IS 3370-1 (2009): Code of practice Concrete structures for the storage of liquids, Part 1: General requirements [CED 2: Cement and Concrete]

BLANK PAGE

भारतीय मानक

द्रवों के संग्रहण के लिये कंक्रीट संरचनाएँ — रीति संहिता

भाग 1 सामान्य अपेक्षाएँ

(पहला पुनरीक्षण)

Indian Standard

CONCRETE STRUCTURES FOR STORAGE OF LIQUIDS — CODE OF PRACTICE

PART 1 GENERAL REQUIREMENTS

(First Revision)

ICS 23.020.01; 19.080.40

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

June 2009

Price Group 7

FOREWORD

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

This standard was first published in 1965. The present revision has been taken up with a view to keeping abreast with the rapid development in the field of construction technology and concrete design and also to bring further modifications in the light of experience gained while applying the earlier version of this standard and the amendment issued.

The design and construction methods in reinforced concrete and prestressed concrete structures for the storage of liquids are influenced by the prevailing construction practices, the physical properties of the materials and the climatic condition. To lay down uniform requirements of structures for the storage of liquids giving due consideration to the above mentioned factors, this standard has been published in four parts, the other parts in the series are:

(Part 2) : 2009 Reinforced concrete structures

(Part 3) : 1967 Prestressed concrete structures

(Part 4) : 1967 Design table

While the common methods of design and construction have been covered in this standard, for design of structures of special forms or in unusual circumstances, special literature may be referred to or in such cases special systems of design and construction may be permitted on production of satisfactory evidence regarding their adequacy and safety by analysis or test or by both.

In this standard it has been assumed that the design of liquid retaining structures, whether of plain, reinforced or prestressed concrete is entrusted to a qualified engineer and that the execution of the work is carried out under the direction of a qualified and experienced supervisor.

The concrete used in liquid retaining structures should have low permeability. This is important not only for its direct effect on leakage but also because it is one of the main factors influencing durability; resistance to leaching, chemical attack, erosion, abrasion and frost damage; and the protection from corrosion of embedded steel. The standard, therefore, incorporates provisions in design and construction to take care of this aspect.

The requirements of IS 456 : 2000 'Code of practice for plain and reinforced concrete (*fourth revision*)' and IS 1343 : 1980 'Code of practice for prestressed concrete (*first revision*)', in so far as they apply, shall be deemed to form part of this standard except where otherwise laid down in this standard. For a good design and construction of structure, use of dense concrete, adequate concrete cover, good detailing practices, control of cracking, good quality assurance measures in line with IS 456 and good construction practices particularly in relation to construction joints should be ensured.

This revision incorporates a number of important modifications and changes, the most important of them being:

a) Scope has been clarified further by mentioning exclusion of dams, pipes, pipelines, lined structures and damp-proofing of basements,
b) A clause on exposure condition has been added,
c) Provisions for concrete have been modified in line with IS 456 : 2000 with minimum grade of concrete as M20 for plain cement concrete, M30 for reinforced concrete and M40 for prestressed concrete (*see also* Note 2 under Table 1),
d) The maximum cement content has been modified from the earlier requirement of 530 kg/m^3 to 400 kg/m^3,
e) A clause on durability has been added giving due reference to IS 456 in place of earlier clause on protection against corrosion,
f) Provisions on control of cracking have been modified,

(*Continued on third cover*)

Indian Standard

CONCRETE STRUCTURES FOR STORAGE OF LIQUIDS — CODE OF PRACTICE

PART 1 GENERAL REQUIREMENTS

(First Revision)

1 SCOPE

1.1 This standard (Part 1) lays down general requirements for the design and construction of plain, reinforced or prestressed concrete structures, intended for storage of liquids, mainly water.

The requirements applicable specifically to reinforced concrete and prestressed concrete liquid retaining structures are covered in IS 3370 (Part 2), and IS 3370 (Part 3) respectively.

1.2 This standard does not cover the requirements for concrete structures for storage of hot liquids and liquids of low viscosity and high penetrating power like petrol, diesel, oil, etc. This standard also does not cover dams, pipes, pipelines, lined structures and damp-proofing of basements. Special problems of shrinkage arising in the storage of non-aqueous liquids and the measures necessary where chemical attack is possible are also not dealt with. The recommendations, however, may generally be applicable to the storage at normal temperatures of aqueous liquids and solutions which have no detrimental action on concrete and steel or where sufficient precautions are taken to ensure protection of concrete and steel from damage due to action of such liquids as in the case of sewage.

1.3 The criteria for design of RCC staging for overhead water tanks are given in IS 11682.

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 as given in Annex A.

3 MATERIALS

3.1 The requirements for materials shall be governed by IS 456 and IS 1343 for reinforced concrete and prestressed concrete members respectively, with the following additional requirements.

3.1.1 *Porous Aggregates*

Under no circumstances shall the use of porous aggregates, such as slag, crushed over burnt brick or tile, bloated clay aggregates and sintered flyash aggregates, be allowed for parts of structure either in contact with the liquids on any face or enclosing the space above the liquid.

3.2 Jointing Materials

Joint fillers, joint sealing compounds, and water bars shall conform to the requirements of relevant Indian Standards. Other jointing materials such as polyurethane and silicone based sealants may also be used provided there are satisfactory data on their suitability. The jointing materials used shall not have any adverse effect on the quality of liquid to be stored.

4 EXPOSURE CONDITION

For the purpose of this standard, parts of the structure retaining the liquid or enclosing the space above the liquid shall be considered as subject to 'severe' condition as per IS 456. In case of members exposed to 'very severe' or 'extreme' conditions, the relevant provisions of IS 456 shall apply.

5 CONCRETE

Provisions given in IS 456 and IS 1343 for concrete shall apply for reinforced concrete and prestressed members respectively subject to the following further requirements:

a) The concrete shall conform to Table 1.
b) The cement content not including flyash and ground granulated blast furnace slag in excess of 400 kg/m^3 should not be used unless special consideration has been given in design to the increased risk of cracking due to drying shrinkage in thin sections, or to early thermal cracking and to increased risk of damage due to alkali silica reactions.

6 DURABILITY

6.1 The provisions for durability shall generally be

Table 1 Minimum Cement Content, Maximum Water-Cement Ratio and Minimum Grade of Concrete

[*Foreword*, and *Clause* 5(a)]

Sl No.	Concrete	Minimum Cement Content kg/m³	Maximum Free Water Cement Ratio	Minimum Grade of Concrete
(1)	(2)	(3)	(4)	(5)
i)	Plain concrete	250	0.50	M20
ii)	Reinforced concrete	320	0.45	M30
iii)	Prestressed concrete	360	0.40	M40

NOTES

1 Cement content prescribed in this table is irrespective of the grades of cement and it is inclusive of additions mentioned in 5.2 of IS 456. The additions such as flyash or ground granulated blast furnace slag may be taken into account in the concrete composition with respect to the cement content and water cement ratio if the suitability is established and as long as the maximum amounts taken into account do not exceed the limit of pozzolana and slag specified in IS 1489 (Part 1) and IS 455 respectively.

2 For small capacity tanks up to 50 m³ at locations where there is difficulty in providing M30 grade concrete, the minimum grade of concrete may be taken as M25. However, this exception shall not apply in coastal areas.

followed as specified in IS 456 for plain and reinforced concrete structures, and as per IS 1343 for prestressed concrete structures unless specified otherwise in this standard.

6.2 Nominal Cover to Reinforcement

6.2.1 The minimum nominal cover to all reinforcement shall be as per IS 456 for relevant exposure conditions.

7 SITE CONDITIONS

7.1 The following conditions of the site in relation to the functional and structural requirements of the liquid retaining (storage) structure materially influence the methods of design and the cost of the structure:

a) Physical characteristics of soil in which the liquid retaining structure may be partly or wholly enclosed and also the physical and geological features of the supporting foundations,
b) Chemical properties of the soil and of the ground water, and
c) Extent of floatation at the site.

7.2 In making the choice of the site and in the preparation of the design, the factors mentioned in **7.1** should be taken into account generally as indicated below:

a) *Earth Pressure* — Allowance should be made for the effects of any adverse soil pressure on walls, according to the compaction and/or surcharge of the soil and the condition of the structure during construction and in service. No relief should be given for beneficial soil pressure effects on the walls of containment structure in the container full condition.
b) *Floatation* — If in the siting of a liquid retaining structure, water-logged ground cannot be avoided, the danger of the external water pressure shall be carefully guarded against by the following:
   1) Designing the structure to resist such pressure under empty or partially-empty conditions and taking precautions to prevent floating and ensuring stable equilibrium under all conditions of internal and external loads. The stability of the structure should be checked against uplift using a factor of safety of 1.2. The individual members shall be designed for stresses due to uplift forces.
   2) Providing effective drainage to reduce the level of external water as far as local conditions permit.
   3) Providing relief valves discharging into the liquid retaining structure when the external pressure exceeds the internal pressure; this arrangement is feasible only in cases when the liquid retaining structure is not required for the storage of liquids which should not be contaminated.
   4) Designing both internal and external faces of the walls and floor as water retaining faces, where the walls and floors of the liquid retaining structure are submerged in water or water bearing soils.
   5) Considering in the design, the possibility of sudden change in ground water table or sudden accumulation of water around.
c) *Stability* — The equilibrium and safety of structure and parts of it against sliding and overturning, especially when the structure is founded on a side of long or sloping ground, shall also be checked.
d) *Settlement and Subsidence* — Geological faults, mining, earthquakes, existence of subsoils of varying bearing capacities may give rise to movement or subsidence of supporting strata which may result in serious cracking of structure. Special considerations should be given in the preparation of the design, to the possible effect of subsidence or movement of the foundation strata for example, subdivision

of the structure into smaller compartments and provision of joints to outlet pipes and other fittings. Joints in structures in mining subsidence areas will need special consideration to provide for extra movement.

e) *Injurious Soils* — Chemical analysis of the soil and ground water is essential in cases where injurious soils are expected to exist, as concrete structure may suffer severe damage in contact with such soils. Where concrete is likely to be exposed to sulphate attack, requirements specified in IS 456 shall be followed. An isolating coat of bituminous or other suitable materials may improve the protective measure.

8 CAUSES AND CONTROL OF CRACKING

8.1 Causes

8.1.1 *Effects of Applied Loads*

Direct or flexural tension in concrete arising from applied external service loads, from temperature gradients due to solar radiation, or from the containment of liquids at temperatures above ambient, may cause cracking in the concrete.

8.1.2 *Temperature and Moisture Effects*

Changes in the temperature of the concrete and reinforcement and in the moisture content of the concrete cause dimensional changes which, if resisted internally or externally may crack the concrete. The distribution and width of such cracks may be controlled by reinforcement, together with the provision of the movement joints. Heat is evolved as cement hydrates, and the temperature will rise for a day or more after casting and then fall towards ambient. Cracking usually occurs at this time, while the concrete is still weak. Subsequent lower ambient temperature and loss of moisture when the concrete is mature will open these cracks although the loss of moisture at the surface under external drying conditions is usually low. A structure built in the summer but not filled or an external structure standing empty will usually be subjected to greater drops in temperature than the same structure filled.

8.2 Methods of Control

8.2.1 Plain concrete liquid retaining structures or members may be designed by allowing direct tension in plain concrete, the permissible tensile stress for M20 and M25 concrete being 1.2 N/mm^2 and 1.3 N/mm^2 for direct tension and 1.7 N/mm^2 and 1.8 N/mm^2 for flexural tension respectively. However, nominal reinforcement in accordance with the requirements given in IS 456 shall be provided for plain concrete structural members.

8.2.2 The most important factor affecting drying shrinkage is the amount of water per unit of concrete. Water can be reduced by use of both plasticizing admixtures and by using minimum amount of cement consistent with quality. The concrete mix should have the largest practical coarse aggregates as this will reduce the cement content.

8.2.3 In cases where structures under construction are exposed to high wind, high temperature and low humidity, adequate measures during the initial stages of construction shall be taken for protection from surface drying, such as covering the concrete surface by polyethylene or tarpaulin sheets.

8.2.4 Cracking may be controlled by avoiding or reducing the gradient of steep changes in temperature and moisture of especially the early age concrete. Type of shuttering, deshuttering procedure and curing method may affect the changes in temperature and moisture. Curing shall be done for a period of not less than 14 days.

8.2.5 The risk of cracking due to overall temperature and shrinkage effects may be minimized by limiting the changes in moisture content in concrete and temperature to which the structure as a whole is subjected. Tanks can remain wet. It will be advantageous if, during construction of such reservoirs, thin sections below final water level are kept damp.

8.2.6 The risk of cracking can also be minimized by reducing the restraints on the free expansion or contraction of the structure. With long walls or slabs founded at or below ground level, restraints can be minimized by the provision of a sliding layer.

8.2.7 Structures may be provided with movement joints if effective and economic means cannot otherwise be taken to avoid unacceptable cracking.

8.2.8 Whenever development of cracks or overstressing of the concrete in tension cannot be avoided, the concrete section should be suitably strengthened. In making the calculations either for ascertaining the expected expansion or contraction or for strengthening the concrete section, the coefficient of expansion of concrete shall be in accordance with the provisions given in IS 456.

8.2.9 Cracking of concrete can be to some extent controlled by slow filling of the tank first time. The rate of filling shall not be more than 1 m per 24 h.

8.2.10 Correct placing of reinforcement bars, use of deformed bars, bars closely spaced and use of small size bars lead to diffused distribution of cracks, and hence are preferred practices.

9 STABILITY OF THE STRUCTURE

Stability of the structure against overturning and sliding shall be as given in IS 456.

A structure subjected to underground water pressure shall be designed to resist floatation as given in 7.2(b).

10 JOINTS

10.1 Joints shall be categorized as follows:

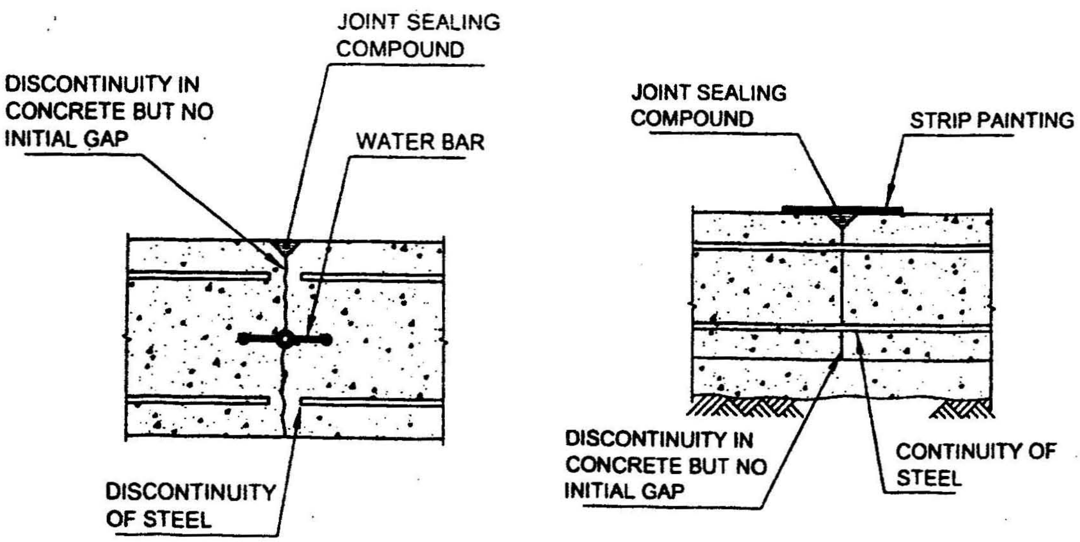
a) *Movement Joints* — A movement joint is intended to accommodate relative movement between adjoining parts of a structure, special provisions being made to maintain the water-2 tightness of the joint. In elevated structures where restraint is small, movement joints may not be required. There are three categories of movement joints:

   1) *Contraction joint* — A movement joint with a deliberate discontinuity but no initial gap between the concrete on either side of the joint, the joint being intended to accommodate contraction of the concrete (*see* Fig. 1).

      A distinction should be made between a complete contraction joint (*see* Fig. 1A) and a partial contraction joint (*see* Fig. 1B). While the complete contraction joints are not restrained to movement and are intended to accommodate only contraction of the concrete, the partial contraction joints provide some restraint but are intended to accommodate some contraction of concrete. In complete contraction joints both concrete and reinforcing steel are interrupted and in partial contraction joints only the concrete is interrupted, the reinforcing steel running through. A water bar shall be provided either centrally in a wall (*see* Fig. 1A) or on the soffit of a floor. To cater for shear across the face a shear key may be provided. In a partial contraction joint, a water bar may be provided, if necessary, preferably centrally in a wall or on the soffit of a floor. These figures show some of the typical joints and other available joint details may also be used.

   2) *Expansion joint* — A movement joint which has no restraint to movement and is intended to accommodate either expansion or contraction of the concrete. This has complete discontinuity in both reinforcement and concrete (*see* Fig. 2). An expansion type water bar shall be provided either centrally in a wall (*see* Fig. 2A) or on the soffit of a floor. A centre-bulb water bar may be used in walls.

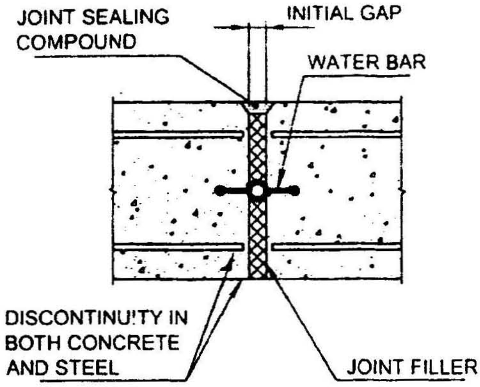
      In general, such a joint requires the provision of an initial gap between the adjoining parts of a structure which by closing or opening accommodates the expansion or contraction of the structure. Design of the joint so as to incorporate sliding surface, is not, however, precluded and may some times be advantageous.



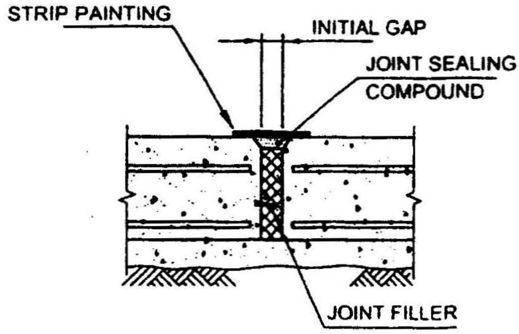
1A Complete Contraction Joint

1B Partial Contraction Joint

FIG. 1 TYPICAL CONTRACTION JOINTS



2A



2B

FIG. 2 TYPICAL EXPANSION JOINTS

3) *Sliding joint* — A movement joint which allows two structural members to slide relative to one another with minimal restraint. This has complete discontinuity in both reinforcement and concrete at which special provision is made to facilitate relative movement in the place of the joint.

A typical application is between wall and floor in some cylindrical tank designs (*see* Fig. 3).

b) *Construction Joints* — A joint in the concrete introduced for convenience in construction at which special measures are taken to achieve subsequent continuity without provision for further relative movement, is called a construction joint.

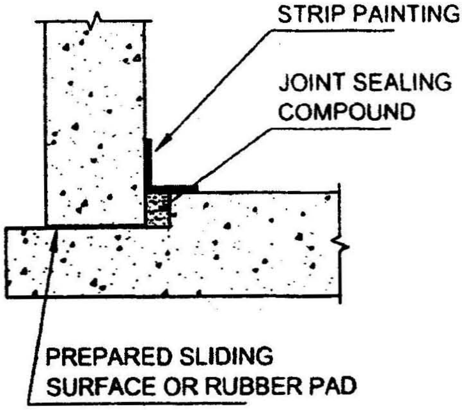


FIG. 3 TYPICAL SLIDING JOINTS

The position of construction joints should be specified by the designer. Full structural continuity is assumed in design at the construction joint and should be realized in practice. If necessary, construction joints should be grouted.

The concrete at joints should be bonded properly. The surface of the earlier pour should be roughened to increase the bond strength and to provide aggregate interlock. This may be best carried out by applying a surface retarder immediately after concreting the earlier pour. For vertical surfaces, the surface retarder should be applied to the formwork. The laitance is removed by applying a jet of water. If the joint surface is not roughened before the concrete is hardened; in that case, the laitance should be removed by sand blasting or by a scrabbler. The joint surface should be cleaned and dampened for at least six hours prior to placing new concrete. It is not desirable to apply layer of mortar over the old surface.

c) *Temporary Open Joints* — A gap temporarily left between the concrete of adjoining parts of a structure which after a suitable interval and before the structure is put into use, is filled with concrete either completely (*see* Fig. 4A) or as provided below, with the inclusion of suitable jointing materials (*see* Fig. 4B). In the former case the width of the gap should be sufficient to allow the sides to be prepared before filling.

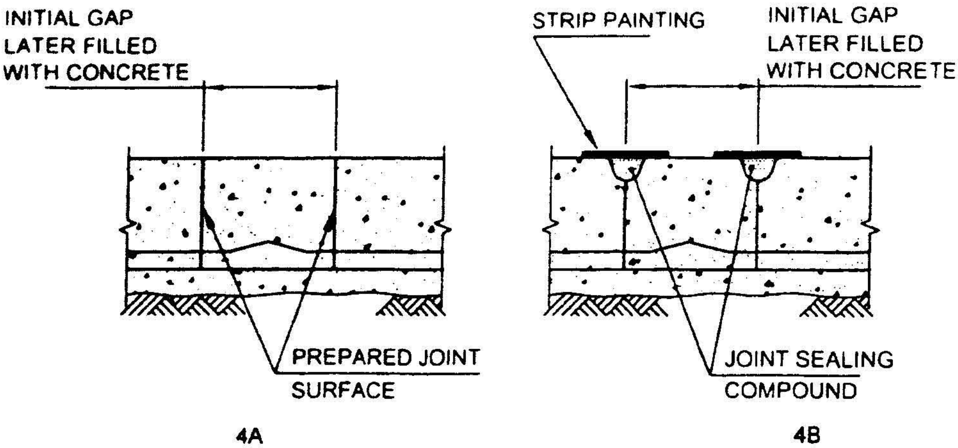


FIG. 4 TYPICAL TEMPORARY OPEN JOINTS

Where measures are taken for example, by the inclusion of suitable jointing materials to maintain the water tightness of the concrete subsequent to the filling of joint, this type of joints may be regarded as being equivalent to a contraction (partial or complete) as defined above.

10.2 Design and Detailing of Joints

Design of a movement joint should aim at following desirable properties for its efficient functioning:

a) The joint should accommodate repeated movement of the structure without loss of water tightness.
b) The design should provide for exclusion of grit and debris which would prevent the closing of the joint.
c) The material used in the construction of movement joints should have the following properties:
   1) It should not suffer permanent distortion or extrusion and should not be displaced by fluid pressure.
   2) It should not slump unduly in hot weather or become brittle in cold weather.
   3) It should be insoluble and durable and should not be affected by exposure to light or by evaporation of solvent or plasticizers.
   4) In special cases, the materials should be non-toxic, taintless or resistant to chemical and biological action as may be specified.

Congestion of reinforcement should be avoided during detailing. Various methods such as choosing the diameter and grade of steel carefully and bundling of reinforcement, if required, are available.

10.3 Spacing of Movement Joints

The provision of movement joints and their spacing are dependent on the design philosophy adopted, that is, whether to allow for or restrain shrinkage and thermal contraction in walls and slabs. At one extreme, the designer may exercise control by providing a substantial amount of reinforcement in the form of small diameter bars at close spacing with no movement joints. At the other extreme, the designer may provide closely spaced movement joints in conjunction with a moderate proportion of reinforcement. Between these extremes, control may be exercised by varying the reinforcement and joint spacing, an increase in spacing being compensated for by an increase in the proportion of reinforcement required.

The three main options for the designer are summarized in Table 2 as follows:

a) *In Option 1 (Design for Full Restraint)* — No contraction joints are provided within the area designed for continuity; and crack widths and spacing are controlled by reinforcement. Construction joints become part of the crack pattern and have similar crack widths.
b) *In Option 2 (Design for Partial Restraint)* — Cracking is controlled by the reinforcement, but the joint spacing is such that some of the daily and seasonal movements in the mature slab or structural member are accommodated at the joints, so reducing the amount of movement to be accommodated at the cracks between the joints.
c) *In Option 3 (Design for Freedom of Movement)*

Table 2 Design Option for Control of Thermal Contraction and Restrained Shrinkage
(*Clause* 10.3)

Option	Type of Construction and Method of Control	Movement Joint Spacing	Steel Ratio (*see* Note 2)	Comments
(1)	(2)	(3)	(4)	(5)
1	Continuous: for full restraint	No joints, but expansion joints at wide spacings may be desirable in walls and roofs that are not protected from solar heat gain or where the contained liquid is subjected to a substantial temperature range	Minimum of ρ_{crit}	Use small size bars at close spacing to avoid high steel ratios well in excess of ρ_{crit}
2	Semi-continuous: for partial restraint	a) Complete joints: ≤ 15 m b) Alternate partial and complete joints (by interpolation): ≤ 11.25 m c) Partial joints: ≤ 7.5m	Minimum of ρ_{crit}	Use small size bars but less steel than in Option 1
3	Close movement joint spacing: for freedom of movement	a) Complete joints, in metres $\le 4.8 + \frac{w}{\varepsilon}$ b) Alternate partial and complete joints, in metres: $\le 0.5\, s_{Max} + 2.4 + \frac{w}{\varepsilon}$ c) Partial joints: $\le s_{Max} + \frac{w}{\varepsilon}$	2/3 ρ_{crit}	Restrict the joint spacing for Options 3 (b) and 3(c)

NOTES

1 References should be made to Annex A and Annex B of IS 3370 (Part 2) for the description of the symbols used in this table and for calculating ρ_{crit}, s_{Max} and ε.

2 In Options 1 and 2, the steel ratio will generally exceed ρ_{crit} to restrict the crack widths to acceptable values. In Option 3, the steel ratio of 2/3 ρ_{crit} will be adequate.

— Cracking is controlled by proximity of the joints, with a moderate amount of reinforcement provided, sufficient to transmit movement at any cracked section to the adjacent movement joints. Significant cracking between the adjacent movement joints should not occur.

The options given in Table 2 are considered in terms of horizontal movement, but vertical movement in walls should also be considered. Two cases are as follows:

1) It is possible for horizontal cracks to occur at any free-standing vertical end because of the change in horizontal restraint with respect to height. For bays of any height the vertical strain arising from this warping effect may be taken as approximately half the horizontal strain, and the vertical steel ratio should not be less than the critical ratio, ρ_{crit}.

2) The vertical restraint exerted on a newly cast bay at a vertical construction joint may be assumed to develop at the depth of 2.4 m from the free top surface. Thus design for freedom of movement (Option 3) may be used for vertical reinforcement in the top 2.4 m of a lift. The design for partial restraint (Option 2) is appropriate for vertical steel below this depth.

The choice of design imposes a discipline on construction. It is desirable to achieve minimum restraint to early thermal contraction of the immature concrete in walls and slabs even though the finished structure may be designed for full continuity. Cracks arising from thermal contraction in a roof supported on columns may be minimized or even prevented if the roof slab is not tied rigidly to the walls during constructions.

10.4 Making of Joints

Joints shall generally be made according to the broad principles discussed in **10.4.1** to **10.4.3**.

10.4.1 *Construction Joints*

Joints are a common source of weakness and, therefore, it is desirable to avoid them. If this is not possible, their number shall be minimized. Concreting shall be carried out continuously up to construction joints, the position and arrangement of which shall be indicated by the designer.

Construction joints shall be placed at accessible locations to permit cleaning out of laitance, cement slurry and unsound concrete, in order to create rough/uneven surface. It is recommended to clean out laitance and cement slurry by using wire brush on the surface of joint immediately after initial setting of concrete and to clean out the same immediately thereafter. The prepared surface should be in a clean saturated surface dry condition when fresh concrete is placed, against it.

In the case of construction joints at locations where the previous pour has been cast against shuttering the recommended method of obtaining a rough surface for the previously poured concrete is to expose the aggregate with a high pressure water jet or any other appropriate means.

Fresh concrete should be thoroughly vibrated near construction joints so that mortar from the new concrete flows between large aggregates and develop proper bond with old concrete.

Where high shear resistance is required at the construction joints, shear keys may be provided.

Sprayed curing membranes and release agents should be thoroughly removed from joint surfaces.

10.4.2 *Movement Joints*

These require the incorporation of special materials in order to maintain water tightness whilst accommodating relative movement between the sides of the joint (*see* **10.5**).

Movement joints, particularly those in floor and roof, also require protection against the entry of debris which may interfere with the closing of the joints.

10.4.2.1 *Contraction joints*

The joints face of the first-cast concrete should be finished against a stopping-off board, or vertical end shutter, which, in the case of a partial contraction joint, should be notched to pass the reinforcement.

Steps should be taken to prevent any appreciable adhesion between the new and the old concrete.

The joint should be suitably treated with water stops and joint sealing compounds so as to maintain water tightness during movement of the joint and prevention of debris entering the joints (*see* Fig. 5 and **10.5**).

10.4.2.2 *Expansion joints*

These require the provision of an initial gap between the concrete faces on the two sides of the joints and this can be conveniently done by the use of materials discussed in **10.5**. The initial width of this gap should be specified by the engineer and should be sufficient to accommodate freely the maximum expansion of the

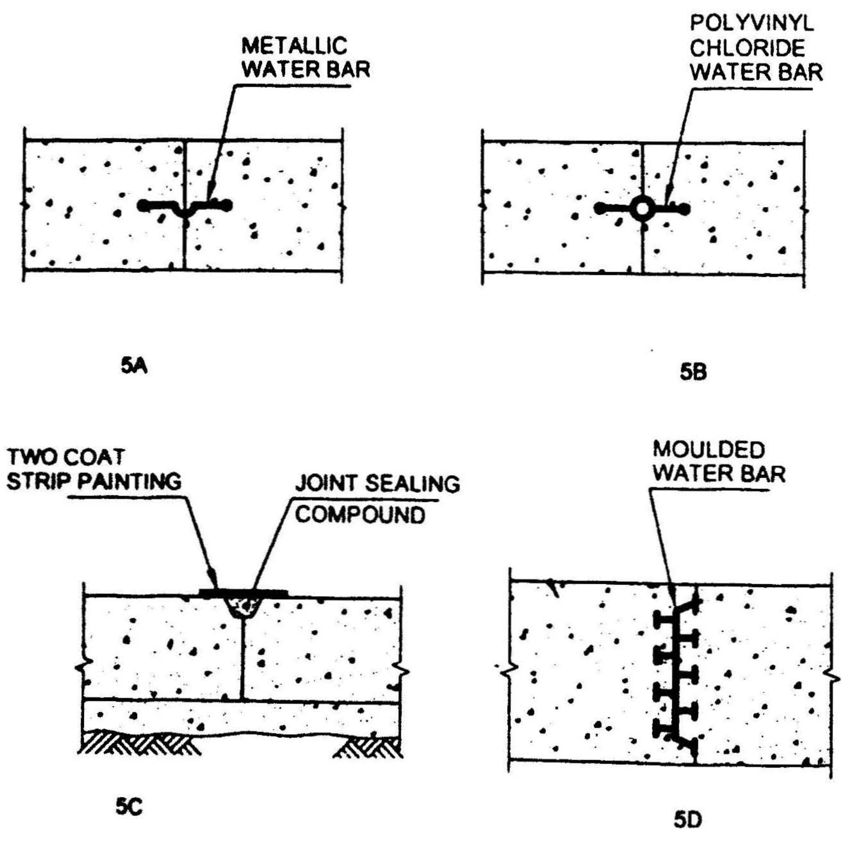


FIG. 5 TYPICAL DETAILS SHOWING USE OF JOINTING MATERIALS IN MOVEMENT JOINTS (CONTRACTION TYPE)

structure. In determining jointing materials due consideration should be given to the requirements of the initial width. These will normally require the maintenance of a certain minimum width of gap during maximum expansion of the structure. The joint should be suitably treated so as to maintain water-tightness during movement of the joint (*see* Fig. 6).

10.4.2.3 *Sliding joints*

The two concrete faces of a sliding joint should be plane and smooth.

Care should be taken by the use of a rigid screening board or other suitable means to make the top of the lower concrete as flat as possible. This surface can usefully be improved by finishing with a steel float and rubbing down with carborundum.

Bond between the concrete of the two components should be prevented by painting or by inserting building paper or other suitable material.

The joint should be suitably treated so as to maintain water-tightness during movement of the joint.

10.4.3 *Temporary Open Joints*

The concrete on both sides of the joints should be finished against stopping off boards.

In order to minimize the extent of subsequent movements due to shrinkage the joint should be left open until shortly before the reservoir is put into service and then filled in with concrete or mortar of specified properties. Where possible, the joint should be filled when the temperature is low.

Immediately before filling the gap, the joint faces should be thoroughly cleaned and prepared in the same way as for construction joints (*see* **10.4.1**).

Where it is intended to treat this type of joint as equivalent to a contraction joint for the purpose of this standard, the joint should be suitably sealed so as to maintain water tightness during subsequent movement of the joint.

NOTE — Figure 1 to Fig. 6 given in this standard are only diagrammatic and are intended merely to illustrate the definitions and principles given in the standard and need not be treated as preferred designs.

10.5 Jointing Materials

Jointing materials normally used are classified as follows:

a) Joint fillers,
b) Water bars, and
c) Joint sealing compounds (including primers where required).

10.5.1 *Joint Fillers*

Joint fillers are usually compressible sheet or strip materials used as spacers. They are fixed to the face of the first placed concrete and against which the second placed concrete is cast.

Joint fillers, may themselves function as water-tight expansion joints. These may be used as support for an effective joint sealing compound in floor and roof joints. But they can only be relied upon as spacers to provide the gap in an expansion joint, the gap being bridged by a water bar (*see* Fig. 6).

10.5.2 *Water Bars*

Water bars are preformed strips of impermeable material which are wholly or partially embedded in the concrete during construction so as to span across the joint and provide a permanent water-tight seal during the whole range of joint movement. For example, water bars may be strips with a central longitudinal corrugation (*see* Fig. 5A and Fig. 6A), Z-shaped strips (*see* Fig. 6B) and a central longitudinal hollow tube (*see* Fig. 5B and Fig. 6C) with thin walls with stiff wings of about 150 mm width. The material used for the water bars are metal sheet, natural or synthetic rubbers and plastics such as polyvinyl chloride (PVC). Galvanized iron sheets may also be used with the specific permission of the engineer-in-charge provided the liquids stored or the atmosphere around the liquid retaining structure is not excessively corrosive, for example, sewage. While selecting the materials for water bars, the possible corrosion aspects may be kept in mind.

Natural and synthetic rubbers and plastics have very considerable advantage in handling, splicing and in making intersections. Wherever use of water bar is stipulated, sufficient thickness of concrete members should be provided so as to ensure proper placing and compaction of concrete adjacent to water bar in order to achieve adequate structural strength.

With all water bars, it is important to ensure proper compaction of the concrete. The bar should have such shape and width that the water path through the concrete round the bar should not be unduly short.

The holes, sometimes provided on the wings of water bars to increase bond, shorten the water path and may be disadvantageous. The water bar should either be placed centrally in the thickness of the wall or its distance from either face of the wall should not be less than half the width of the bar. The full concrete cover to all reinforcement should be maintained.

The strip water bars at present available in the newer materials need to be passed through the end shutter of

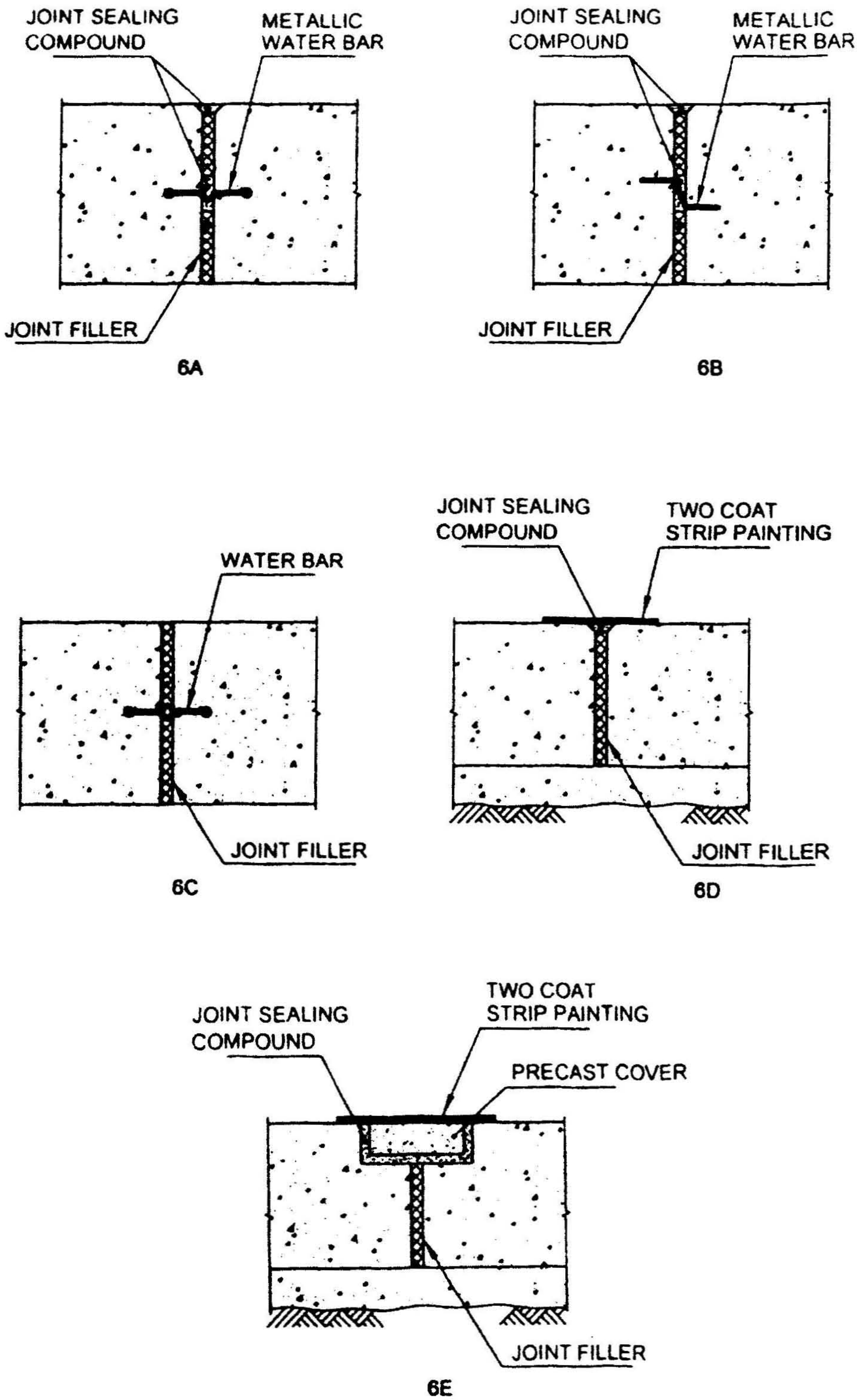


FIG. 6 TYPICAL DETAILS SHOWING USE OF JOINTING MATERIALS IN MOVEMENT JOINTS (EXPANSION TYPE)

the first-placed concrete. It can be appreciated, however, that the use of newer materials makes possible a variety of shapes or sections. Some of these designs, for example, those with several projections (*see* Fig. 5D), would not need to be passed through the end shutter and by occupying a bigger proportion of the thickness of the joint would also lengthen the shortest alternative water path through the concrete.

10.5.3 *Joint Sealing Compounds*

Joint sealing compounds are impermeable ductile materials which are required to provide a water-tight seal by adhesion to the concrete throughout the range of joint movements. The commonly used materials are based on asphalt, bitumen, or coal tar pitch with or without fillers, such as limestone or slate dust, asbestos fibre, chopped hemp, rubber or other suitable material. These are usually applied after construction or just before the reservoir is put into service by pouring in the hot or cold state, by trowelling or gunning or as performed strips ironed into position. These may also be applied during construction such as by packing round the corrugation of a water bar. A primer is often used to assist adhesion and some local drying of the concrete surface with the help of a blow lamp is advisable. The length of the shortest water path through the concrete should be extended by suitably painting the surface at the concrete on either side of the joint.

The main difficulties experienced with this class of material are in obtaining permanent adhesion to the concrete during movement of the joint whilst at the same time ensuring that the material does not slump or is not extruded from the joint.

In floor joints, the sealing compound is usually applied in a chase formed in the surface of the concrete along the line of the joint (*see* Fig.6A). The actual minimum width will depend on the known characteristics of the material. In the case of an expansion joint, the lower part of the joint is occupied by a joint filler (*see* Fig. 6D). This type of joint is generally quite successful since retention of the material is assisted by gravity and, in many cases, sealing can be delayed until just before the reservoir is put into service so that the amount of joint opening subsequently to be accommodated is quite small. The chase should not be too narrow too deep to hinder complete filling and the length of the shortest water path through the concrete on either side of the joint. Here, again a wider joint demands a smaller percentage distortion in the material.

An arrangement incorporating a cover slab, similar to that shown in Fig. 6E, may be advantageous in reducing dependence on the adhesion of the sealing compound in direct tension.

11 CONSTRUCTION

11.1 Unless otherwise specified in this standard, the provisions of IS 456 and IS 1343 shall apply to the construction of reinforced concrete and prestressed concrete liquid retaining structures, respectively.

11.2 Joints

Joints shall be constructed in accordance with requirements of **10**.

11.3 Construction of Floors

11.3.1 *Floors Founded on the Ground*

11.3.1.1 Where walls or floors are founded on the ground, a layer of lean concrete not less than 75 mm thick shall be placed over the ground. In normal circumstances this flat layer of concrete may be weaker than that used in other parts of the structure, but not weaker than M 15 as specified in IS 456. Where, however injurious soils or aggressive ground water are expected, the concrete should not be weaker than M 20 as specified in IS 456, and if necessary sulphate resisting or other special cement should be used.

11.3.1.2 Following a layer of lean concrete, the floor shall be cast in a single layer. A separating layer of polyethylene sheet of mass 1 kg/m^2 should be provided in between the floor slab and the layer of lean concrete.

11.4 Construction of Walls

11.4.1 The height of any lift should be as large as possible. It is desirable to place the concrete to full height of the member in one go. Thorough compaction by vibration shall be ensured.

11.4.2 All vertical joints should extend the full height of the wall in unbroken alignment.

11.5 Surface Finish to Prestressed Concrete Cylindrical Tanks

The circumferential prestressing wires of a cylindrical tank should be covered with a protective coat, which may be pneumatic mortar, having a thickness that will provide a minimum cover of 40 mm over the wires.

11.6 Formwork

11.6.1 Removal of Formwork

The requirements shall conform to IS 456.

11.6.2 Bolts passing completely through liquid retaining slabs for the purpose of securing and aligning the form work should not be used unless effective precautions are taken to ensure water-tightness after removal.

11.7 Lining of Tanks

The type of liquid to be stored should be considered in relation to the possibility of corrosion of the steel or attack on the concrete. Provision of an impermeable protective lining should be considered for resistance to the effects of corrosive liquids. Certain natural waters exhibit corrosive characteristics and in such cases it is important to obtain a dense impermeable concrete and with a higher cement content. An increased cover to the steel is also desirable. Use of sulphate resisting Portland cement, Portland pozzolana cement, or Portland slag cement may in certain cases be advantageous.

12 TEST OF STRUCTURE

12.1 In addition to the structural test of structures as given in IS 456, tanks shall also be tested for water-tightness at full supply level as described in **12.1.1** and **12.1.2**. In addition, the roofs of tanks should be tested in accordance with **12.1.3**.

12.1.1 The tanks shall be filled with water and after the expiry of seven days after the filling, the level of the surface of the water shall be recorded. The level of the water shall be recorded again at subsequent intervals of 24 hours over a period of seven days. The total drop in surface level over a period of seven days shall be taken as an indication of the water-tightness of the tank. The actual permissible nature of this drop in the surface level shall be decided by taking into account whether the tanks are open or closed and the corresponding effect it has on evaporation losses and/or on account of rainfall. However, underground tanks whose top is covered may be deemed to be water-tight if the total drop in the surface level over a period of seven days does not exceed 20 mm.

In case of tanks whose external faces are exposed such as elevated tanks, the requirements of the tests shall be deemed to be satisfied if the external faces show no signs of leakage and remain apparently dry over the period of observation of seven days after allowing a seven day period for absorption after filling.

12.1.2 If the structure does not satisfy the conditions of test, and the daily drop in water level is decreasing, the period of test may be extended for further seven days and if specified limit is then reached, the structure may be considered as satisfactory.

12.1.3 The roofs of liquid-retaining structures should be water-tight and should be tested on completion by flooding the roof with water to a minimum depth of 25 mm for 24 h or longer, if so specified. Where it is impracticable, because of roof slopes or otherwise, to contain a 25 mm depth of water, the roof should have continuous water applied by a hose or sprinkler system to provide a sheet flow of water over the entire area of the roof for not less than 6 h. In either case the roof should be considered satisfactory if no leaks or damp patches show on the soffit. Should the structure not satisfy either of these tests then after the completion of the remedial work it should be retested in accordance with this clause. The roof insulation and covering if any, should be completed as soon as possible after satisfactory testing.

13 LIGHTNING PROTECTION

The liquid retaining structures shall be protected against lightning in accordance with IS 2309.

14 VENTILATION

The minimum required ventilation shall be ensured.

ANNEX A

(*Clause* 2)

LIST OF REFERRED INDIAN STANDARDS

IS No.	*Title*
455 : 1989	Specification for Portland slag cement (*fourth revision*)
456 : 2000	Code of practice for plain and reinforced concrete (*fourth revision*)
1343 : 1980	Code of practice of prestressed concrete (*first revision*)
1489 (Part 1) : 1991	Specification for Portland pozzolana cement: Part 1 Fly ash based (*third revision*)
2309 : 1989	Code of practice for the protection of buildings and allied structures against lightning
3370 (Part 2) : 2009	Code of practice for concrete structures for storage of liquids: Part 2 Reinforced concrete structures (*first revision*)
11682 : 1985	Criteria for design of RCC staging for overhead water tanks

ANNEX B

(Foreword)

COMMITTEE COMPOSITION

Cement and Concrete Sectional Committee, CED 2

Organization	*Representative(s)*
Delhi Tourism and Transportation Development Corporation Ltd, New Delhi	Shri Jose Kurian (***Chairman***)
ACC Ltd, Mumbai	Shri Naveen Chadha Shri P. Srinivasan (*Alternate*)
Atomic Energy Regulatory Board, Mumbai	Dr Prabir C. Basu Shri L. R. Bishnoi (*Alternate*)
Building Materials and Technology Promotion Council, New Delhi	Shri J. K. Prasad Shri C. N. Jha (*Alternate*)
Cement Corporation of India Limited, New Delhi	Shri R. R. Deshpande Shri M. K. Agarwal (*Alternate*)
Cement Manufacturers' Association, Noida	Shri E. N. Murthy Dr S. P. Ghosh (*Alternate*)
Central Board of Irrigation and Power, New Delhi	Member Secretary Director (Civil) (*Alternate*)
Central Building Research Institute (CSIR), Roorkee	Dr B. K. Rao Dr S. K. Agarwal (*Alternate*)
Central Public Works Department, New Delhi	Chief Engineer (Design) Superintending Engineer (S & S) (*Alternate*)
Central Road Research Institute (CSIR), New Delhi	Dr Ram Kumar Shri Satander Kumar (*Alternate*)
Central Soil and Materials Research Station, New Delhi	Shri Murari Ratnam Shri N. Chandrasekharan (*Alternate*)
Central Water Commission, New Delhi	Director (CMDD) (N&W) Deputy Director (CMDD) (NW & S) (*Alternate*)
Conmat Technologies Pvt Ltd, Kolkata	Dr A. K. Chatterjee
Construction Industry Development Council, New Delhi	Shri P. R. Swarup Shri Ravi Jain (*Alternate*)
Delhi Development Authority, New Delhi	Shri A. P. Singh Shri B. B. Arry (*Alternate*)
Directorate General of Supplies & Disposals, New Delhi	Shri P. K. Lahiri Shri A. K. M. Kashyap (*Alternate*)
Engineers India Limited, New Delhi	Shri Arvind Kumar Shri A. K. Mishra (*Alternate*)
Fly Ash Unit, Department of Science & Technology, Ministry of Science & Technology, New Delhi	Dr Vimal Kumar Shri Mukesh Mathur (*Alternate*)
Gammon India Limited, Mumbai	Shri S. A. Reddi Shri V. N. Heggade (*Alternate*)
Grasim Industries Limited, Mumbai	Shri A. K. Jain Shri M. C. Agrawal (*Alternate*)
Gujarat Ambuja Cements Limited, Ahmedabad	Shri C. M. Dordi Shri B. K. Jagetia (*Alternate*)
Housing and Urban Development Corporation Limited, New Delhi	Chairman and Managing Director Shri V. Arul Kumar (*Alternate*)
Indian Bureau of Mines, Nagpur	Shri S. S. Das Shri Meeraul Hasan (*Alternate*)
Indian Concrete Institute, Chennai	Shri L. N. Apte Shri D. Srinivasan (*Alternate*)
Indian Institute of Technology, Roorkee	Prof V. K. Gupta Dr Bhupinder Singh (*Alternate*)

Organization	*Representative(s)*
Indian Roads Congress, New Delhi	SECRETARY GENERAL DIRECTOR (*Alternate*)
Institute for Research, Development & Training of Construction Trade, Bangalore	DR N. RAGHAVENDRA
Institute for Solid Waste Research & Ecological Balance, Visakhapatnam	DR N. BHANUMATHIDAS SHRI N. KALIDAS (*Alternate*)
Madras Cements Ltd, Chennai	SHRI V. JAGANATHAN SHRI BALAJI K. MOORTHY (*Alternate*)
Military Engineer Services, Engineer-in-Chief's Branch, Army Headquarters, New Delhi	SHRI J. B. SHARMA SHRI YOGESH SINGHAL (*Alternate*)
Ministry of Road Transport & Highways, New Delhi	SHRI A. N. DHODAPKAR SHRI S. K. PURI (*Alternate*)
National Council for Cement and Building Materials, Ballabgarh	SHRI R. C. WASON DR M. M. ALI (*Alternate*)
National Test House, Kolkata	SHRI B. R. MEENA SHRIMATI S. A. KAUSHIL (*Alternate*)
Nuclear Power Corporation of India Ltd, Mumbai	SHRI U. S. P. VERMA SHRI ARVIND SHRIVATAVA (*Alternate*)
OCL India Limited, New Delhi	DR S. C. AHLUWALIA
Public Works Department, Government of Maharashtra, Mumbai	REPRESENTATIVE
Public Works Department, Government of Tamil Nadu, Chennai	SUPDTT ENGINEER (DESIGN) EXECUTIVE ENGINEER (*Alternate*)
Research, Design & Standards Organization (Ministry of Railways), Lucknow	SHRI R. M. SHARMA SHRI V. K. YADAVA (*Alternate*)
Sanghi Industries Limited, Sanghi Nagar, Ranga Reddy District	SHRI D. B. N. RAO DR H. K. PATNAIK (*Alternate*)
Sardar Sarovar Narmada Nigam Limited, District Narmada	CHIEF ENGINEER (NAVGAM DAM) SUPERINTENDING ENGINEER (*Alternate*)
Structural Engineering Research Centre (CSIR), Chennai	SHRI A. CHELLAPPAN SHRI J. PRABHAKAR (*Alternate*)
The India Cements Limited, Chennai	SHRI S. GOPINATH SHRI R. ARUNACHALAM (*Alternate*)
The Indian Hume Pipe Company Limited, Mumbai	SHRI P. D. KELKAR SHRI S. J. SHAH (*Alternate*)
The Institution of Engineers (India), Kolkata	DR H. C. VISVESVARAYA SHRI BALBIR SINGH (*Alternate*)
Ultra Tech Cement Ltd, Mumbai	SHRI SUBRATO CHOWDHURY SHRI BISWAJIT DHAR (*Alternate*)
Voluntary Organization in Interest of Consumer Education, New Delhi	SHRI HEMANT KUMAR
BIS Directorate General	SHRI A. K. SAINI, Scientist 'F' & Head (Civ Engg) [Representing Director General (*Ex-officio*)]

Member Secretaries

SHRI SANJAY PANT
Scientist 'E' & Director (Civ Engg), BIS

SHRI S. ARUN KUMAR
Scientist 'B' (Civ Engg), BIS

Concrete Subcommittee, CED 2 : 2

Delhi Tourism & Transportation Development Corporation Ltd, New Delhi	SHRI JOSE KURIAN (*Convener*)
ACC Ltd, Mumbai	SHRI ANIL BANCHHOR SHRI P. BANDOPADHYAY (*Alternate*)

Organization	*Representative(s)*
Atomic Energy Regulatory Board, Mumbai	Dr Prabir C. Basu Shri L. R. Bishnoi (*Alternate*)
Building Materials and Technology Promotion Council, New Delhi	Shri J. K. Prasad Shri Pankaj Gupta (*Alternate*)
Central Building Research Institute (CSIR), Roorkee	Dr B. K. Rao Dr S. K. Agarwal (*Alternate*)
Central Public Works Department, New Delhi	Superintending Engineer (Design) Executive Engineer (Design) (*Alternate*)
Central Road Research Institute (CSIR), New Delhi	Dr Renu Mathur Shri Satander Kumar (*Alternate*)
Central Soil & Materials Research Station, New Delhi	Shri Murari Ratnam Shri N. Chandrasekharan (*Alternate*)
Central Water Commission, New Delhi	Director (C & MDD) Deputy Director (C & MDD) (*Alternate*)
Engineers India Limited, New Delhi	Shri Arvind Kumar Shri T. Balraj (*Alternate*)
Fly Ash Unit, Department of Science and Technology, Ministry of Science & Technology, New Delhi	Dr Vimal Kumar Shri Mukesh Mathur (*Alternate*)
Gammon India Limited, Mumbai	Shri S. A. Reddi Dr N. K. Nayak (*Alternate*)
Grasim Industries Ltd, Mumbai	Shri A. K. Jain Shri M. C. Agrawal (*Alternate*)
Gujarat Ambuja Cement Limited, Ahmedabad	Shri C. M. Dordi Shri B. K. Jagetia (*Alternate*)
Indian Concrete Institute, Chennai	Prof M. S. Shetty Shri L. N. Apte (*Alternate*)
Indian Institute of Technology, New Delhi	Dr B. Bhattacharjee
Indian Institute of Technology, Kanpur	Dr Sudhir Mishra
Indian Institute of Technology, Roorkee	Dr Ashok Kumar Jain
Larsen and Toubro Limited, Chennai	Dr B. Sivarama Sarma Shri Kingsley J. D. Ernest (*Alternate*)
Military Engineer Services, Engineer-in-Chief's Branch, Army Headquartes, New Delhi	Brig R. K. Gupta Col V. K. Badola (*Alternate*)
Ministry of Road Transport and Highways, New Delhi	Shri T. B. Banerjee Shri Kamlesh Kumar (*Alternate*)
National Buildings Construction Corporation Limited, New Delhi	Shri L. P. Singh Shri Darshan Singh (*Alternate*)
National Council for Cement & Building Materials, Ballabgarh	Shri R. C. Wason Shri H. K. Julka (*Alternate*)
National Institute of Technology, Warangal	Dr C. B. Kameswara Rao Dr D. Rama Seshu (*Alternate*)
Nuclear Power Corporation of India Limited, Mumbai	Shri U. S. P. Verma Shri Arvind Shrivastava (*Alternate*)
Pidilite Industries Limited, Mumbai	Shri P. L. Patry Shri K. Padmakar (*Alternate*)
Ready Mixed Concrete Manufacturers' Association, Bangalore	Shri Vijaykumar R. Kulkarni
Research, Design & Standards Organization (Ministry of Railways), Lucknow	Joint Director Standards (B&S)/CB-I Joint Director Standards (B&S)/CB-II (*Alternate*)
Structural Engineering Research Centre (CSIR), Chennai	Shri T. S. Krishnamoorthy Shri K. Balasubramanian (*Alternate*)
Tandon Consultants Private Limited, New Delhi	Shri Mahesh Tandon Shri Vinay Gupta (*Alternate*)
TCE Consulting Engineers Limited, Mumbai	Shri J. P. Haran Shri S. M. Palekar (*Alternate*)

Organization	*Representative(s)*
Torsteel Research Foundation in India, New Delhi	DR P. C. CHOWDHURY DR C. S. VISHWANATHA (*Alternate*)
In personal capacity (*35, Park Avenue, Annamma, Naicker Street, Kuniamuthur, Coimbatore*)	DR C. RAJKUMAR
In personal capacity (*36, Old Sneh Nagar, Wardha Road, Nagpur*)	SHRI LALIT KUMAR JAIN

Panel for Revision of IS 3370 (Parts 1 and 2), CED 2 : 2/P1

National Council for Cement and Building Material, Ballabgarh	DR ANIL KUMAR (*Convener before 18 October 2006*)
In personal capacity (*36, Old Sneh Nagar, Wardha Road, Nagpur*)	SHRI LALIT KUMAR JAIN (*Convener since 18 October 2006*)
Central Road Research Institute (CSIR), New Delhi	DIRECTOR SHRI SATANDER KUMAR (*Alternate*)
Delhi Tourism and Transportation Development Corporation Ltd, New Delhi	SHRI JOSE KURIAN
Gammon India Ltd, Mumbai	SHRI S. A. REDDI
Indian Institute of Technology, New Delhi	DR S. N. SINHA
Indian Institute of Technology, Roorkee	DR ASHOK K. JAIN
Military Engineer Services, Engineer-in-Chief's Branch, Army Headquarters, New Delhi	SHRI J. B. SHARMA SHRI YOGESH K. SINGHAL (*Alternate*)
National Council for Cement and Building Material, Ballabgarh	SHRI H. K. JULKA SHRI R. C. WASON (*Alternate*)
School of Planning and Architecture, New Delhi	DR V. THIRUVENGADAM
Structural Engineering Research Centre (CSIR), Chennai	SHRI T. S. KRISHNAMOORTHY SHRI K. BALASUBRAMANIAN (*Alternate*)
TCE Consulting Engineers Limited, Mumbai	SHRI S. M. PALEKAR SHRI S. KRISHNA (*Alternate*)
In personal capacity (*K-L/2, Kavi Nagar, Ghaziabad*)	DR A. K. MITTAL

GMGIPN—139 BIS/ND/09—300

(*Continued from second cover*)

g) The clause on thick section has been deleted,

h) The provision for joints including spacing of joints and making of joints has been modified,

j) Provisions on construction of liquid retaining structures have been modified in line with the latest practices, and

k) A new clause on testing of roof of liquid retaining structure has been added apart from modifications in other existing provisions in testing.

The composition of the Ccommittee responsible for 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 results 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.

Bureau of Indian Standards

BIS is a statutory institution established under the *Bureau of Indian Standards Act*, 1986 to promote harmonious development of the activities of standardization, marking and quality certification of goods and attending to connected matters in the country.

Copyright

Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Catalogue' and 'Standards : Monthly Additions'.

This Indian Standard has been developed from Doc No.: CED 2 (7329).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002
Telephones : 2323 0131, 2323 3375, 2323 9402 *Website*: www.bis.org.in

Regional Offices: *Telephones*

Central :	Manak Bhavan, 9 Bahadur Shah Zafar Marg NEW DELHI 110002	2323 7617 2323 3841
Eastern :	1/14 C.I.T. Scheme VII M, V. I. P. Road, Kankurgachi KOLKATA 700054	2337 8499, 2337 8561 2337 8626, 2337 9120
Northern :	SCO 335-336, Sector 34-A, CHANDIGARH 160022	60 3843 60 9285
Southern :	C.I.T. Campus, IV Cross Road, CHENNAI 600113	2254 1216, 2254 1442 2254 2519, 2254 2315
Western :	Manakalaya, E9 MIDC, Marol, Andheri (East) MUMBAI 400093	2832 9295, 2832 7858 2832 7891, 2832 7892

Branches: AHMEDABAD. BANGALORE. BHOPAL. BHUBANESHWAR. COIMBATORE. FARIDABAD. GHAZIABAD. GUWAHATI. HYDERABAD. JAIPUR. KANPUR. LUCKNOW. NAGPUR. PARWANOO. PATNA. PUNE. RAJKOT. THIRUVANANTHAPURAM. VISAKHAPATNAM.

PRINTED BY THE GENERAL MANAGER, GOVT. OF INDIA PRESS, NASHIK-422 006