, shall then be levelled smooth with 1 : 6 cement sand mortar. In case of roofs, the entire wall top shall be levelled smooth with the mortar and given a thick coat of white wash or bitumenised paper or polythene film shall be placed for free movement of roof/floor.

5.4 Precast planks shall now be placed over the joists/walls side by side. Fan hooks may be provided if the fan is to be hung in between the planks (see Fig. 3A and Fig. 3B). If, however, the fan is to be hung from the joist, a through and through hole of around 15 mm diameter is to be left in the joist during its casting and the fan can be hung by a clamp (see Fig. 3C). The minimum bearing of joists shall be 50 mm on load bearing walls and 40 mm on beams.

5.5 Reinforcing bars across the joist (that is, parallel to planks) having an area required to resist negative moment and to provide continuity to planks in successive spans shall then be placed in the haunch portions. This negative reinforcement may be determined in accordance with IS 456 : 1978. Alternatively, two 6 mm diameter mild steel grade I bars conforming to IS 432 (Part 1) : 1982 may be provided which satisfies the reinforcement requirements for normal residential buildings. Distribution reinforcement consisting of two mild steel grade I bars of 6 mm diameter conforming to IS 432 (Part 1) : 1982 shall be kept parallel to joists near the ends of the planks as shown in Fig. 4. These bars shall then be tied with the cross bars.

5.6 Near the supports of joists where two joists are meeting the negative reinforcement shall be provided (see 4.2.2.2), as shown in Fig. 1 and Fig. 4.

5.7 Cement slurry wash at the rate of 4 kg cement per 10 m² of the floor/roof shall be applied over the joists and in the haunch

portions of the precast planks where *in-situ* concrete is to be laid.

5.8 A thick paste of cement-sand (1:4) mortar shall be laid in the gaps between the planks along their length, to fill them up completely.

5.9 Cement concrete of M 15 grade with well graded coarse aggregate of maximum size 10 mm shall then be laid over the joists and in haunches between the planks and the top levelled flush with the top of central portion of the planks.

5.10 In case of roofs without parapet, the planks shall be kept projecting out by a maximum of 100 mm in either direction to avoid leakage at the junction of wall and roof (see Fig. 5). Alternatively, a maximum projection of 500 mm across the joists may be provided by providing shuttering, laying reinforcement and concreting flush with the roof treatment as shown in Fig. 5. A projection of 100 cm may be provided along the joists by providing the negative reinforcement in joist at top and projecting the same and concreting as shown in Fig. 6.

5.11 *In-situ* concrete shall be cured for a minimum period of 10 days. The props of the joists shall not be removed before the curing period is over and *in-situ* concrete has attained strength.

5.12 A minimum clear cover to all the reinforcement bars shall be 15 mm or the diameter of the bar whichever is greater.

6 FLOOR/ROOF FINISHING

6.1 For waterproofing using bitumen felts, bitumen mastic, glass fibre tissue reinforced bitumen and lime concrete, IS 1346 : 1978, IS 4365 : 1967, IS 9918 : 1991 and IS 3036 : 1992 may be referred.

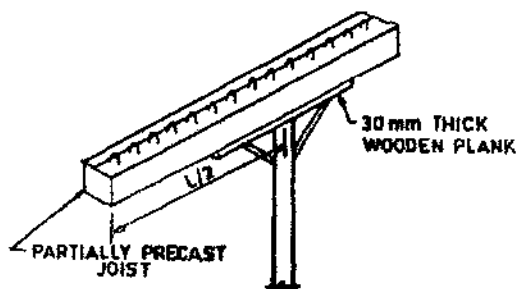
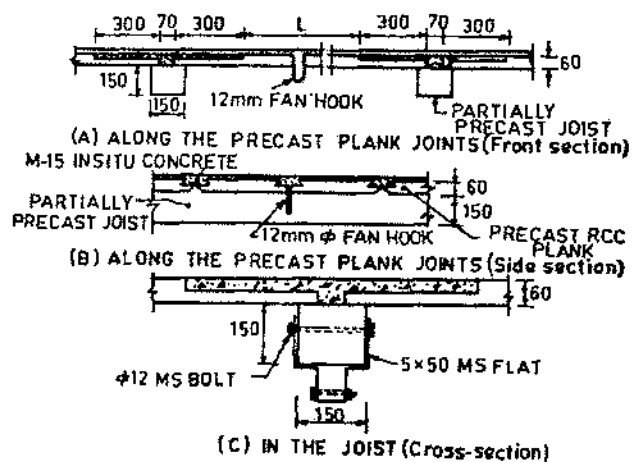
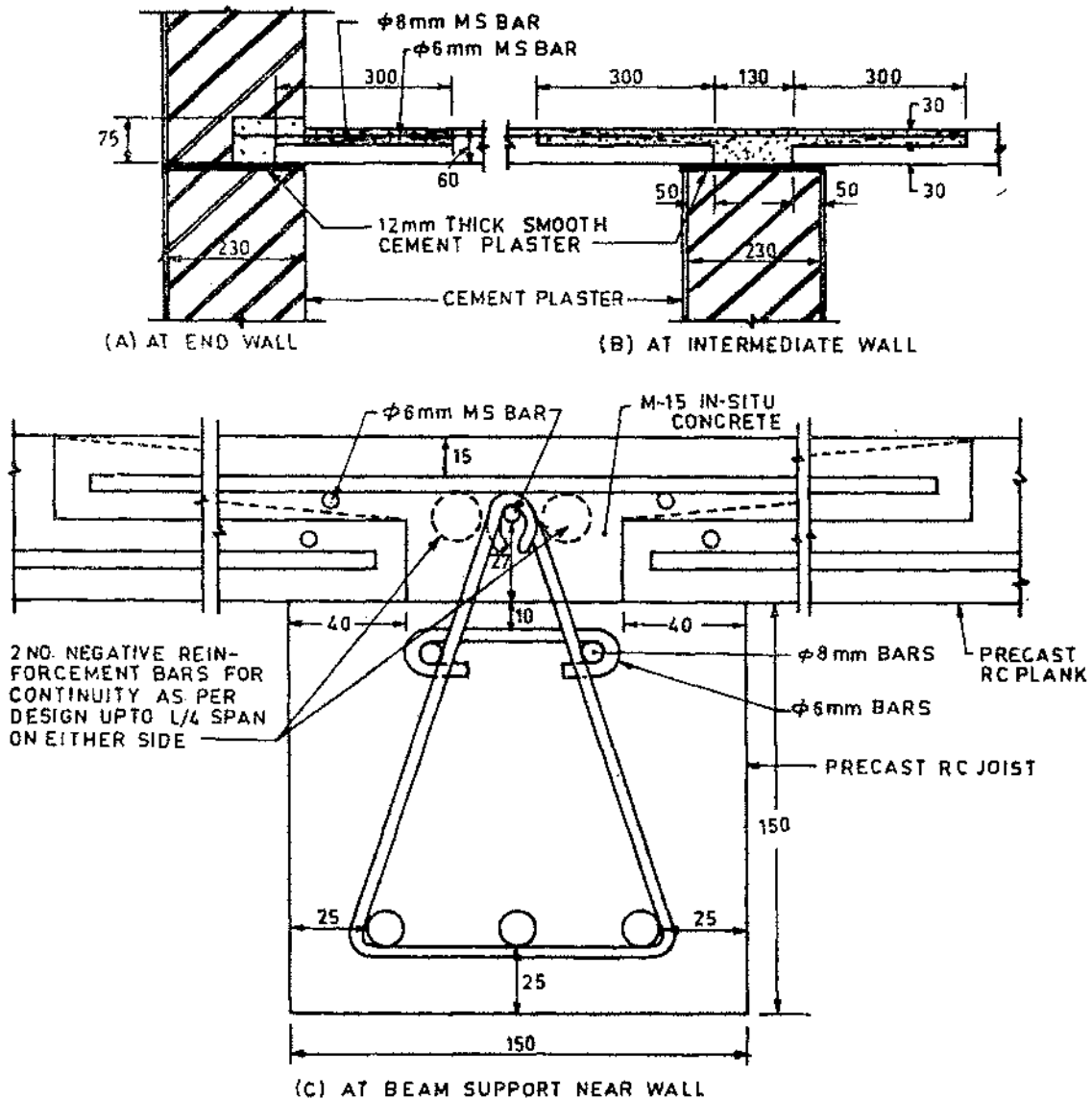


FIG. 2 PROPPING OF PARTIALLY PRECAST JOIST



All dimensions in millimetres.
FIG. 3 FIXING OF FAN HOOK



All dimensions in millimetres.

FIG. 4 TYPICAL SKETCH SHOWING DETAILS OF DIFFERENT BEARING POSITION

7 CARE DURING AND AFTER ERECTION

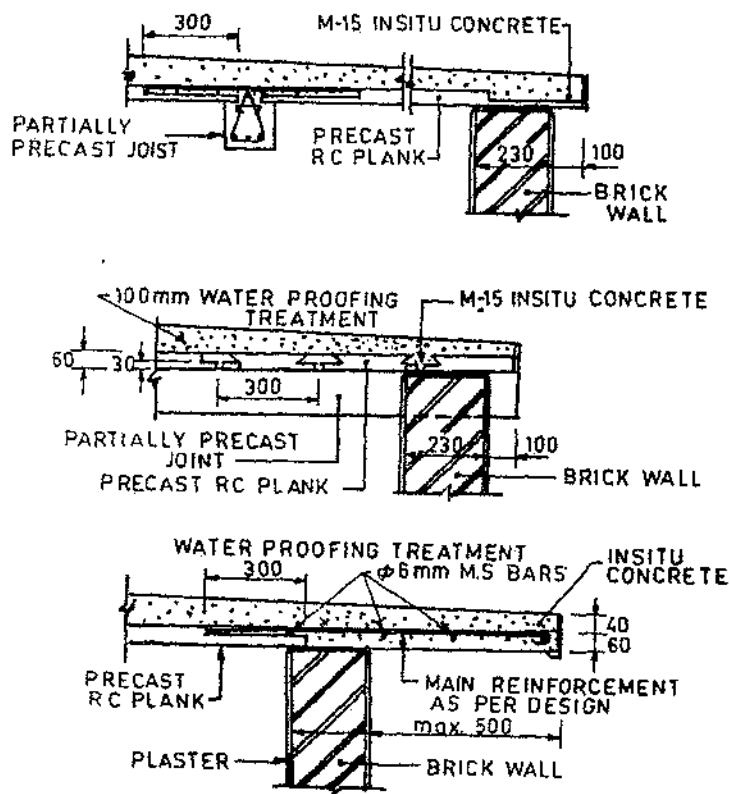
7.1 Concentrated load shall not be allowed on the roof/floor till *in-situ* concrete has attained strength. Workers shall not walk on the roof/floor before the *in-situ* concrete has attained strength. For placing of reinforcement and concreting in the haunches and over joists, cat walks resting on joists/walls shall be provided.

7.2 The planks shall be handled and transported in nearly vertical position as far as possible and these should be supported only near the edges. The joists shall be handled from very near the ends or at a distance of $L/5$ from the ends.

7.3 Partition walls shall not be constructed over the planks but only over joists or walls in which case their weight has to be considered while designing the joists.

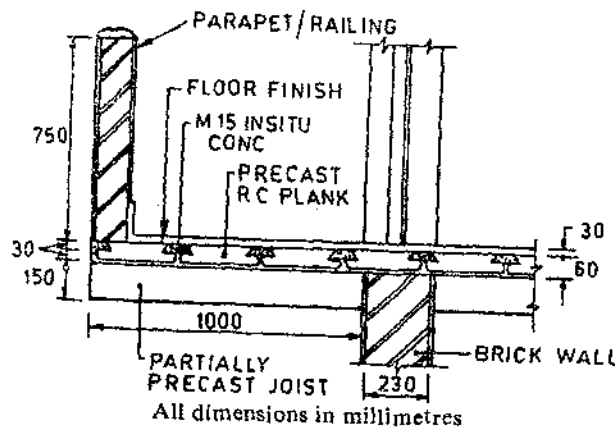
8 SERVICE AREA PROVISIONS

8.1 In service area, pipes, floor trap, water closet, etc, are provided and hence the supporting slab is sunk. In such cases, to take care of the additional load of the filling and also to make the floor leak-proof, the *in-situ* concrete thickness shall be increased by 25 mm over top of the planks in addition to haunch filling.



All dimensions in millimetres.

FIG. 5 TYPICAL SKETCH OF DETAILS OF ROOF WITHOUT DARAPET



All dimensions in millimetres

FIG. 6 TYPICAL SKETCH OF CANTILEVER ALONG THE JOIST FLOOR LEVEL

9 BALCONY/CHHAJJA PROJECTIONS

9.1 Balcony projections shall be provided along the partially precast joists as shown in Fig. 6. The joist shall be designed with an overhang, carrying superimposed loads for balcony as specified in IS 875 (Part 2) : 1987,

in addition to the self load and the load due to railing. Main reinforcement shall be provided at the top in *in-situ* concrete while the precast portion will take the compression. The free end of the joist shall be propped adequately until *in-situ* concrete attains sufficient strength.

ANNEX A
(*Clause 2*)

LIST OF REFERRED INDIAN STANDARDS

<i>IS No.</i>	<i>Title</i>	<i>IS No.</i>	<i>Title</i>
432 (Part 1) : 1982	Mild steel and medium tensile steel bars and hard-drawn steel wire for concrete reinforcement : Part 1 Mild steel and medium tensile steel bars (<i>third revision</i>)	1786 : 1985	Specification for high strength deformed steel bars and wires for concrete reinforcement (<i>third revision</i>)
456 : 1978	Code of practice for plain and reinforced concrete (<i>third revision</i>)	3036 : 1992	Code of practice for laying lime concrete for a water-proofed roof finish (<i>second revision</i>)
875 (Part 1) : 1987	Code or practice for design loads (other than earthquake) for buildings structures: Part 1 Dead loads — Unit weights of building material and stored materials (<i>second revision</i>)	4326 : 1993	Code of practice for earthquake resistant design and construction of buildings (<i>first revision</i>)
875 (Part 2) : 1987	Code of practice for design loads (other than earthquake) for buildings structures: Part 2 Imposed loads (<i>second revision</i>)	4365 : 1967	Code of practice for application of bitumen mastic for waterproofing of roofs
1346 : 1991	Code of practice for water-proofing of roofs with bitumen felts (<i>third revision</i>)	9918 : 1981	Code of practice for <i>in-situ</i> water-proofing and damp-proofing treatment with glass fibre tissue reinforced bitumen (<i>first revision</i>)
		13990 : 1994	Specification for precast reinforced concrete planks and joist for flooring and roofing

IS 14142: 1994

(Reaffirmed 2005)

भारतीय मानक

पूर्व निर्मित ईंट पैनल एवं आंशिक पूर्वढलित जॉइस्ट से
बनी फर्श एवं छत के डिजाइन एवं निर्माण— रीति संहिता

Indian Standard

**DESIGN AND CONSTRUCTION OF FLOORS
AND ROOFS WITH PREFABRICATED
BRICK PANEL — CODE OF PRACTICE**

UDC 691.328-413.692.4 : 006.76

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BUREAU OF INDIAN STANDARDS
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NEW DELHI 110002

July 1994

Price Group 3

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Housing Sectional Committee had been approved by the Civil Engineering Division Council.

Considerable shortage of houses in the country, which is also increasing continuously, has led to increasing stress being laid in the development programmes of central and state governments, on facilitating speedy and economical construction of houses. Problem of housing being greatest amongst the lower income groups, both rural and urban, the greatest stress is being laid on housing for these target groups.

This standard is one of a series of standards being published by BIS on new materials and techniques of roof/floor construction which when implemented will result in substantial savings in materials and cost of construction, in addition to achieving speedy construction. The other standards to be published in the series are:

- a) Prefabricated brick panel and partially precast concrete joist for flooring and roofing — Specification
- b) Precast reinforced concrete channel unit for construction of floors and roofs — Specification
- c) Design and construction of floors and roofs with precast reinforced concrete channel units — Code of practice
- d) Precast reinforced concrete planks and joists for roofing and flooring — Specification
- e) Design and construction of floor and roof with precast reinforced concrete planks and joists — Code of practice
- f) Design and construction of roof with precast reinforced concrete L-panel units — Code of practice
- g) Precast reinforced concrete L-panel units for roofing — Specification

The use of reinforced brick roofs had been quite common in Northern parts of India. Its design was based on the crushing strength of brick. The large variation in crushing strength of bricks had however, inhibited their use and raised doubts about the feasibility and performance of reinforced brick roofing/flooring slab. Further, the corrosion of reinforcement due to contact between mild steel bars and bricks also cause reduction in the life of roof. Also, the crushing strength of bricks usually being low, the thickness of slab increases causing an increase in dead load too.

Central Building Research Institute (CBRI), Roorkee has developed prefabricated brick panel system which is a combination of concrete, bricks and reinforcement such that concrete is used in the zone of maximum compressive stresses and hence bricks of lower compressive strength may also be used. T-beams action develops between partially precast joist and the *in-situ* concrete. Considerable assistance has been rendered in the preparation of this standard by CBRI, Roorkee.

The technical committee responsible for the formulation of this standard is given in Annex B.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

DESIGN AND CONSTRUCTION OF FLOORS AND ROOFS WITH PREFABRICATED BRICK PANEL — CODE OF PRACTICE

1 SCOPE

This standard lays down recommendations for design and construction of floor and roof with prefabricated brick panels.

2 REFERENCES

The Indian Standards listed in Annex A are necessary adjuncts to this standard.

3 ELEMENTS OF ROOF/FLOOR

3.1 Prefabricated Brick Panels and Partially Precast Joist

The prefabricated brick panels and partially precast joist used for construction of roofs and floors shall conform to IS 14143 : 1994.

3.2 Concrete

Concrete used for *in-situ* concrete shall conform to grade M15 or higher conforming to IS 456 : 1978. The aggregate used for concrete shall be well graded with a maximum size of 20 mm and 10 mm for joists and *in-situ* concrete respectively.

3.3 Reinforcement

Reinforcing steel shall be as recommended in IS 456 : 1978.

4 DESIGN CRITERIA

4.1 Prefabricated Brick Panels

4.1.1 The prefabricated brick panel shall be designed as simply supported between two joists or a joist and a wall

4.1.2 The panel shall be designed for three stages as follows:

- i) Precasting, lifting, transportation and handling (Stage I)
- ii) Placing and accidental loading during construction (Stage II)
- iii) Final loading condition (Stage III)

4.1.2.1 The following loads shall be considered for different stages of design:

- i) For stage I, self weight of panel without *in-situ* concrete plus 50 percent of self weight of panel for impact or vibration during handling and transporting.

- ii) For stage II, self weight of panel including weight of *in-situ* concrete and an accidental load, which, in absence of more accurate information, may be taken as half the imposed load given for stage III

- iii) For stage III, self weight of panel including *in-situ* concrete and imposed load as specified in IS 875 (Part 2) : 1987 and a load of 200 kg/m² or 100 kg/m² for roofs or floors respectively. Load of 200 kg/m² is taken for weight of waterproofing and insulation treatment while the load of 100 kg/m² in case of intermediate floors is taken for weight of floor finish. In case other specification being followed the loads for the floors or roofs may be accordingly considered in the design.

4.1.2.2 While designing the panel for stage II, the *in-situ* concrete shall not be considered as sharing the compression because it does not attain strength at this stage. While designing for stage III, the *in-situ* concrete of 3.5 cm depth shall be considered as acting together with brick panels in the compression zone.

4.2 Partially Precast Joists

4.2.1 The partially precast joist shall be designed for three stages as follow:

- i) Precast, lifting, transportation and handling (Stage I)
- ii) Placing and accidental loading during construction (Stage II)
- iii) Final loading condition (Stage III)

4.2.1.1 The following loads shall be considered for different stages of design:

- i) Stage I, self weight of joists plus 50 percent of self weight of joist for impact or vibration during handling and transportation.
- ii) Stage II, joist shall be propped at two points at $\frac{1}{3}$ rd span before laying bricks panel and $\frac{1}{3}$ span shall be taken for design purpose and self weight of joist and panel including *in-situ* concrete and accident load, which in the absence of more accurate information, may be taken as half the imposed load given for stage II.

- iii) Stage III, self weight of joist, dead weight of brick panels including *in-situ* concrete, imposed load in accordance with IS 875 (Part 2) : 1987 and load of roof or floor.

4.2.2 The partially precast concrete joist shall be designed as T-beam with 35 mm flange thickness for stage III of loading and as a partially precast beam for stage I and II of loading. Reinforcement required with normal loading for various span of joist for a spacing of 1 200 mm c/c may be taken from Table 1.

4.2.3 The joist shall be designed as continuous beam, it may be designed either as simply supported or continuous T-beam in accordance with IS 456 : 1978.

4.2.3.1 When the joist is designed as continuous beam, it may be designed as doubly reinforced beam. When it is possible to weld the bottom reinforcement at supports the same shall be kept projecting. If the welding is not possible, the joist shall be designed as singly reinforced for hogging bending moment at support. In such a case, redistribution of moment in accordance with IS 456 : 1978 may be resorted.

4.2.4 A clear cover of 25 mm shall be provided for longitudinal reinforcement.

4.3 When precast units are used for construction of building in high seismic zones, the roofs/floors shall be strengthened as per the provision of IS 4326 : 1993.

5 TRANSPORTATION AND HANDLING

5.1 The prefabricated brick panel shall be transported by placing them vertically against the side of the truck/trailer or any other carriage. The prefabricated brick panel shall be handled in the horizontal position using suitable rope slings. They should be lifted and transported without jerks and vibration.

The RC joist shall be lifted by placing slings at either ends. These shall be placed in carriage in such a way that the overhang is not more than 1/5 of the length.

6 ERECTION

6.1 Joists and panels shall be cleaned properly to remove dust and loose particles before placing these in position.

6.2 Surface of the wall on which joists are to be placed shall be overlaid by a 10 to 15 mm thick layer cement coarse sand (1 : 4) mortar. Top of the mortar shall have smooth finish. The joists shall be placed above this and properly aligned. The joist shall be propped, immediately after placing, at two places dividing the length of joist in three equal parts. The props

shall not be removed before the *in-situ* concrete has hardened. Minimum bearing of joists over walls shall be 75 mm. The wall in between the joists shall be raised up to the level of joists using cement sand (1 : 6) mortar.

6.3 The brick panels shall then be placed over the joists/walls, side by side after laying a 6 mm thick layer of cement coarse sand (1 : 4) mortar over the joists/walls to ensure proper setting of panels. Frogs of bricks should be kept upward while casting and placing brick panel on joist. The minimum bearing 40 mm shall be provided for panels. A gap of 20 to 40 mm shall be left in between adjacent panels. These gaps between the panels shall be filled up with M 15 concrete with the help of wooden strip placed below the joist and held in position during filling of concrete. The strip can be removed immediately by sliding horizontally.

6.4 Distribution/temperature reinforcement shall then be laid over the panels in both the directions, that is, parallel and perpendicular to the joist. This may consist of atleast one 6 mm mild steel grade I bar conforming to IS 432 (Part 1) : 1982 in each direction.

6.5 Concrete shall then be laid over the panels and joists up to a depth of 135 mm above the top of panels. The roof shall then be finished with a floating coat of 1 : 3 cement fine sand mortar of not more than 6 mm thickness just after laying the *in-situ* concrete. The *in-situ* concrete shall be cured for atleast 2 weeks by ponding.

6.6 The sprouts for rain water shall be made while laying the deck concrete to avoid any seepage through this joint.

6.7 To have proper drainage in case of roof, a slope of 1 : 40 shall be given to the roof either by raising the joists on one side, or, if needed otherwise, by completing and finishing the walls with the required slope.

6.8 A typical section through the assembled roof is shown in Fig. 1.

7 FLOOR/ROOF FINISH

7.1 Floor/roof finish shall be provided after the *in-situ* concrete has hardened. Guidance for providing different types of floor/roof finishes may be taken from relevant Indian Standard. Waterproofing treatment to the roofs shall be provided as desired. Guidance for this may be taken from relevant Indian Standards. For waterproofing using bitumen felts, bitumen mastic, glass fibre tissue reinforced bitumen and lime concrete, IS 1346 : 1978, IS 4365 : 1967, IS 9918 : 1981 and IS 3036 : 1992 may be referred.

Table 1 For Steel Reinforcement Requirement for Various Spans for Joists for a Spacing to 1 200 mm c/c
(Clause 4.2.2)

Reinforcement at	Clear Span of Joists in mm								
	1 800	2 100	2 400	2 700	3 000	3 300	3 600	3 900	4 200
Bottom	2-8 ϕ or 2-8 ϕ	2-10 ϕ or 2-8 ϕ	2-10 ϕ or 3-8 ϕ	2-12 ϕ or 1-10 ϕ ⁺ 2-8 ϕ	3-10 ϕ or 1-12 ϕ ⁺ 2-8 ϕ	3-12 ϕ or 2-12 ϕ ⁺ 1-10 ϕ	2-16 ϕ or 3-12 ϕ	2-16 ϕ or 1-10 ϕ 2-16 ϕ	3-16 ϕ or 1-16 ϕ ⁺ 2-12 ϕ
Middle	1 No. 6 ϕ	1 No. 6 ϕ	1 No. 6 ϕ	1 No. 6 ϕ	1 No. 8 ϕ ⁺	1 No. 8 ϕ ⁺	1 No. 8 ϕ ⁺	1 No. 10 ϕ ⁺	1 No. 10 ϕ ⁺
Top	1 No. 6 ϕ	1 No. 6 ϕ	1 No. 6 ϕ	1 No. 6 ϕ	1 No. 6 ϕ	1 No. 6 ϕ	1 No. 6 ϕ	1 No. 6 ϕ	1 No. 6 ϕ
Stirrups	6 ϕ 130 mm c/c	6 ϕ 130 mm c/c	6 ϕ 130 mm c/c	6 ϕ 130 mm c/c	6 ϕ 130 mm c/c	6 ϕ 130 mm c/c	6 ϕ 130 mm c/c	6 ϕ 130 mm c/c	4 No. 6 ϕ 100 mm c/c at ends and 130 mm c/c in middle portion

⁺ = Can be reduced to 6 ϕ if proper handling is ensured.
 ϕ = Mild steel bars.
 ϕ = Deformed bars.

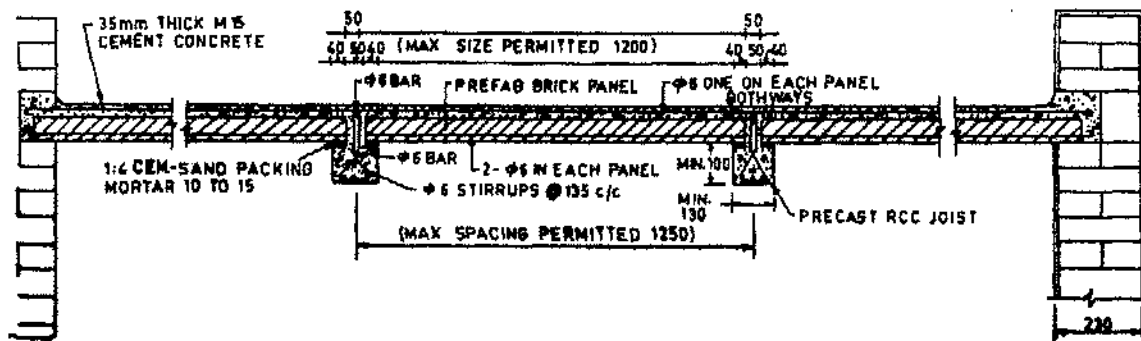


FIG. 1 TYPICAL SECTION THROUGH BRICK PANEL ROOF

ANNEX A
(Clause 2)

LIST OF REFERRED INDIAN STANDARDS

IS No.	Title	IS No.	Title
432 (Part 1) : 1982	Specification for mild steel and medium tensile steel bars and hard-drawn steel wire for concrete reinforcement ; Part 1 Mild steel and medium tensile steel bars (third revision)	875 (Part 2) : 1987	Code of practice for design loads (other than earthquake) for buildings and structures ; Part 2 Imposed loads (third revision)
456 : 1978	Code of practice for plain and reinforced concrete (third revision)		

IS 14142 : 1994

<i>IS No.</i>	<i>Title</i>	<i>IS No.</i>	<i>Title</i>
1346 : 1991	Code of practice for waterproofing of roofs with bitumen felts (<i>second revision</i>)	4365 : 1967	Code of practice for application of bitumen mastic for waterproofing of roofs
3036 : 1992	Code of practice for laying lime concrete for a waterproofed roof finish (<i>second revision</i>)	9918 : 1981	Code of practice for <i>in-situ</i> waterproofing and damp-proofing treatments with glass fibre tissue reinforced bitumen
4326 : 1993	Code or practice for earthquake resistant design and construction of buildings (<i>second revision</i>)	14143 : 1994	Prefabricated brick panel and partially precast concrete joist for flooring and roofing — Specification

IS 15912 : 2012

भारतीय मानक
बांस प्रयुक्त संरचनात्मक डिजाईन – रीति संहिता

Indian Standard
STRUCTURAL DESIGN USING BAMBOO —
CODE OF PRACTICE

ICS 91.100.10



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July 2012

Price Group 7

Building Construction Practices Sectional Committee, CED 13

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Building Construction Practices Sectional Committee had been approved by the Civil Engineering Division Council.

Bamboo is a versatile resource possessing high strength-to-weight ratio and cost ratio and offers considerable ease in working with simpler tools. Resilience coupled with light weight makes bamboo an ideal material for housing in disaster prone/earthquake prone areas. The application of bamboo as a constructional material is largely based on established traditions and intuitions of forefathers throughout the tropical and sub-tropical regions. A need is now felt for design and construction code for bamboo to cater to a number of social and trade advantages, engineering recognition and the improved status. Research Institutes of repute across the country have been engaged in bamboo research in the country to establish its silviculture, botanical, entomological and pathological aspects besides creating a utilization base.

The bamboo culm has a tubular structure consisting of nodes and inter-nodes. In the inter-nodes the cells are axially oriented while the nodes provide the transverse inter-connections. This disposition of the nodes and the wall thickness are significant in imparting mechanical strength to bamboo. In a circular cross-section, bamboo is generally hollow and for structural purposes this form is quite effective and advantageous.

While utilizing the information as given in the 'National Building Code of India - 2005', SP 7 : 2005 (Part 6, Section 3B) for structural designing with bamboo, was of considerable assistance in developing this separate standard on the design and construction using bamboo. The information contained in this standard is systematized based on the R&D carried out earlier at institutes like FRI, Dehradun, IPIRTI, Bangalore the technical literature by the International Network for Bamboo and Rattan (INBAR) and national and other International Standards. For specific technical details, reference may be made to them. Reference was also made to ISO 22156 : 2004 'Bamboo-structural design'.

The composition of the Committee responsible for the formulation of this standard is given at Annex B. Figures 1 to 4 providing joint types are meant for information only.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

STRUCTURAL DESIGN USING BAMBOO — CODE OF PRACTICE

1 SCOPE

1.1 This Code covers the general principles involved in the design of structural bamboo in buildings with regard to mechanical resistance and durability of structures. It covers minimum strength data, dimensional stability, grading requirements and traditional bamboo joints for quality assurance. Work on site, fabrication of components off-site and their erection on site is covered to the extent necessary to indicate and ensure the quality of material and standard of workmanship to comply with the assumptions of the design rules and the limitations.

1.2 The following aspects are not covered in this standard:

- a) Bamboo foundations;
- b) Limit state design and performance of structures;
- c) Scientific designing of bamboo joints and their fastenings; and
- d) Bamboo reinforced cement concrete/mud structures.

2 REFERENCES

The standards listed in Annex A contain provisions which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated in Annex A.

3 TERMINOLOGY

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

- 3.1 **Bamboo** — Tall perennial grasses found in tropical and sub-tropical regions. They belong to the family *Poaceae* and sub-family *Bambusoideae*.
- 3.2 **Bamboo Culm** — A single shoot of bamboo usually hollow except at nodes which are often swollen.
- 3.3 **Cross Wall** — A wall at the node closing the whole inside circumference and completely separating the hollow cavity below from that above (Syn. Diaphragm,

that is horizontal partition in a standing culm) (see also 3.18 and 3.28).

3.4 **Sliver** — Thin strips of bamboo processed from bamboo culm.

3.5 **Tissue** — Group of cells, which in higher plants consist of (a) *Parenchyma* — a soft cell of higher plants as found in stem pith or fruit pulp, (b) *Epidermis* — the outermost layer of cells covering the surface of a plant, when there are several layers of tissue.

3.6 **Bamboo Mat Board** — A board made of two or more bamboo mats bonded with an adhesive.

3.7 **Beam** — A structural member which supports load primarily by its internal resistance to bending.

3.8 **Breaking Strength** — A term loosely applied to a given structural member with respect to the ultimate load it can sustain under a given set of conditions.

3.9 **Bundle-Column** — A column consisting of three or more number of culms bound as integrated unit with wire or strap type of fastenings.

3.10 **Centre Internode** — A test specimen having its centre between two nodes.

3.11 **Characteristic Load** — The value of load which has a 95 percent probability of not exceeding during the life of the structure.

3.12 **Characteristic Strength** — The strength of the material below which not more than 5 percent of the test results are expected to fall.

3.13 **Column** — A structural member which supports axial load primarily by inducing compressive stress along the fibres.

3.14 **Common Rafter** — A roof member which supports roof battens and roof coverings, such as boarding and sheeting.

3.15 **Curvature** — The deviation from the straightness of the culm.

3.16 **Delamination** — Separation of mats through failure of glue.

3.17 **End Distance** — The distance measured parallel to the fibres of the bamboo from the centre of the fastener to the closest end of the member.

3.18 Flattened Bamboo — Bamboo consisting of culms that have been cut and unfolded till it is flat. The culm thus is finally spread open, the diaphragms (cross walls) at nodes removed and pressed flat.

3.19 Full Culm — The naturally available circular section/shape.

3.20 Fundamental or Ultimate Stress — The stress which is determined on a specified type/size of culms of bamboo, in accordance with standard practice and does not take into account the effects of naturally occurring characteristics and other factors.

3.21 Inner Diameter — Diameter of internal cavity of a hollow piece of bamboo.

3.22 Inside Location — Position in buildings in which bamboo remains continuously dry or protected from weather.

3.23 Joint — A connection between two or more bamboo structural elements.

3.24 Joist — A beam directly supporting floor, ceiling or roof of a structure.

3.25 Length of Internode — Distance between adjacent nodes.

3.26 Loaded End or Compression End Distance — The distance measured from the centre of the fastener to the end towards which the load induced by the fastener acts.

3.27 Net Section — Section obtained by deducting from the gross cross-section (A), the projected areas of all materials removed by boring, grooving or other means.

3.28 Node — The place in a bamboo culm where branches sprout and a diaphragm is inside the culm and the walls on both sides of node are thicker.

3.29 Outer Diameter — Diameter of a cross-section of a piece of bamboo measured from two opposite points on the outer surface.

3.30 Outside Location — Position in building in which bamboos are occasionally subjected to wetting and drying as in case of open sheds; and outdoor exposed structures.

3.31 Permissible Stress — Stress obtained after applying factor of safety to the ultimate stress. This is also the working stress unless adjusted to the particular structural form in design.

3.32 Principal Rafter — A roof member which supports purlins.

3.33 Purlins — A roof member directly supporting roof covering or common rafter and roof battens.

3.34 Roof Battens — A roof member directly supporting tiles, corrugated sheets, slates or other roofing materials.

3.35 Roof Skeleton — The skeleton consisting of bamboo truss or rafter over which solid bamboo purlins are laid and lashed to the rafter or top chord of a truss by means of galvanized iron wire, cane, grass, bamboo leaves, etc.

3.36 Slenderness Ratio — The ratio of the length of member to the least radius of gyration is known as slenderness ratio of member. (The length of the member is the equivalent length due to end conditions.)

3.37 Splits — The pieces made from quarters by dividing the quarters radially and cutting longitudinally.

3.38 Taper — The ratio of difference between minimum and maximum outer diameter to length.

3.39 Unloaded End Distance — The end distance opposite to the loaded end.

3.40 Wall Thickness — Half the difference between outer diameter and inner diameter of the piece at any cross-section.

3.41 Wet Location — Position in buildings in which the bamboos are almost continuously damp, wet or in contact with earth or water, such as piles and bamboo foundations.

3.42 Bamboo Bore/GHOON Hole — The defect caused by bamboo ghoon beetle (*Dinoderus* spp. *Bostrychidae*), which attacks felled culms.

3.43 Crookedness — A localized deviation from the straightness in a piece of bamboo.

3.44 Discolouration — A change from the normal colour of the bamboo which does not impair the strength of bamboo or bamboo composite products.

3.45 Collapse — The defect occurring on account of excessive shrinkage, particularly in thick walled immature bamboo. When the bamboo wall shrinks, the outer layers containing a larger concentration of strong fibro-vascular bundles set the weaker interior portion embedded in parenchyma in tension, causing the latter to develop cracks. The interior crack develops into a wide split resulting in a depression on the outer surface. This defect also reduces the structural strength of round bamboo.

3.46 Surface Cracking — Fine surface cracks not detrimental to strength. However, the cracking which occurs at the nodes reduces the structural strength.

4 SYMBOLS

For the purpose of this Code, the following letter symbols shall have the meaning indicated against each,

unless otherwise stated:

A = cross-sectional area of bamboo (perpendicular to the direction of the principal fibres and vessels), in mm^2 ;

$$= \frac{\pi}{4}(D^2 - d^2)$$

D = outer diameter, in mm;

d = inner diameter, in mm;

E = modulus of elasticity in bending, in N/mm^2 ;

f_c = calculated stress in axial compression, in N/mm^2 ;

f_{cp} = permissible stress in compression along the fibres, in N/mm^2 ;

I = moment of Inertia (the second moment of area), in mm^4 ;

$$= \frac{\pi}{64}(D^4 - d^4)$$

l = unsupported length of column, in mm;

m = moisture content, percent;

r = radius of gyration, in mm;

$$= \sqrt{I/A}$$

R = modulus of rupture, in N/mm^2 ;

w = wall thickness, in mm;

Z = section modulus, in mm^3 ; and

δ = deflection or deformation, in mm.

5 MATERIALS

The requirements shall be met by the choice of suitable materials, by appropriate design and detailing and by specifying control procedures for production, construction and use.

5.1 Species of Bamboo

More than 100 species of bamboo are native to India and a few of them are solid but most of them are hollow in structure. In all 20 species have been systematically tested so far. Sixteen species of bamboo are recommended for structural usages in round form. Some physical and mechanical properties of the same are given in Table 1 both for air-dry conditions and green conditions.

5.1.1 Matured bamboo of at least 4 years of age shall be used. The bamboo shall be used after at least six weeks of felling period.

5.1.2 Bamboo shall be properly treated in accordance with IS 9096.

5.1.3 Solid bamboos or bamboos whose wall thickness

is comparatively more and which are generally having nodes very closer are often considered good for structural purposes.

5.1.4 Broken, damaged or collapsed bamboo shall be rejected. Dead and immature bamboos, bore/*GHOON* holes, decay, collapse, checks more than 3 mm in depth, shall be avoided.

5.2 Grouping

5.2.1 Sixteen species of bamboo recommended for structural applications are classified in three groups on the basis of their strength properties, namely, modulus of elasticity (E) in bending in green condition and modulus of rupture (R) (extreme fibre stress in bending). For structural use in components in piles and mines, components, an additional criterion of compressive strength is considered in classification. The limits in ultimate strength values of these groups shall be corresponding to the spread of properties in structural timber as given in Table 2.

5.2.2 Bamboo species may be identified using suitable methods.

NOTE — Methods of identification of bamboo through anatomical characters have not been perfected so far. Identification through morphological characters could be done only on full standing culm by experienced sorters.

5.2.3 Species of bamboo other than those listed in the Table 1 may be used, provided their strength characteristics are determined and found in accordance with 5.2.

5.3 Moisture Content in Bamboo

Normally only dry or seasoned bamboo shall be used otherwise special attention shall be given to dimensional changes occurring during the drying process in the joints, assemblies.

With decrease of moisture content (M) the strength of bamboo increases exponentially and bamboo has an intersection point (fibre saturation point) at around 25 percent moisture content depending upon the species. The moisture content of bamboo shall be determined in accordance with IS 6874. Matured culms shall be seasoned to about 20 percent moisture content before use.

Freshly felled bamboo with shoots and leaves intact, dry fairly well in the open sun with lesser surface cracking, etc, and reduced starch contents. Rapid drying in the open can control degrades.

5.4 Grading of Structural Bamboo

5.4.1 Bamboo shall be graded to ensure that the properties of bamboo are satisfactory for use particularly the strength and stiffness properties.

Table 1 Physical and Mechanical Properties of Indian Bamboos (in Round Form)
(Clauses 5.1 and 5.2.3)

Sl No.	Species	Properties								
		In Green Condition				In Air Dry Condition				
		Density kg/m ³	Modulus of rupture N/mm ²	Modulus of elasticity × 10 ³ N/mm ²	Maximum compressive strength N/mm ²	Density kg/m ³	Modulus of rupture N/mm ²	Modulus of elasticity × 10 ³ N/mm ²	Density kg/m ³	Modulus of rupture N/mm ²
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(9)	
i)	<i>Bambusa auriculata</i>	594	65.1	15.01	36.7	670	89.1	21.41		
ii)	<i>B. balcooa</i>	783	63.4	7.31	46.7	—	—	—		
iii)	<i>B. bambos</i> (Syn. <i>B. arundinaceae</i>)	559	58.3	5.95	35.5	663	80.1	8.96		
iv)	<i>B. burmanica</i>	570	59.7	11.01	39.9	672	105.0	17.81		
v)	<i>B. glaucescens</i> (Syn. <i>B. nana</i>)	691	82.8	14.77	53.9	—	—	—		
vi)	<i>B. nana</i>	603	52.9	6.62	45.6	673	52.4	10.72		
vii)	<i>B. pallida</i>	731	55.2	12.90	54.0	—	—	—		
viii)	<i>B. nuda</i>	658	51.1	7.98	40.7	722	66.7	10.07		
ix)	<i>B. verticosa</i>	626	34.1	3.38	36.1	—	—	—		
x)	<i>B. vulgaris</i>	626	41.5	2.87	38.6	—	—	—		
xi)	<i>Cephalostachyum peryratile</i>	601	57.6	11.16	36.7	640	71.3	19.22		
xii)	<i>Dendrocalamus longispinus</i>	711	33.1	5.51	42.1	684	47.8	6.06		
xiii)	<i>D. strictus</i>	631	73.4	11.98	35.9	728	119.1	15.00		
xiv)	<i>Melocanna baccifera</i>	817	53.2	11.39	53.8	751	57.6	12.93		
xv)	<i>Oxytenanthera abyssinica</i>	688	83.6	14.96	46.6	—	—	—		
xvi)	<i>Thyrsostachys oliveri</i>	733	61.9	9.72	46.9	758	90.0	12.15		

NOTES

1. As the strength of split bamboo is more than that of round bamboo, the results of tests on round bamboo can be safely used for designing with split bamboo.
2. The values of stress in N/mm² have been obtained by converting the values, in kgf/cm², by dividing the same by 10.

Table 2 Properties of Structural Timber
(Clause 5.2.1)

Sl No.	Group	Modulus of Rupture (R) N/mm ²	Modulus of Elasticity (E) In Bending 10 ³ N/mm ²	Maximum Compressive Strength ($f_{c,0,0.05}$) N/mm ²
(1)	(2)	(3)	(4)	(5)
i)	A	$R > 70$	$E > 9$	$MCS > 35$
ii)	B	$70 \geq R > 50$	$9 \geq E > 6$	$35 > MCS > 30$
iii)	C	$50 \geq R > 30$	$6 \geq E > 3$	$30 > MCS > 25$

5.4.1.1 Grading is sorting out bamboo on the basis of characteristics important for structural utilization as under:

- Diameter and length of culm;
- Taper of culm;
- Straightness of culm;
- Inter nodal length and distribution of nodes;
- Wall thickness;
- Density and strength; and
- Durability and seasoning.

One of the above characteristics or sometimes combination of 2 or 3 characteristics form the basis of grading. The culms shall be segregated species-wise.

5.4.2 Diameter and Length

5.4.2.1 Gradation according to the mean outer diameter

For structural Group A and Group B species, culms shall be segregated in steps of 10 mm of mean outer diameter as follows:

- Special Grade 70 mm < Diameter \leq 100 mm
- Grade I 50 mm < Diameter \leq 70 mm
- Grade II 30 mm < Diameter \leq 50 mm
- Grade III Diameter \leq 30 mm

For structural Group C species culms shall be segregated in steps of 20 mm of mean outer diameter as follows:

- Grade I 80 mm < Diameter \leq 100 mm
- Grade II 60 mm < Diameter \leq 80 mm
- Grade III Diameter \leq 60 mm

5.4.2.2 The minimum length of culms shall be preferably 6 m for facilitating close fittings at joints, etc.

5.4.3 Taper

The taper shall not be more than 5.8 mm/m length (or

0.58 percent) (1 in 170) of bamboo in any grade of bamboo.

5.4.4 Curvature

The maximum curvature shall not be more than 75 mm in a length of 6 m of any grade of bamboo.

5.4.5 Wall Thickness

Preferably minimum wall thickness of 8 mm shall be used for load bearing members unless calculations and the availability dictates otherwise.

5.5 Durability and Treatability

5.5.1 Durability

The natural durability of bamboo is low and varies between 12 months and 36 months depending on the species and climatic conditions. In tropical countries the bio-deterioration is very severe. Bamboos are generally destroyed in about one to two years' time when used in the open and in contact with ground; while a service life of two to five years can be expected from bamboo when used under cover and out of contact with ground. The mechanical strength of bamboo deteriorates rapidly with the onset of fungal decay in the sclerenchymatous fibres. Split bamboo is more rapidly destroyed than round bamboo. For making bamboo durable, suitable treatment for preserving bamboo shall be given as per IS 1902. However, special attention shall be given to environmental impact and to the health aspects of labour and the users.

5.5.2 To ensure an adequately durable structure, bamboo shall be treated in accordance with IS 9096 and the following inter-related factors shall be considered:

- Expected service life of the bamboo;
- Use of the structure and expected environmental conditions;
- Required performance criteria; and
- Quality of workmanship.

5.5.3 For provisions on safety of bamboo structures against fire, fire resistance shall be determined in accordance with the applicable national standards.

6 PERMISSIBLE STRESSES

6.1 Ultimate stress values of different species and groups of bamboo shall be determined according to IS 6874. These values shall then be divided by appropriate factors of safety to obtain permissible stresses to cover the effects of variability, long-term loading, grade, location of use and expected dynamic loading.

6.1.1 The strength factors for deriving safe working

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stresses of bamboo shall be as under :

Extreme fibre stress in beams	: 4
Modulus of elasticity	: 4.5
Maximum compressive stress parallel to grain/fibres	: 3.5

6.2 The available data for the safe working stresses for 16 species of bamboos are given in Table 3.

6.3 For change in duration of load other than continuous (long-term), the permissible stresses given in Table 3 shall be multiplied by the modification factors given below:

For permanent loads	: 1.0
For imposed or medium-term loading (permanent + temporary load)	: 1.25
For short-term loading (permanent + temporary load + wind load)	: 1.50

7 DESIGN CONSIDERATIONS

7.1 Basic Requirements

A structure shall be designed and constructed by personnel having the appropriate skill and experience in such a way that,

- with acceptable probability, it will remain fit for the use for which it is required, having due regard to its intended life and costs;
- with appropriate degree of reliability, it will sustain all forces and effects likely to occur during execution and use and have adequate durability in relation to maintenance costs;
- the structure will be adequately maintained;
- the structure will be used in accordance with design limit briefs;
- all structural members, assemblies or framework in a building shall be capable of sustaining, without exceeding the limits of relevant stress specified, the worst combination of all loadings;
- a fundamental aspect of design will be to determine the forces to which the structure/ structural element might be subjected to, starting from the roof and working down to the soil by transferring the forces through various components and connections;
- accepted principles of mechanics for analysis and specified design procedures shall be applied (or) the design requirements may be

Table 3 Safe Permissible Stresses of Bamboos for Structural Designing¹⁾
(Clauses 6.2 and 6.3)

Sl No.	Species	Extreme Fibre Stress in Bending N/mm ²	Modulus of Elasticity 10 ³ N/mm ²	Allowable Compressive Stress N/mm ²
(1)	(2)	(3)	(4)	(5)
i)	Group A:			
	a) <i>Bambusa glaucescens</i> (Syn. <i>B. nana</i>)	20.7	3.28	15.4
	b) <i>Dendrocalamus strictus</i>	18.4	2.66	10.3
	c) <i>Oxytenanthera abyssinica</i>	20.9	3.31	13.3
ii)	Group B:			
	a) <i>Bambusa balcooa</i>	16.4	1.62	13.3
	b) <i>B. pallida</i>	13.8	2.87	15.4
	c) <i>B. nutans</i>	13.2	1.47	13.0
	d) <i>B. tulda</i>	12.8	1.77	11.6
	e) <i>B. auriculata</i>	16.3	3.34	10.5
	f) <i>B. burmanica</i>	14.9	2.45	11.4
	g) <i>Cephalostachyum pergracile</i>	13.2	2.48	10.5
	h) <i>Melocanna baccifera</i> (Syn. <i>M. bambusoides</i>)	13.3	2.53	15.4
	j) <i>Thyrsotachys oliveri</i>	15.5	2.16	13.4
iii)	Group C:			
	a) <i>Bambusa arundinacea</i> (Syn. <i>B. bambos</i>)	14.6	1.32	10.1
	b) <i>B. ventricosa</i>	8.5	0.75	10.3
	c) <i>B. vulgaris</i>	10.4	0.64	11.0
	d) <i>Dendrocalamus longispatus</i>	8.3	1.22	12.0

NOTE—The values of stress in N/mm² have been obtained by converting the values in kgf/cm² by dividing the same by 10.

¹⁾ The values given pertain to testing of bamboo in green condition.

- satisfied by prototype testing;
- h) loads shall be in accordance with IS 875 (Parts 1 to 5); and
- j) The worst combination and location of loads shall be considered for design. Also, wind and seismic forces shall not be considered to act simultaneously.

7.2 Unlike timber, bamboo properties do not relate well to species, being dependent among other factors, on position of the culm, geographic location and age. The practice in timber engineering is to base designs on safe working stresses (*see Note*) and the same may be adopted to bamboo with the limitations that traditional experience rather than precise calculations generally govern the detailing.

NOTE — Limit states are states beyond which the structure no longer satisfies the design performance requirements. Limit states are classified into ultimate limit state relating to collapse mode and serviceability limit states associated with deformations, vibrations, etc. Design is usually based on ultimate stages with partial factors of safety.

7.3 Age old traditional experience of construction with bamboo is to be well preserved as non-standard practices for similar situations considered as an informal based on general social pattern and wisdom. Confirmation of such structures be based on reports after they have sustained the severity of earthquakes, hurricanes, etc, as criteria for recommendations by the evaluation by competent engineer/builder with adequate experience in the field.

7.4 Net Section

It is determined by passing a plane or a series of connected planes transversely through the members. Least net sectional area is used for calculating load carrying capacity of a member. In the design of an intermediate or a long column gross section shall be used in calculating load carrying capacity of column.

7.5 Structural Components

7.5.1 Main structural applications in bamboo may include roofing and flooring, shear walls, wall paneling, beams, piles, columns, arches, etc. Both from the point of view of capacity and deformation, trusses and framed skeletons are much better options in bamboo.

7.5.2 Peculiarity of Bamboo as a Design Material

This shall be based on the principles of applied mechanics involving the following assumptions:

- a) Elastic behaviour of bamboo, until failure; (plastic behaviour being considered to be not significant);
- b) Bamboo culms are analyzed as hollow tube structures (not perfectly straight) member on

mean diameter and mean wall thickness basis;

- c) Nodes do not occur at constant intervals;
- d) Structural elements of bamboo shall be appropriately supported near the nodes of culm as and where the structural system demands. The joints in the design shall be located near nodes;
- e) Bamboo structures are designed like any other conventional structural analysis taking care of details with regards to supports and joints; and the diameter, wall thickness and initial curvature; and
- f) Joints shall be considered to generally act as a hinge or as pinned, unless substantiating data justify a fixed joint.

7.6 Flexural Members

7.6.1 All flexural members may be designed using the principles of beam theory.

7.6.2 The moment of inertia, *I* shall be determined as follows:

- a) Outside diameter and the wall thickness shall be measured at both ends, correct up to 1 mm for diameter of culm and 0.1 mm for the wall thickness. (For each cross-section, the diameter shall be taken twice, in direction perpendicular to each other and the wall thickness shall be taken four times, in the same points where the diameter has been measured.)
- b) With these values the mean diameter and the mean thickness for the middle of the beam shall be calculated and moment of inertia determined.

7.6.3 The maximum bending stress shall be calculated and should be within the allowable stress.

7.6.4 The deflection shall be within the prescribed limits. The initial curvature shall also be considered in the calculation of the deflection.

7.6.5 The shear stress in the neutral layer at the small end shall be checked, if the length of the beam is less than 25 times the diameter at that end.

NOTE — The shear stress values (N/mm²) for at least three species of bamboo for structural use in split form in green condition have been determined as under:

<i>Bambusa pallida</i>	: 9.77
<i>Bambusa vulgaris</i>	: 9.44
<i>Oxytenanthera abyssinica</i>	: 11.2

7.6.6 Forces acting on a beam, being loads or reaction forces at supports, shall act in nodes or as near to nodes as by any means possible.

7.7 Columns (Predominantly Loaded in Axial Direction)

7.7.1 Columns and struts are essential components sustaining compressive forces in a structure. They transfer load to the supporting media.

7.7.2 Design of columns shall be based on one of the following two criteria:

- a) Full scale buckling tests on the same species, size and other relevant variables.
- b) Calculations, based on the following:
 - 1) The moment of inertia shall be determined as per 7.6.3;
 - 2) For bamboo columns the best available straight bamboo culms shall be selected; and
 - 3) The bending stresses due to initial curvature, eccentricities and induced deflection shall be taken into account, in addition to those due to any lateral load.

7.7.3 Buckling calculation shall be according to Euler, with a reduction to 90 percent of moment of inertia, to take into account the effect of the taper which shall be less than 1 : 170.

7.7.4 For strength and stability, larger diameter thick walled sections of bamboo with closely spaced nodes shall be used. Alternatively, smaller sections may be tied together as a bundle-column.

7.8 Assemblies and Roof Trusses

7.8.1 Elements in structure are generally built-up in the form of assembled members for which a triangle is a simple figure of stability. Besides sloped chords, parallel chord construction is also appropriate as external profile.

7.8.2 A truss is essentially a plane structure which is very stiff in the plane of the members, that is the plane in which it is expected to carry load, but very flexible in every other direction. Roof truss generally consists of a number of triangulated frames, the members of which are fastened at ends and the nature of stresses at joints is either tensile or compressive and designed as pin-ended joints.

7.8.3 Trusses shall be analyzed for the determination of axial forces in members and the deformation of joints. For the influence of eccentricities, due allowance shall be made in design.

7.8.4 The truss height shall exceed 0.15 times the span in case of a triangular truss (pitched roofing) and 0.10 times the span in case of a rectangular (parallel) truss.

7.8.5 For members in compression, the effective length for in-plane strength verification shall be taken as the distance between two adjacent points of contraflexure.

For fully triangulated trusses, effective length for simple span members without especially rigid end-connection shall be taken as the span length.

7.8.6 The spacing of trusses shall be consistent with use of bamboo purlins.

7.8.7 The ends in open beams, joists, rafters, purlins shall be suitably plugged. Bamboo roof coverings shall be considered as non-structural in function.

7.8.8 The common roof covering shall include bamboo mat board, bamboo mat corrugated sheet, bamboo tiles, plastered bamboo reeds, thatch, corrugated galvanized iron sheeting, asphaltic sheets, plain clay tiles, etc.

8 DESIGN AND TECHNIQUES OF JOINTS

8.1 Connecting the load-bearing elements together for effective transfer of stress and to achieve continuity between elements with controlled displacements is one of the serious problem. As joints are a source of weakness in any bamboo structure, they have to be made as strong and rigid as possible. Joints are quite critical in assemblies, and these should be stable in relation to time. For general information, the details of typical joints given in Fig. 1 to Fig. 4 may be used.

8.2 Bamboo Joints

Susceptibility to crushing at the open ends, splitting tendency, variation in diameter, wall thickness and straightness are some of the associated issues which have to be taken care of while designing and detailing the connections with bamboo.

Joints shall be designed to include force transmissions in a required manner, predictable deformations to be within prescribed limits and specific geometry/load direction.

Tests on full scale joints or on components shall be carried out in accordance with IS 2366 and IS 4924 (Parts 1 and 2) for nailed jointed timber structures.

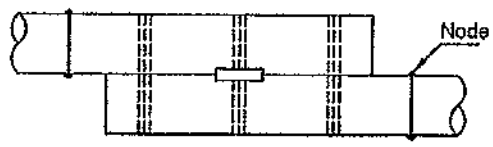
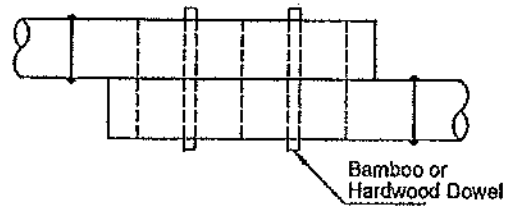
8.2.1 Traditional Practices

Such joining methods revolve around lashing or tying by rope or string with or without pegs or dowels. Such joints lack stiffness and have low efficiency but have served the mankind for long in traditional bamboo construction.

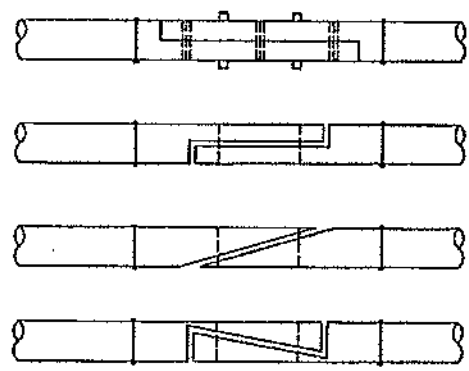
8.2.1.1 Lengthening joints (end jointing)

8.2.1.1.1 Lap joint

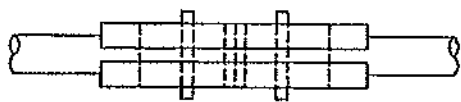
End of one piece of bamboo is made to lap over that of the other in line and the whole is suitably fastened. It may be full lapping or half lapping. Full section culms are overlapped by at least one internode and tied together in two or three places. Efficiency could be improved by using bamboo or hardwood dowels.



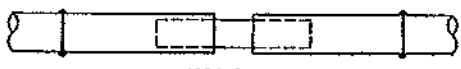
1A Full Lapped Joint



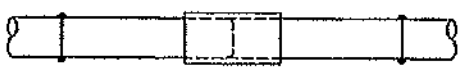
1B Half Lapped Joint (Rebated/Splayed)



With Side Plates of Bamboo



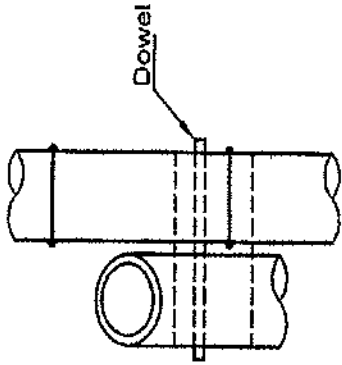
With Inserts



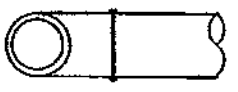
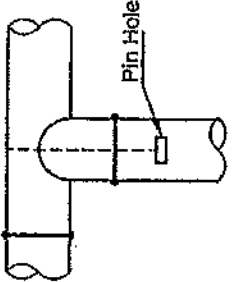
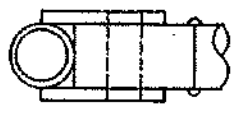
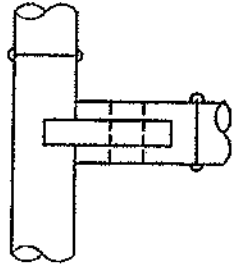
With Sleeves

1C Butt Joint

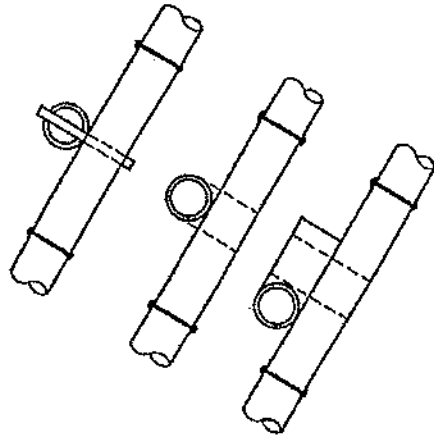
FIG. 1 SPLICED JOINTS



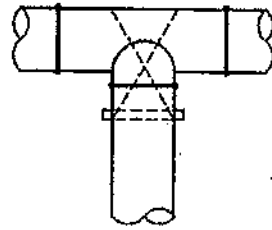
2B Beam Supported on Independent Short Culm Tied to the Post



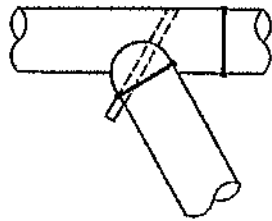
2A Saddle Joint with Lashing and Side Plates (or Seated Joints)



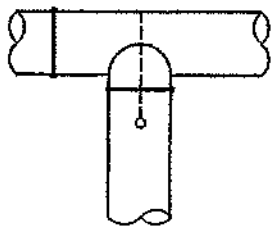
2F Purlin Tied to Rafter



2E Dowelled and Tied System

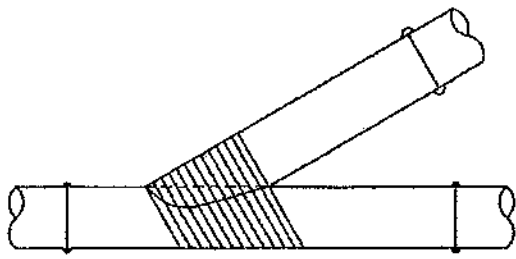


2D Pegged and Tied System

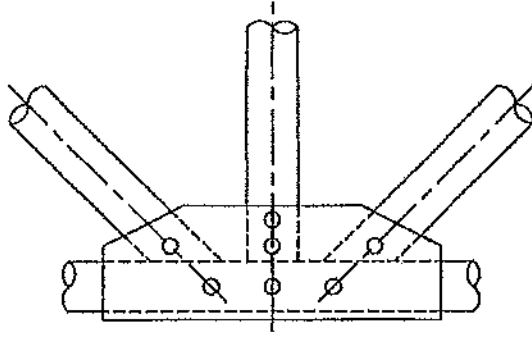
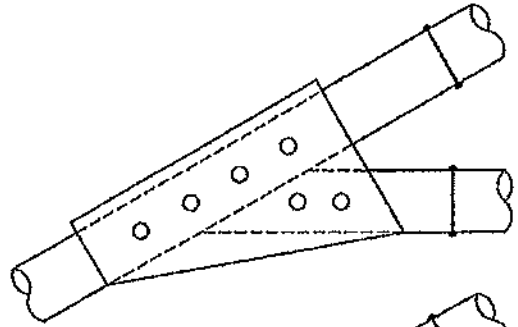


2C Ties Passing Through a Pre-drilled Hole or Around Peg

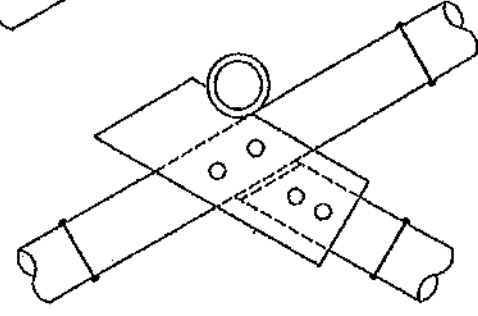
FIG. 2 BEARING JOINTS



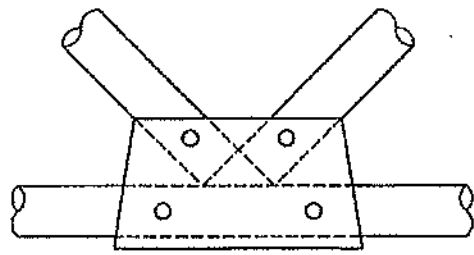
3A Lashed Joint



3B Trust Chord and Web Connections



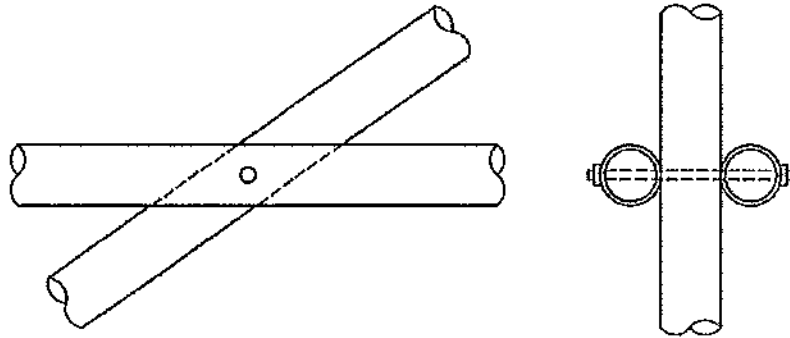
3C Solid Timber or Shuttering Grade Plywood Plates Fixed with Either MS Bolts or Bamboo Pegs



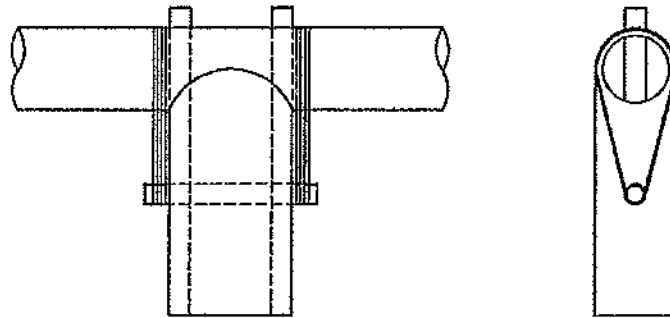
3D Gusset Plated Joint

FIG. 3 GUSSET PLATED JOINTS

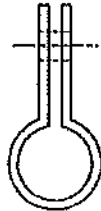
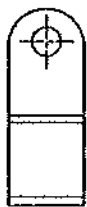
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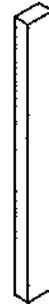
4A Simply Bolted Connection with MS Arc Washers



4B Horned Joint with Pin and Rope Lashing



4C Steel Band to be Fitted Around Bamboo Section



4D Hardwood Dowel (Square or Circular)



4E Solid Bamboo or Split-Bamboo Pins (with skin on)

FIG. 4 OTHER JOINTS AND SECTIONS

8.2.1.1.2 Butt joints

Culms of similar diameter are butted end-to-end, interconnected by means of side plates made of quarter-round culm of slightly large diameter bamboo, for two or more internode lengths. Assembly shall be fixed and tied preferably with dowel pins.

8.2.1.1.3 Sleeves and inserts

Short length of bamboo of appropriate diameter may be used either externally or internally to join two culms together.

8.2.1.1.4 Scarf joints

A scarf joint is formed by cutting a sloping plane 1 in 4 to 6 on opposite sides from the ends of two similar diameter bamboo culms to be joined. They shall be lapped to form a continuous piece and the assembly suitably fastened by means of lashings or glued.

8.2.1.2 Bearing joints

For members which either bear against the other or cross each other and transfer the loads at an angle other than parallel to the axis, bearing joints are formed.

8.2.1.2.1 Butt joints

The simplest form consists of a horizontal member supported directly on top of a vertical member. The top of the post may be cut to form a saddle to ensure proper scalling of beam for good load transfer. The saddle should be close to a node to reduce risk of splitting.

8.2.1.2.2 Angled joints

When two or more members meet or cross other than at right angles, angled joints are formed.

8.2.2 Improved Practices in Bamboo Jointing

- a) Plywood or solid timber gusset plates may be used at joint assemblies of web and chord connection in a truss and fixed with bamboo pins or M.S. (mild steel) bolts. Hollow cavities of bamboo need to be stuffed with wooden plugs or otherwise by suitable means.
- b) Use of wooden inserts to reinforce the ends of the bamboo before forming the joints. Alternatively steel bands clamps with integral bolt/eye may be fitted around bamboo sections for jointing.

8.2.3 Fixing Methods and Fastening Devices

In case of butt joints the tie-wire may be passed through a pre-drilled hole or around hardwood or bamboo pegs or dowels inserted into preformed holes to act as horns. Pegs are driven from one side, usually at an angle to increase strength and dowels pass right through the

member, usually at right angles. Normally 1.60 mm diameter galvanized iron wire may be used for tight lashing.

8.2.3.1 Wire bound joints with or without pins

Usually 2.00 mm diameter galvanized iron wire is tightened around the joints by binding the respective pieces together. At least two holes are drilled in each piece and wire is passed through them for good results. Generally 10-12 mm dia bamboo pins are driven and fastened to culms.

8.2.3.2 Fish plates/gusset plated joints

At least 25 mm thick hardwood splice plate or 12 mm thick structural grade plywood are used. Solid bamboo pins help in fastening the assembly.

8.2.4 For any complete joint alternative for a given load and geometry, description of all fastening elements, their sizes and location shall be indicated. Data shall be based on full scale tests.

8.2.5 Tests on full scale joints or on components shall be carried out in a recognized laboratory.

8.2.6 In case of high wind and seismic areas, good construction practice shall be followed taking care of joints, their damping and possible ductility. Bracings in walls shall be taken care of in bamboo structures.

8.3 Metal fasteners and other structural joints shall be made inherently corrosion resistant or be protected against corrosion, thereby making the joints more durable.

The designer shall ensure to detail that bamboo in building shell remain air-dry to avoid deterioration due to moisture.

The permeability of walls, floors and roof made from bamboo affect the wind load factor.

9 PANELS FOR WALL/ROOF CLADDING

9.1 Until Indian Standards for bamboo panels are available, the following is applicable.

9.1.1 Ply Bamboo

Ply bamboo sheets are composed of woven bamboo mats glued together, or of layers of split bamboo strips, laid across each other and glued together.

9.1.2 Particle Board and Fibre Board/Reed Board

9.1.3 These shall be produced so that they maintain their integrity and strength in the assigned service class through out the expected life of the structure.

9.1.4 Testing for the determination of structural properties of panels shall be carried out in accordance with IS 1734, for ply wood tests; IS 2380, for particle boards and other boards and IS 4407, for reed walling.

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ANNEX A

(Clause 2)

LIST OF REFERRED INDIAN STANDARDS

IS No.	Title	IS No.	Title
875	Design loads for building and structures:	(Part 17) : 1983	Long time loading test of plywood strips (<i>second revision</i>)
(Part 1) : 1987	Unit weights of building material and stored materials (<i>second revision</i>)	(Part 18) : 1983	Impact resistance test on the surface of plywood (<i>second revision</i>)
(Part 2) : 1987	Imposed loads (<i>second revision</i>)	1902 : 2006	Preservation of bamboo and cane for non-structural purposes (<i>second revision</i>)
(Part 3) : 1987	Wind loads (<i>second revision</i>)		
(Part 4) : 1987	Snow loads (<i>second revision</i>)		
(Part 5) : 1987	Special loads and load combinations (<i>second revision</i>)	2366 : 1983	Code of practice for nail-jointed timber construction (<i>first revision</i>)
1734	Methods of test for plywood:	2380	Methods of test for wood particle boards and boards from other lignocellulosic materials:
(Part 4) : 1983	Determination of glue shear strength (<i>second revision</i>)	(Part 4) : 1977	Determination of static bending strength (<i>first revision</i>)
(Part 5) : 1983	Test for adhesion of plies (<i>second revision</i>)	(Part 5) : 1977	Determination of tensile strength perpendicular to surface (<i>first revision</i>)
(Part 9) : 1983	Determination of tensile strength (<i>second revision</i>)	(Part 6) : 1977	Determination of tensile strength parallel to surface (<i>first revision</i>)
(Part 10) : 1983	Determination of compressive strength (<i>second revision</i>)	4407 : 1967	Code of practice for reed walling
(Part 11) : 1983	Determination of static bending strength (<i>second revision</i>)	4924	Method of test for nail jointed timber trusses:
(Part 12) : 1983	Determination of scarf joint strength (<i>second revision</i>)	(Part 1) : 1968	Destructive test
(Part 13) : 1983	Determination of panel shear strength (<i>second revision</i>)	(Part 2) : 1968	Proof test
(Part 14) : 1983	Determination of plate shear strength (<i>second revision</i>)	6874 : 2008	Method of test for round bamboo (<i>first revision</i>)
(Part 15) : 1983	Central loading of plate test (<i>second revision</i>)	9096 : 2006	Code of practice for preservation of bamboo for structural purposes (<i>first revision</i>)
(Part 16) : 1983	Vibration of plywood plate test (<i>second revision</i>)		

ANNEX B

(Foreword)

COMMITTEE COMPOSITION

Building Construction Practices Sectional Committee, CED 13

Organization	Representative(s)
In personal capacity (Flat No. 2061, Engineers Apartments, Plot 11, Sector 18A, Dwarka, New Delhi 110 078)	SHRI D. S. SACHDEV (Chairman)
Ahtuwalia Contracts (India) Limited, New Delhi	SHRI SHOBHIT UPPAL SHRI VINAY PAL (Alternate)
Rhabha Atomic Research Centre, Mumbai	SHRI K. SRINIVAS SHRI H. E. IYER (Alternate)
Building Materials & Technology Promotion Council, New Delhi	SHRI J. K. PRASAD SHRI S. K. GUPTA (Alternate)
Central Building Research Institute, Roorkee	SHRI S. G. DAVE SHRI R. K. GARG (Alternate)
Central Public Works Department, CDO, New Delhi	CHIEF ENGINEER (CDO) SUPERINTENDING ENGINEER (D) II (Alternate)
Central Public Works Department, CSQ, New Delhi	SHRI VIRENDRA SHARMA SHRI MAYANK K. TULAK (Alternate)
Confederation of Construction Products and Services, New Delhi	SHRI DEEPAK GADLOWT SHRI SHASHI KANT (Alternate)
Construction Industry Development Council, New Delhi	SHRI P. R. SWARUP
Delhi Development Authority, New Delhi	CHIEF ENGINEER (SWZ) SUPERINTENDING ENGINEER (P) (SWZ) (Alternate)
Engineers India Limited, New Delhi	SHRI SUDHIR CHATURVEDI SHRI RAVINDRA KUMAR (Alternate)
Fly Ash Unit, Department of Science & Technology, New Delhi	DR VIMAL KUMAR
Forest Research Institute, Dehradun	DR V. S. KISHAN KUMAR
Housing & Urban Development Construction Corporation, New Delhi	SHRIMATI MANORAMA DUTTA SHRIMATI MANJU SAUAYA (Alternate)
Indian Buildings Congress, New Delhi	SHRI S. C. BHATIA SHRI P. S. CHADHA (Alternate)
Indian Glass Manufacturers' Association, New Delhi	SHRI ALOK MODI SHRI SANJAY LABROO (Alternate)
Indian Plywood Industries Research & Training Institute, Bangalore	SHRI JAGADISH VENGALA SHRI AMITAYA SIL (Alternate)
Metallizing Equipment Co Pvt Limited, Jodhpur	SHRI S. C. MODI SHRI ANKUR MODI (Alternate)
Military Engineering Services, Engineer-in-Chief's Branch, New Delhi	SHRI JAGDEV THAKUR SHRI KUSHAL YADAV (Alternate)
National Buildings Construction Corporation, New Delhi	SHRI AMITABHA BASU SHRI RAHV TYAGI (Alternate)
North East Institute of Science and Technology (CSIR), Jorhat	DR S. D. BARUAH SHRI AMITAYA BISWAS (Alternate)
NTPC Ltd, New Delhi	SHRI R. L. DAS SHRI ANIL KAPOOR (Alternate)
Pest Control (India) Pvt Ltd, Mumbai	SHRI SHANKAR M. GHUGE SHRI P. N. NOWROOZI (Alternate)
Public Works Department, Government of NCT of Delhi, New Delhi	SHRI A. K. SINHA SHRI PUNEET KUMAR VATS (Alternate)
Research, Designs and Standards Organization, Ministry of Railways, Lucknow	SHRI PRABHAT KUMAR SHRI ASHUTOSH KUMAR (Alternate)

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PROF M. L. BAIJI (*Alternate*)
DR NAGESH R. IYER
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SHRI VIJAY GARG
SHRI SHAMIT MANCHANDA (*Alternate*)
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SHRI DEVENDRA GILL (*Alternate*)
SHRI K. S. PRUTHI
SHRI A. K. SAINI, Scientist 'P' & Head (Civil Engg)
[Representing Director General (*Ex-officio*)]

Member Secretary
SHRI S. ARUN KUMAR
Scientist 'C' (Civil Engg), BIS

