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Indian Standard

CODE OF PRACTICE FOR DESIGN AND CONSTRUCTION OF FLOORS AND ROOFS USING PRECAST REINFORCED/PRESTRESSED CONCRETE RIBBED OR CORED SLAB UNITS

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(*Continued on page* 14)

Indian Standard

CODE OF PRACTICE FOR DESIGN AND CONSTRUCTION OF FLOORS AND ROOFS USING PRECAST REINFORCED/PRESTRESSED CONCRETE RIBBED OR CORED SLAB UNITS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 30 September 1982, after the draft finalized by the Prefabricated and Composite Construction Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 Precast ribbed slab units generally have a thin flange stiffened by longitudinal and/or transverse ribs. Cored slab units are those precast panels in which voids are created in manufacturing process to reduce the cross section without appreciably decreasing the stiffness or strength. These ribbed slabs as well as cored slabs are generally lighter than the normal cast *in situ* solid slabs or beam and slab. Structurally advantageous sections like channels, double tees, hollow core cross sections can be used, effecting considerably decrease in dead load and resultant saving in material. These units can be used for floors, roofs as well as for wall panels, in general building construction including residential, public and industrial buildings. These units can be advantageously used for spans up to 9 metres in case of reinforced concrete units and up to 30 metres in case of prestressed concrete units.

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

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 rounded off value should be the same as that of the specified value in this standard.

*Rules for rounding off numerical values (*revised*).

1. SCOPE

1.1 This standard covers the details of design and construction of floors and roofs using precast reinforced and prestressed concrete ribbed/cored slab units. This standard is intended to supplement the requirements for design and construction already covered by IS : 456-1978* and IS : 1343-1980† and other relevant codes for reinforced/prestressed concrete structures.

2. DETAILS OF PRECAST UNITS

2.1 Design Dimensions — The width of the ribbed units may be a maximum of 3 000 mm with cross ribs and 2 100 mm for units without cross ribs. For residential buildings the nominal width of the unit may be from 600 mm to 1 200 mm in increments of 300 mm chosen as per relevant standards and modular coordination. For industrial and other buildings, however, the preferred nominal width is 1 500 mm for channel units and 2 100 mm for double tee units. For the cored slab units the width shall be chosen taking into consideration the aspects of modular coordination as per relevant codes up to a maximum width of 2 100 mm. The actual width of the precast unit will however be slightly less to take into consideration the tolerance in casting the units and also to provide for cast *in situ* grouting at the joints.

NOTE — The units with nominal width of minimum 300 mm may also be used in residential buildings.

2.2 The overall depth of the longitudinal ribs shall not be less than 1/25 of span for reinforced concrete units and 1/30 of span in the case of prestressed concrete units. It is, however, recommended that deflection calculations in accordance with the relevant Indian Standard code are made to ensure that these serviceability conditions are met (*see* IS : 456-1978* and IS : 1343-1980†).

2.3 The minimum width of the rib shall not be less than 50 mm for spans up to 5 m and 70 mm in the case of larger spans. The cross section of the rib shall, however, have adequate slopes to facilitate demoulding during manufacture. Normally, the internal slopes may be in the range of 1/15 to 1/8.

2.4 The minimum thickness of flange shall be 35 mm provided the concreting is done with proper mechanical vibration or by other methods to achieve equivalent compaction assuming that the maximum size of aggregate shall be 12 mm. It is essential that the reinforcement in the flange shall be provided in the form of a mesh with spacing of bars/wires not exceeding those stipulated for slabs in IS : 456-1978* subject to the

*Code of practice for plain and reinforced concrete (*third revision*).
†Code of practice for prestressed concrete (*first revision*).

condition that the maximum unreinforced concrete area does not exceed 15 t^2 where t is the thickness of the flange. In the thin units (of 35 mm thickness of flange) the spacing may be a maximum of 150 mm both ways.

3. MATERIALS

3.1 The materials used for the construction shall conform to IS : 456-1978* and IS : 1343-1980†.

4. STRUCTURAL DESIGN

4.1 The precast units shall have adequate strength and stability in accordance with the relevant code of practice (IS : 456-1978* or IS : 1343-1980†) during the following stages:

a) Demoulding;

b) Handling, stacking, transporting and placing; and

c) With all design loads together with dead load of *in situ* concrete placed for connection purposes.

In situations where *in situ* concrete brings in monolithic connection and continuity it shall be designed according to IS : 3935-1966‡.

NOTE — Where Portland pozzolana cement is used delayed strength development at the early ages shall be considered.

4.2 Loads shall be in accordance with IS : 875-1964§.

4.3 For calculating the limit state of collapse at the critical cross sections, at stage of demoulding and handling, a load factor of at least 1 5 shall be applied for calculating the design limit state of collapse load.

The actual strength of the cross section at this stage can either be calculated or proved through necessary tests.

4.4 Effective Flange Width

4.4.1 *Reinforced Concrete Ribbed Slab Units* — When the thickness of flange is more than 1/10 of overall depth of the rib, the overall width of the flange is effective in the compressive zone and can be taken into consideration in calculations for moment of resistance of the cross sections In case the thickness of flange is less than 1/10 of the overall depth of the rib, the effective flange width can be taken as in T-section in accordance with IS : 456-1978*. Typical sketch of the channel unit and double tee unit is shown in Fig. 1.

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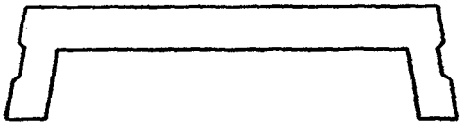
*Code of practice for plain and reinforced concrete (*third revision*).
†Code of practice for prestressed concrete (*first revision*).
‡Code of practice for composite construction.
§Code of practice for structural safety of buildings: Loading standards.



1A CHANNEL SLAB UNIT

1B DOUBLE TEE SLAB UNIT

FIG. 1 RIBBED SLAB UNITS

4.4.2 *Prestressed Concrete Ribbed Slab Units* — In the design of prestressed ribbed slabs, however, the entire flange should be taken as effective for all cases and the T-beam formula should not be applied as this may lead to underestimation of the prestressing force required, if a lesser cross section is assumed to be effective.

4.4.3 *Reinforced or Prestressed Cored Slab Units* — The thickness 'd' of cored slab units shall be in accordance with **2.2.** The dimension 'd_1' shall be at least $\frac{1}{4}$ d and 'd_2' shall be at least $\frac{1}{5}$ d (*see* Fig. 2) subject to minimum of 20 mm.

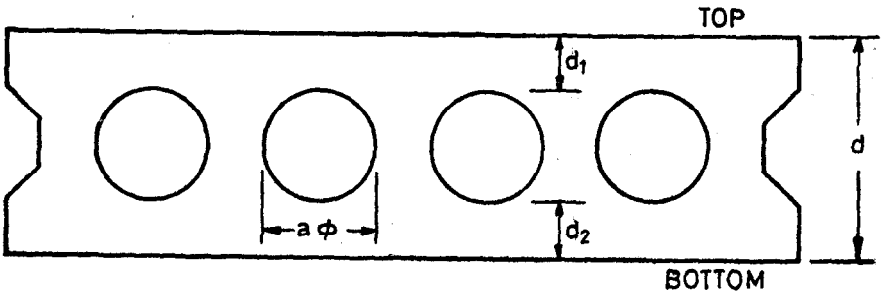


FIG. 2 CORED SLAB UNIT

The smallest cross-section width excluding the hollow space, $b_o = b - \Sigma a$, shall be at least $\frac{'1b'}{3}$ unless a greater width is required for contemplated shear stress.

4.4.3.1 *Reinforced or prestressed cored slab units* — The effective cross section for design can be modified by adopting equivalent rectangular/square instead of circular or elliptical openings as given in Fig. 3.

5. MOULD

5.1 The mould used for manufacturing ribbed slabs normally consist of two parts, (a) bottom mould, and (b) side moulds. The bottom mould can be made out of timber, masonry, concrete, steel, FRP, plastic or any other material acceptable to engineer-in-charge. The side moulds similarly can be of timber, steel, FRP, or plastic. When using masonry or concrete moulds, the top surface shall be finished to the required accuracy (*see* Table 1) and made smooth.

In case of masonry moulds, the use of chicken mesh or fibre reinforcement in the top surface will help in making the mould last longer for higher efficiency.

5.2 In the case of cored slabs, the voids can be created either by an extrusion process, by inflated tubes, mild steel tubes, timber, cardboard/hard paper or any other material.

5.3 The castellations/depressions/roughening of required depth shall be provided in the sides of the precast units. Suitable provisions in the side shutters of the mould may create better keying between *in situ* concrete and precast concrete units at the joints.

6. REINFORCEMENT COVER

6.1 Minimum cover for the reinforcement for precast units shall be as follows:

a) For reinforcement in the flange, 12 mm clear in all directions. This shall be increased to 15 mm when surfaces of precast members are exposed to corrosive atmosphere; and

b) For main reinforcement in the rib, 20 mm or diameter of bar whichever is greater. In case of corrosive atmosphere, this shall be increased to 25 mm, or diameter of bar, whichever is greater.

6.2 It shall be ensured that the reinforcement cages are not in any way distorted during storage, handling, placement and casting. In the case of mass production in large precasting factories, the use of reinforcement ladders and mesh made by using a resistant-welding machine will be advantageous for improving production.

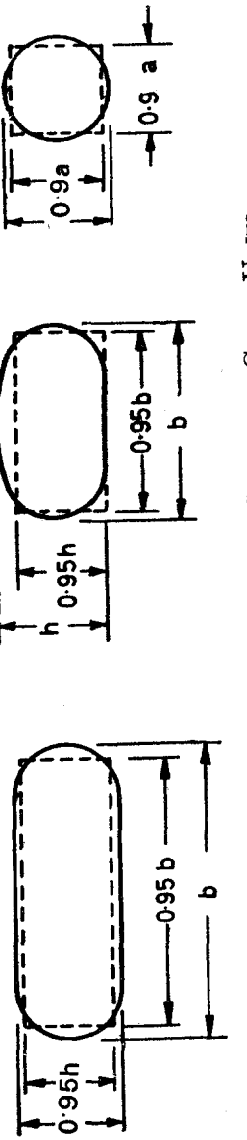


FIG. 3 EFFECTIVE SPANS AND CROSS-SECTION OF CORED UNITS

7. CONCRETE

7.1 The concrete mix used shall be minimum of M-15 grade in accordance with IS : 456-1978* but M-20 and above grade of concrete is preferred for reinforced concrete units and in accordance with IS : 1343-1980† in the case of prestressed concrete units. The maximum size of aggregate used shall be restricted to 12 mm in the case of ribbed slabs and cored slabs with flange thickness less than 50 mm.

8. CASTING AND CURING OF UNITS

8.1 Mechanical vibration either through mould/table vibrators or screed vibrators is essential to ensure good compaction. Needle vibrators can be used for compacting concrete in the ribs and screed vibrators for compacting concrete in the flange. For larger factories, concrete placing machine which level, vibrate and finish the concrete units can be advantageously utilized for this purpose.

8.2 Curing shall be done as per IS : 456-1978*. If necessary, low pressure steam curing may be provided to get early stripping/release strength.

9. TOLERANCES

9.1 Tolerances of units shall be as follows.

9.1.1 *Length* — ± 5 mm or $\pm 0{\cdot}1$ percent, whichever is greater.

9.1.2 *Cross-Sectional Dimensions* — ± 3 mm or $\pm 0{\cdot}1$ percent, whichever is greater.

9.1.3 *Straightness of Bow* — ± 5 mm or 1/750 of the length, whichever is greater.

9.1.4 *Squareness* — When considering the squareness of the corner, the longer of the two adjacent sides being checked shall be taken as the base line. The shorter side shall not vary in length from the perpendicular by more than 5 mm.

For the purpose of this requirement any error due to lack of straightness shall be ignored; squareness shall be measured with respect to the straight lines which are mostly nearly parallel with the features being checked when nominal angle is other than 90°, the included angle between the check lines should be varied accordingly.

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*Code of practice for plain and reinforced concrete (*third revision*).
†Code of practice for prestressed concrete (*first revision*).

9.1.5 *Twist* — Any corner shall not be more than the tolerance given below from the plane containing the other three corners:

Up to 60 cm in width and up to 6 mm in length	5 mm
Over 60 cm in width and for any length	10 mm

9.1.6 *Flatness* — The maximum deviation from a 1·5-m straight edge placed in any position on a nominal plane surface shall not exceed 5 mm.

9.2 Tolerances of the mould are given in Table 1.

TABLE 1 TOLERANCES OF MOULDS

(*Clauses* 5.1 *and* 9.2)

	(mm)
Length	−10·0
Width	−3·0
Height	+3·0
Diagonal	±5·0
Warp/Bow	±3·0

9.3 Suitable erection tolerances shall be taken into account while erecting the precast units.

10. SAMPLING AND TESTING OF UNITS

10.1 Sampling — Sampling shall be done in accordance with Appendix A.

10.2 Load Test

10.2.1 Load tests shall be carried out in accordance with IS : 456-1978*.

10.2.2 All the units passing the load test can be used in the construction.

10.3 After the load test, an optional test on the precast unit up to destruction can be performed as agreed to between the supplier and the purchaser. This test is primarily intended to re-confirm the load-factor actually available *vis-a-vis* the design load.

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

11. TRANSPORTATION AND ERECTION OF PRECAST ELEMENTS

11.1 Lifting Hooks — Wherever lifting hooks/holes are used these shall be provided at structurally advantageous points (for example, 1/5 of the length from the end of the element) to facilitate demoulding and erection of the precast unit. The lifting hooks can be formed out of normal mild steel reinforcing bars with adequate carrying capacity to carry the self weight during demoulding, handling and erection. After erection, the hooks can either be cut or bent down inside the screed or joint concrete that will be laid subsequently.

11.2 Stacking of Units — After removal from moulds the precast units shall be stacked over supports placed at about 1/6 of span from ends. Care shall be taken to see that no support is placed at the centre of span. Care also shall be taken to see that the main reinforcement is always at the bottom of stacked units.

11.3 Transportation — The units shall be transported always with the main reinforcement at the bottom. For transporting and erecting the units, rope slings shall be tied near the ends at 1/5 of the length from either end of the unit. In case the units are transported in trolleys, the over-hang of the units from the trolley shall not be more than 1/5 of the length. The unit shall be lifted manually or with the help of chain pulley blocks or mechanically with a hoist or a crane.

11.4 Placing and Aligning — The units shall be placed and aligned side by side across the span to be covered. While placing the units, care shall be taken to see that they have the specified bearing on supporting wall/beam. Placing of units shall be started from one end of the building.

11.5 Bearing — The precast units shall have a minimum bearing of 75 mm on the beams and 100 mm on the conventional masonry wall.

11.5.1 If ribbed slab units without end diaphragm are used over conventional masonry wall, concrete bed blocks shall be provided beneath the ribs.

12. CURING OF *IN SITU* CONCRETE IN JOINTS

12.1 The *in situ* concrete in the joint shall be cured for at least 7 days in accordance with IS : 456-1978*. The concrete shall then be allowed to dry for at least a week. A coat of cement slurry may be applied to the joints to fill the hairline cracks that might have developed.

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

13. FIXTURES

13.1 Designers shall indicate provisions for fixtures like fanhooks/inserts/electric conduits, etc, to be incorporated within the precast units or the *in situ* joints/screed concrete.

13.1.1 In case of concealed wiring, conduits may be placed within the joints along the length or within the screed before concreting. If adequate thickness is available this may be concealed within the floor/roof finish.

13.1.2 Holes, openings and fixtures required to be provided within the precast units shall be fixed accurately with adequate embeddment at the precasting stage. Drilling of holes/cutting of edges shall not be made unless permitted by the engineer-in-charge beforehand.

14. FLOOR FINISH

14.1 In case of floor slab, the floor finish shall be done as per the relevant Indian Standard Code of practice. The Indian Patent Stone or mosaic flooring shall be layed in bays with the bay lines in the direction of the unit coinciding with any of the joints between the units.

14.2 When the floor is made up of series of strips, mechanical connections/screed concrete/overlapping reinforcement may be provided to account for differential loading.

14.3 To provide adequate resistance against impact/acoustic treatment, the floor thickness at any place shall not be less than 75 mm.

15. ROOF TREATMENT

15.1 Adequate waterproofing and thermal insulation to suit local climatic conditions shall be adopted in accordance with relevant Indian Standard Code of practice.

APPENDIX A

(*Clause* 10.1)

SAMPLING PROCEDURE FOR PRECAST SLAB UNITS

A-1. LOT

A-1.1 All the precast slab units of the same size, manufactured from the same material under similar conditions of production shall be grouped together to constitute a lot.

A-1.2 The number of units to be selected from each lot for dimensional requirements 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 REJECTION NUMBER

Lot Size	First Sample Size	Second Sample Size	First Rejection Number	Second Rejection Number
(1)	(2)	(3)	(4)	(5)
Up to 100	5	5	2	2
101 to 300	8	8	2	2
301 to 500	13	13	2	2
501 and above	20	20	3	4

A-1.2.1 The units shall be selected from the lot at random. In order to ensure the randomness of selection, procedure given in IS : 4905-1968* may be followed.

A-2. NUMBER OF TESTS AND CRITERIA FOR CONFORMITY

A-2.1 All the slab units selected at random in accordance with col 1 and 2 of Table 2 shall be subjected to the dimensional requirements. A unit failing to satisfy any of the dimensional requirements shall be termed as defective. The lot shall be considered as conforming to the dimensional requirements if no defective is found in the sample, and shall be rejected if the number of defectives is greater than or equal to the first rejection number. If the number of defectives is less than the first rejection number the second sample of the same size as taken in the first stage shall be selected from the lot at random and subjected to the dimensional requirements. The number of defectives in the first sample and the second sample shall be combined and if the combined number of defectives is less than the second rejection number, the lot shall be considered as conforming to the dimensional requirements; otherwise not.

A-2.2 The lot which has been found as satisfactory with respect to the dimensional requirements shall then be tested for load test. For this purpose one unit shall be selected for every 300 units or part thereof. The lot shall be considered as conforming to the requirement if all the units meet the requirement; otherwise not.

*Methods for random sampling.

(*Continued from page* 2)

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