भारतीय मानक
Indian Standard

IS 3370 (Part 3) : 2021

जलीय तरल पदार्थों को प्रतिधारित करने के लिए कंक्रीट संरचनाएँ — रीति संहिता

भाग 3 पूर्वप्रबलित कंक्रीट

(पहला पुनरीक्षण)

Concrete Structures for Retaining Aqueous Liquids — Code of Practice

Part 3 Prestressed Concrete

(First Revision)

ICS 23.020.10; 91.080.40

भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDARDS
मानक भवन, 9 बहादुरशाह ज़फर मार्ग, नई दिल्ली – 110002
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI-110002
www.bis.gov.in www.standardsbis.in

March 2021 **Price Group 6**

Cement and Concrete Sectional Committee, CED 02

FOREWORD

This Indian Standard (Part 3) (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.

The design and construction methods in reinforced concrete and prestressed concrete structures for retaining aqueous 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 retaining 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 1 General requirements

Part 2 Plain and reinforced concrete

Part 4 Design tables

This standard was first published in 1967. This revision has been brought out 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. In this revision, the title of the standard has been modified from 'Concrete structures for storage of liquids — Code of practice: Part 3 Prestressed concrete structures' to 'Concrete structures for retaining aqueous liquids — Code of practice: Part 3 Prestressed concrete' for better representation of the contents of the revised standard.

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 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 pre-stressed 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 engineer.

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 'Plain and reinforced concrete — Code of practice (*fourth revision*)' and IS 1343 : 2012 'Prestressed concrete — Code of practice (*second 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 long term performance of the structure, use of dense, nearly impermeable and durable concrete, adequate concrete cover without macro defects in cover concrete, proper detailing practices, control of cracking, effective quality assurance measures in line with IS 456 and good construction practices particularly in relation to construction joints should be ensured. Designer should take appropriate measures to the need for chemical resistance while dealing with liquids or sewage/effluents.

Following are the significant modifications incorporated in this revision:

a) Scope and provisions of the standard have been updated to reflect the applicability of the standard to concrete structures retaining all aqueous liquids.
b) Design recommendations are generally applicable to the retaining of aqueous liquids having temperature not exceeding 50 °C, and the same has been indicated.
c) A new sub-clause on loads has been added.
d) Limit state method has been introduced and working stress method has been removed.
e) All the design provisions, as per limit state method, have been revised and made comprehensive.
f) Prestressed concrete members retaining liquid shall be designed as either Type 1 or Type 2, based on tensile stresses permitted.

(*Continued to third cover*)

Indian Standard

CONCRETE STRUCTURES FOR RETAINING AQUEOUS LIQUIDS — CODE OF PRACTICE

PART 3 PRESTRESSED CONCRETE

(First Revision)

1 SCOPE

1.1 This standard (Part 3) lays down requirements applicable specifically to design of prestressed concrete structures, intended for storage or retaining of aqueous liquids. A concrete structure or member can function as liquid retaining, when the amount of liquid permeating through its thickness, under hydraulic gradient, is practically negligible.

The recommendations are generally applicable to the storage/retaining of aqueous liquids having temperature not exceeding 50 °C and no detrimental action on concrete and steel or where sufficient precautions have been taken to ensure protection of concrete and steel from damage due to action of such liquids.

1.2 This standard does not cover the requirements for concrete structures for storage/retaining of hot liquids, hazardous materials and liquids of low viscosity and high penetrating power, such as petrol, diesel and oil. This standard also does not cover dams, pipes, pipelines, tunnels and damp-proofing of basements.

This standard does not cover all the requirements of pressurised tanks, floating structures and tanks having the additional requirement of gas tightness. The selection and design of coatings and linings are not covered in this standard.

1.3 This standard applies to members having prestress in one or more direction. For liquid retaining structures, members not prestressed in any direction shall be designed conforming to IS 456, IS 3370 (Part 1) and IS 3370 (Part 2), and additional requirements, if any, given in this standard for the junction of such members with liquid retaining members.

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*
456 : 2000	Plain and reinforced concrete — Code of practice (*fourth revision*)
1343 : 2012	Prestressed concrete — Code of practice (*second revision*)
3370	Concrete structures for retaining aqueous liquids — Code of practice:
(Part 1) : 2021	General requirements (*second revision*)
(Part 2) : 2021	Plain and Reinforced concrete (*second revision*)
(Part 4) : 2021	Design tables (*first revision*)
12330 :1988	Sulphate resisting Portland cement — Specification

3 GENERAL REQUIREMENTS

Design and construction of prestressed concrete liquid retaining structures shall comply with the requirement of IS 3370 (Part 1) and IS 1343, unless otherwise laid down in this standard.

4 DESIGN

4.1 General

4.1.1 Provisions shall be made for all conditions of stresses that may occur in accordance with the principles of mechanics, recognized methods of design and sound engineering practice. In particular, adequate consideration shall be given to the effects of monolithic construction in the assessment of axial forces, bending moments and shear.

4.1.2 Before taking up the detailed design, the designer should satisfy himself on the correct estimate of loads and adequate static equilibrium of the structure, particularly in regard to safety against overturning of overhanging members [*see* **10.1** of IS 3370 (Part 1)].

4.1.3 The design of members in contact with the liquid on any face or enclosing the space above the liquid shall be based on consideration of adequate resistance to cracking as well as adequate strength.

4.2 Loads

4.2.1 The provisions given in **4.2.1** to **4.2.5** and **4.2.7** to **4.2.12** of IS 3370 (Part 2) shall apply.

4.2.2 Allowance should be made for the effects of any adverse soil pressure on the walls, according to the compaction and/or surcharge on the soil and the condition of the structure during construction and in service. Relief may be given for beneficial soil pressure effects on the walls of liquid retaining structures in the container full condition (*see* **6.2**).

4.3 Method of Design

4.3.1 General basis of design shall be in line with the requirements of IS 1343 and IS 456, except where stated otherwise in this standard. Structural elements that are not exposed to the retained liquid shall be designed in accordance with the requirements of IS 456 and IS 1343, as applicable.

4.3.2 While designing the liquid retaining concrete structure, plastic redistribution of moments as per IS 456 shall not apply. For design of flat slab, estimate of bending moments as per direct design method of IS 456 shall not apply. Bending moments and stresses shall be worked out based on methods such as finite element method.

4.3.3 Additional provisions for design of floors, walls and roof shall be as given in **5**, **6** and **7**, respectively.

4.3.4 Prestressed members shall be designed for the exposure condition as per **5** of IS 3370 (Part 1).

4.4 LIMIT STATE DESIGN

4.4.1 *Limit State Requirements*

All relevant limit states shall be considered in the design to ensure an adequate degree of safety and serviceability.

4.4.1.1 *Limit state of collapse (ultimate limit state)*

The recommendations given in IS 1343 shall be followed.

4.4.1.2 *Limit state of serviceability*

a) *Deflection* — The limit of deflection shall be as per IS 1343.
b) *Cracking* — The cracking shall be limited by checking tension in concrete under limit state of serviceability, as per **4.4.2** and **8.1**.

4.4.2 *Cracking Control*

The prestressed concrete members retaining liquid shall be designed either as, Type 1 or Type 2 members, as given in **4.4.2.3**.

4.4.2.1 For the purpose of analysis of stresses, a statically determinate member subjected to axial (or nearly axial) prestressing, should be assumed to have a minimum eccentricity of prestressing 20 mm or 0.05 times the overall thickness in the plane of bending, whichever is less. The requirement of minimum eccentricity need not be considered in case of indeterminate and cylindrical prestressed members.

4.4.2.2 For the prestressed member, in the direction other than prestress, the crack-width requirement as given in **4.4.3** of IS 3370 (Part 2) with limiting crack width of 0.1 mm shall govern the design, in addition to requirements given in this standard.

4.4.2.3 *Flexural tensile stress in concrete*

In the direction of prestress, tension shall not be allowed at the joints in the members (cold/construction joint) or junctions of members (cast separately or precast) under design load. The criteria of tensile stress for Type 1 and Type 2 prestressed concrete members shall be as follows:

Type 1 member — No tensile stress under normal working loads.

Type 2 member — The design flexural tensile stress shall not exceed the design flexural strength of concrete, in case of pre-tensioned members, and 0.8 times the design flexural strength of concrete, in case of post-tensioned members (these limits are also applicable for stress at transfer).

The design flexural strength shall be 0.5 times the characteristic flexural strength of concrete, f_{cr}, which should be determined from the test results on the concrete mix being used. The values given in Table 1 may be used in the absence of the test results.

Table 1 Design Flexural Tensile Stress, f_{cr} for Type 2 Members

(*Clause* 4.4.2.3)

Characteristic Strength	Limiting Stress for the Concrete (in MPa)			
	M35	M40	M45	M50 and above
Characteristic flexural strength, f_{cr}	3.90	4.20	4.40	4.60

For temporary load, which may be rare or occur few times in the life of structure, the design flexural tensile stresses may be increased by 25 percent, provided that the stress is compressive under normal conditions to ensure that any cracks which might occur would close. In such case, tendons should be well distributed throughout tension zone, in case of pre-tensioned members and supplemented by reinforcement near the tension face, in case of post-tensioning.

Design maximum wind or design seismic loads may be treated as temporary loads.

4.4.3 *Exposure Conditions*

For the purpose of design, type of member should be decided by the designer on the basis of exposure conditions. However, the following guidance may be adopted:

a) A member in contact with the liquid, considered to be subject to very severe/extreme exposure conditions or liquid can penetrate in the concrete in normal service condition at a pressure (equivalent to water column) more than 25 times the concrete thickness, shall be designed as Type 1.

b) A concrete member in which liquid can penetrate at a pressure less than the limit in (a), may be designed as Type 2.

4.4.4 In the direction of prestress, the member shall not have residual tension due to direct tension in the member.

4.4.5 *Shrinkage and Creep of Concrete*

The provisions regarding shrinkage and creep shall comply with the requirement of IS 1343. Where reservoirs are protected with an internal impermeable lining, consideration should be given to the possibility of concrete eventually drying out. Unless the engineer is satisfied that the lining has sufficient crack-bridging properties, allowance for the increased effect of drying shrinkage should be made in the design.

4.4.6 *Losses in Prestress*

While assessing the stresses in concrete and steel during tensioning operations and later in service, due regard shall be paid to all losses and variations in stress resulting from creep of concrete and steel, the shrinkage of concrete, the shortening of concrete at transfer, friction and slip of anchorage. Requirements given in IS 1343 shall be complied with.

4.4.7 For cylindrical prestressed tanks, additional requirements as specified in **8** shall also be satisfied.

5 FLOORS

5.1 Provision of Movement Joints

Movement joints shall be provided in accordance with **11** of IS 3370 (Part 1).

5.2 Floors of Tanks Resting on Ground

If the tank is resting directly on ground, its floor may be constructed of concrete with the nominal percentage of reinforcement conforming to IS 3370 (Part 1) and IS 3370 (Part 2), if not prestressed.

5.2.1 Under normal circumstances PCC base concrete shall be of grade not leaner than M15; where injurious soils or aggressive water are expected, the base concrete shall be of grade not leaner than M20, and if necessary, a sulphate resisting portland cement conforming to IS 12330 or other special cement as given in IS 456 may be used.

5.3 Floors of Tanks Resting on Supports

See **5.3** of IS 3370 (Part 2).

6 WALLS

6.1 Provision of Joints

6.1.1 *Sliding Joints at Base of the Wall*

Where it is desired to allow the wall to expand or contract separately from the floors, or to prevent moment at the base of the wall owing to its fixity with the floor, sliding joints may be employed.

6.1.2 Considerations should be given to the positions of the joints in the floor affecting the spacing of vertical movement joints in wall. While the majority of these joints may be the partial or complete contraction type, sufficient joints of the expansion type should be provided to satisfy the requirements of **11** of IS 3370 (Part 1).

6.2 Effect of Earth Pressure

When a tank wall is built in the ground or has earth fill against it, relief in bending moments due to simultaneous action of water pressure inside the wall and that due to earth pressure (up to 0.5 times the active earth pressure only) from outside the wall may be made, provided that,

a) there is no risk of slip in the embankment or fear of a reduction in the earth pressure arising from shrinkage or future excavations or any other cause; and

b) the earth pressure allowed by way of relief in the bending moment caused by internal water pressure is the minimum which can be relied upon under the most unfavourable conditions possible, including those under which the reservoir is to be tested for liquid-tightness.

7 ROOFS

7.1 Provision of Movement Joints

The movement joints in the roof shall correspond with those in walls, if roof and walls are monolithic to avoid the possibility of sympathetic cracking. This is not applicable if provision for movement between the roof and the wall is made by means of a sliding joint.

7.2 Loading

Roofs should be designed for gravity loads, such as the weight of roof slab, earth cover, if any, live loads and mechanical equipment. Imposed load arrangements which can give more critical bending moments should also be considered.

They should also be designed for upward pressure, if the tank is subjected to internal pressure or if roof is subjected to upward pressure due to sloshing of liquid.

7.2.1 An adequate load condition to ensure safety in case of unequal intensity of loading, which may occur during construction and the placing of the earth cover, should be considered in the design. In roof design, allowance should be made for the temporary condition of some spans loaded and other spans unloaded, even though in the final state the load may be small and/or evenly distributed.

7.2.2 In tanks having fixed or floating covers, the gas pressure developed above liquid surface shall be added to liquid pressure for design of wall.

7.3 Liquid-tightness

In case of tanks intended for the retaining treated water or liquid for domestic purposes, the roof shall be made liquid-tight. This may be achieved by designing the roof as liquid retaining member, and by providing slopes to ensure adequate drainage.

7.4 Protection Against Corrosion

Protective measures shall be taken to prevent the underside of the roof from corrosion due to condensation and chlorine attack. It shall also be designed as a liquid retaining member, particular care being taken that the stipulations regarding minimum cover to reinforcement and crack width are complied with.

8 CYLINDRICAL PRESTRESSED TANKS

8.1 For cylindrical structures prestressed circumferentially and vertically, the following design recommendations shall apply:

a) The jacking force in circumferential tendons shall not exceed 75 percent of the characteristic strength.

b) The principal compressive stress in the concrete should not exceed 0.3 f_{ck}.

c) The temporary vertical moment induced during the circumferential prestressing operation in the partially stressed condition should also be considered.

   The maximum value of the flexural stress (caused due to moment in vertical direction) may be assumed to be numerically equal to 0.3 times the circumferential compressive stress, in the absence of FEM results. Where the tensile stress would exceed 1 MPa, either the vertical prestress should be increased or the circumferential prestress should be built up in stages, with each stage involving a progressive application of prestress from one end of the cylinder.

d) When the structure is full (with liquid), there should be no resultant tension in the concrete in the circumferential direction, after making allowances for all losses of prestress, and on the assumption that the top and bottom edges of the wall are free of all restraint.

e) The bending moment in the vertical direction should be estimated on the basis of a restraint equal to one-half of that provided by a hinged bottom, if the bottom of the wall is free to slide. In other cases, where sliding at the bottom of the wall is prevented, the moment in the vertical direction should be estimated for the actual restraint at the bottom of the wall. The tensile stress resulting from the vertical moments should not exceed 1.0 MPa in concrete.

f) If the structure is to be emptied and filled at frequent intervals, or may be left empty for a prolonged period, the structure should be designed so that there is no residual tension in the concrete at any point when the structure is full or empty.

   Cylindrical concrete structures which are prestressed circumferentially and reinforced vertically may be allowed to have tensile stresses not exceeding 1 MPa. The design for the vertical reinforcement shall be as per IS 3370 (Part 2) with limiting crack width of 0.1 mm.

g) The average shear stress on the gross cross-section of the concrete under serviceability state should not exceed one third of the maximum shear stress specified in Table 9 of IS 1343.

8.2 Prestressing wires may be placed outside the walls, provided they are protected with pneumatic mortar. Prestressing shall be protected by proper coating before applying pneumatically placed mortar. However, in industrial areas or near the sea coast, where there is a possibility of inadequate protection against corrosion by such mortar, the cables should preferably be placed within the wall and grouted. Non-bonded tendons may be used provided that they and their anchorages are adequately protected against corrosion.

Pneumatically placed mortar should have water cement ratio less than 0.40, low permeability and good adhesion.

8.3 Radial tensile stress across the thickness direction should be checked to protect prestressed concrete cylindrical cell from delamination, where outer layer of concrete separates from inner layer, when prestressing cables are provided inside the thickness. Radial reinforcements in the form of links should be provided, if radial tensile stresses are more than permissible direct tensile stress of concrete and the following design recommendations shall apply:

a) Radial force per unit length of cable can be estimated as *P/R*, where *P* is average prestress force without long term loss and *R* is the radius of curvature of prestressing cable (from the centre of cylinder). This shall be multiplied with clear spacing between the cables to get tensile stress.
b) This shall be checked for post-tensioned cylindrical tank during construction stage before grouting and during tank empty condition, when un-grouted cables are used. This check may not be required in case of external prestressing cables. Permissible stress in reinforcing bars should be as per construction load case or service load case, whichever is applicable.

8.4 The base of wall may be designed either fixed with the floor or as sliding or hinged at the junction with the floor.

8.5 Prestressing should be provided on the transverse and longitudinal cross-section so as to contain these effects within the critical stresses specified.

8.6 When the stressing of the prestressing wires is proposed to be carried out with wires in position, anchorages may advantageously be staggered and placed at suitable points of the cylinder with a view to offset the heavy frictional losses.

8.7 The worst conditions of stresses resulting from the pressure of retained liquid, surrounding pressure, if any, temperature, shrinkage, restraint from roof, etc, should be considered.

8.8 Necessity of prestressing the cylinder wall in the direction of the axis of the cylinder (vertical) should always be investigated.

8.9 Longitudinal prestressing may be replaced with a reinforced concrete section satisfying the requirements of IS 3370 (Part 2) with limiting crack width of 0.1 mm.

9 DETAILING

9.1 Concrete Cover

The minimum cover to prestressing rods, wires or cables, and to sheathings, spacers and reinforcement, if present, shall conform to the requirements given in IS 1343 and IS 456.

9.2 The requirements of untensioned steel shall be as per IS 1343. For a member not prestressed in a direction, minimum reinforcement (in the direction having no prestress) shall conform to the requirement given in IS 1343 and IS 3370 (Part 2).

9.3 Un-bonded cable may be used if they and their anchorages are adequately protected against corrosion.

9.4 Construction joint shall not be provided along the prestressing wire/strand/tendon/cable/duct or within a distance of *d* from it, where *d* is the diameter of the prestressing element.

10 WORKMANSHIP, INSPECTION AND TESTING

The requirements specified in IS 3370 (Part 1) and IS 1343 shall be complied with.

ANNEX A

(*Foreword*)

COMMITTEE COMPOSITION

Cement and Concrete Sectional Committee, CED 02

Organization	*Representative(s)*
In personal capacity (*Grace Villa, Kadamankulam P.O, Thiruvalla 689583*)	Shri Jose Kurian (***Chairman***)
ACC Ltd, Mumbai	Shri Rajesh J. Modi Dr Manish V. Karandikar (*Alternate*)
Ambuja Cements Limited, Ahmedabad	Shri Umesh P. Soni Shri Sukuru Ramarao (*Alternate*)
Atomic Energy Regulatory Board, Mumbai	Shri L. R. Bishnoi Shri Sourav Acharya (*Alternate*)
Builders' Association of India, Mumbai	Shri Sushanta Kumar Basu Shri D. R. Sekor (*Alternate*)
Building Materials & Technology Promotion Council, New Delhi	Shri C. N. Jha
Cement Manufacturers' Association, Noida	Dr V. Ramachandra Ms Shashwati Ghosh (*Alternate*)
Central Public Works Department, New Delhi	Shri D. K. Garg Shri Naveen Kumar Bansal (*Alternate*)
Central Soil and Materials Research Station, New Delhi	Director Shri U. S. Vidyarthi (*Alternate*)
Central Water Commission, New Delhi	Director (CMDD) (N&W) Deputy Director (CMDD) (NW&S) (*Alternate)*
Conmat Technolgies Pvt Ltd, Kolkata	Dr A. K. Chatterjee Dr Subrato Chowdhury (*Alternate*)
Construction Chemical Manufacturers' Association, Mumbai	Shri Samir Surlaker Shri Nilotpol Kar (*Alternate*)
CSIR – Central Building Research Institute, Roorkee	Shri S. K. Singh Shri Subhash Gurram (*Alternate*)
CSIR – Central Road Research Institute, New Delhi	Dr Rakesh Kumar Dr V. V. L. Kanta Rao (*Alternate*)
CSIR – Structural Engineering Research Centre, Chennai	Dr K. Ramanjaneyulu Dr P. Srinivasan (*Alternate*)
Delhi Development Authority, New Delhi	Shri Laxman Singh Shri Vijay Shankar (*Alternate*)
Department of Science and Technology, Ministry of Science and Technology, New Delhi	Shri S. S. Kohli
Engineers India Limited, New Delhi	Shri Rajanji Srivastava Shri Anurag Sinha (*Alternate*)
Gammon India Limited, Mumbai	Shri Shriram B. Kulkarni Shri Rahul Biradar (*Alternate*)
Hindustan Construction Company Limited, Mumbai	Shri Satish Kumar Sharma Shri Mukesh Valecha (*Alternate*)

Organization	*Representative(s)*
Housing and Urban Development Corporation Limited, New Delhi	Representative
Indian Association of Structural Engineers, New Delhi	Shri Mahesh Tandon Shri Ganesh Juneja (*Alternate*)
Indian Concrete Institute, Chennai	Shri Vivek Naik Secretary General (*Alternate*)
Indian Institute of Technology Delhi, New Delhi	Dr Shashank Bishnoi Dr Dipti Ranjan Sahoo (*Alternate*)
Indian Institute of Technology Madras, Chennai	Dr Devdas Menon Dr Manu Santhanam (*Alternate*)
Indian Institute of Technology Roorkee, Roorkee	Dr V. K. Gupta Dr Bhupinder Singh (*Alternate*)
Indian Roads Congress, New Delhi	Shri S. K. Nirmal Shri R. V. Patil (*Alternate*)
Military Engineer Services, Engineer-in-Chief's Branch, Army HQ, New Delhi	Maj Gen S. K. Srivastav Shri Man Singh (*Alternate*)
Ministry of Road Transport and Highways, New Delhi	Shri Y. Balakrishna Shri Sanjeev Kumar (*Alternate*)
National Council for Cement and Building Materials, Ballabgarh	Shri V. V. Arora Dr S. K. Chaturvedi (*Alternate*)
National Test House, Kolkata	Shri D. V. S. Prasad Dr Somit Neogi (*Alternate*)
Nuclear Power Corporation of India Ltd, Mumbai	Shri Arvind Shrivastava Shri Raghupati Roy (*Alternate*)
Nuvoco Vistas Corporation Limited, Mumbai	Shri Pranav Desai Shri Ravindra Khamparia (*Alternate*)
Public Works Department, Govt of Tamil Nadu, Chennai	Superintending Engineer Executive Engineer (*Alternate*)
The India Cements Limited, Chennai	Representative
The Indian Hume Pipe Company Limited, Mumbai	Shri P. R. Bhat Shri S. J. Shah (*Alternate*)
The Institution of Engineers (India), Kolkata	Dr H. C. Visvesvaraya Shri S. H. Jain (*Alternate*)
The Ramco Cements Limited, Chennai	Shri Balaji K. Moorthy Shri Anil Kumar Pillai (*Alternate*)
Ultra Tech Cement Ltd, Mumbai	Shri Surya Valluri Dr M. R. Kalgal (*Alternate*)
Voluntary Organization in Interest of Consumer Education, New Delhi	Shri M. A. U. Khan Shri B. Mukhopadhyay (*Alternate*)
In personal capacity [*B-803, Oberoi Exquisite, Oberoi Garden City, Goregaon (East), Mumbai*]	Shri A. K. Jain
In personal capacity (*36, Old Sneh Nagar, Wardha Road, Nagpur*)	Shri L. K. Jain

Organization	*Representative(s)*
In personal capacity (*EA-92, Maya Enclave, Hari Nagar, New Delhi*)	Shri R. C. Wason
BIS Directorate General	Shri Sanjay Pant, Scientist 'F' and Head (Civil Engineering) [Representing Director General (*Ex-officio*)]

Member Secretaries

Shri S. Arun Kumar
Scientist 'E' (Civil Engineering), BIS

and

Shri Milind Gupta
Scientist 'C' (Civil Engineering), BIS

Concrete Subcommittee, CED 2:2

Organization	*Representative(s)*
In Personal Capacity (*Grace Villa, Kadamankulam P.O, Thiruvalla 689583*)	Shri Jose Kurian (***Convener***)
ACC Limited, Mumbai	Shri Prahlad Mujumdar Shri Anil Kulkarni (*Alternate*)
Ambuja Cements Limited, Ahmedabad	Shri Umesh P. Soni Shri Sukuru Ramarao (*Alternate*)
AFCONS Infrastructure Limited, Mumbai	Shri Manish Mokal
Association of Consulting Civil Engineers (India), Bengaluru	Shri Avinash D. Shirode Shri K. K. Meghashyam (*Alternate*)
Atomic Energy Regulatory Board, Mumbai	Shri L. R. Bishnoi Shri Sourav Acharya (*Alternate*)
Building Materials and Technology Promotion Council, New Delhi	Shri Pankaj Gupta
Bureau of Design for Hydel and Irrigation Project, Bhopal	Shri S. K. Khare Shri Bhagwati Prasad Gupta (*Alternate*)
Bureau Veritas India Ltd, Mumbai	Representative
Central Public Works Department, New Delhi	Shri D. K. Garg Shri Rajesh Khare (*Alternate*)
Central Soil and Materials Research Station, New Delhi	Shri Rajeev Kumar Shri Raj Kumar (*Alternate*)
Creative Design Consultants & Engineers Pvt Ltd, Ghaizabad	Shri Aman Deep Garg Shri Manik Chatterjee (*Alternate*)
CSIR – Central Building Research Institute, Roorkee	Dr Rajesh Deolia Shri H. C. Arora (*Alternate*)
CSIR – Central Road Research Institute, New Delhi	Shri J. B. Sengupta Shri Satish Pandey (*Alternate*)

Organization	*Representative(s)*
CSIR – Structural Engineering Research Centre, Chennai	Dr B. H. Bharathkumar Dr P. Srinivasan (*Alternate*)
Department of Science and Technology, Ministry of Science and Technology, New Delhi	Shri S. S. Kohli
Elkem South Asia Pvt Ltd, Navi Mumbai	Shri Brajesh Malviya Shri Surendra Sharma (*Alternate*)
Engineers India Limited, New Delhi	Shri Rajanji Srivastava Shri Anurag Sinha (*Alternate*)
Gammon India Limited, Mumbai	Shri Sudeesh Rajendran
Hindustan Construction Company Ltd, Mumbai	Shri Satish Kumar Sharma Shri Khatarbatcha Jimmetain (*Alternate*)
Indian Concrete Institute, Chennai	Shri K. C. Tayade Secretary General (*Alternate*)
Indian Institute of Technology Delhi, New Delhi	Dr B. Bhattacharjee Dr Shashank Bishnoi (*Alternate*)
Indian Institute of Technology Kanpur, Kanpur	Dr Sudhir Mishra
Indian Institute of Technology Madras, Chennai	Dr Manu Santhanam Dr Radhakrishna G. Pillai (*Alternate*)
Indian Institute of Technology Roorkee, Roorkee	Representative
Indian Society of Structural Engineers, Mumbai	Shri Umesh Joshi Shri Hemant Vadalkar (*Alternate*)
Irrigation and Power Research Institute, Amritsar	Chief Engineer (Research) Research Officer (*Alternate*)
Larsen and Toubro Limited, ECC Division, Chennai	Dr B. Sivarama Sarma Shri S. Manohar (*Alternate*)
Military Engineer Services, Engineer-in-Chief's Branch, Integrated HQ of MoD (Army), New Delhi	Maj Gen S. K. Srivastav Shri Man Singh (*Alternate*)
Ministry of Road Transport and Highways, New Delhi	Shri A. P. Pathak Shri A. K. Pandey (*Alternate*)
NBCC (India) Ltd, New Delhi	Shri H. S. Yadav Shri Arun Kumar Sharma (*Alternate*)
National Council for Cement and Building Materials, Ballabgarh	Shri V. V. Arora Shri P. N. Ojha (*Alternate*)
National Institute of Technology Warangal, Warangal	Dr C. B. Kameswara Rao Dr D. Rama Seshu (*Alternate*)
Nuclear Power Corporation of India Limited, Mumbai	Shri Arvind Shrivastava Shri N. M. Rao (*Alternate*)
Pidilite Industries Limited, Mumbai	Dr Suguna Naik
Ready Mixed Concrete Manufacturers' Association, Mumbai	Shri Vijaykumar R. Kulkarni Shri Srirang Sondur (*Alternate*)
Research, Designs & Standards Organisation (Ministry of Railways), Lucknow	Joint Director Stdrs (B&S)/CB-I Joint Director Stdrs (B&S)/CB-II (*Alternate*)
RDC Concrete (India) Pvt Ltd, Thane	Shri Anil Banchhor Shri Simranjit Singh (*Alternate*)

Organization	*Representative(s)*
Shapoorji Pallonji and Company Private Limited, Mumbai	Shri Girish Bonde Shri D. N. Vishwanath (*Alternate*)
Tandon Consultants Pvt Limited, New Delhi	Shri Mahesh Tandon Shri Vinay Gupta (*Alternate*)
Tata Consulting Engineers Limited, Mumbai	Shri S. N. Diwakar Shri Manos Kumar De (*Alternate*)
Ultra Tech Cement Ltd, Mumbai	Dr V. Ramachandra Dr A. K. Singh (*Alternate*)
Water Resource Department, Govt. of Madhya Pradesh, Mumbai	Shri S. K. Khare Shri B. P. Gupta (*Alternate*)
In personal capacity (*452 Sector 14, Sonipat, Haryana*)	Shri R. K. Jain
In personal capacity (*36, Old Sneh Nagar, Wardha Road, Nagpur)*	Shri L. K. Jain
In personal capacity [*B-803, Oberoi Exquisite, Oberoi Garden City, Goregaon (East), Mumbai*]	Shri A. K. Jain
In personal capacity (*EA-92, Maya Enclave, Hari Nagar, New Delhi*)	Shri R. C. Wason
In personal capacity (*M1 F1 VGN Minerva Apartments, Guruswamy Road, Nolambur*, *Chennai*)	Dr C. Rajkumar

Panel for Review/Revision of IS 3370, CED 2:2/P1

Organization	*Representative(s)*
In personal capacity (*36, Old Sneh Nagar, Wardha Road, Nagpur 440015*)	Shri L. K. Jain (***Convener***)
Creative Design Consultants & Engineers Pvt Ltd, Ghaziabad	Shri Aman Deep Garg Shri Manik Chatterjee (*Alternate*)
CSIR–Central Road Research Institute, New Delhi	Director
CSIR–Structural Engineering Research Centre, Chennai	Dr B. H. Bharathkumar Dr P. Srinivasan (*Alternate*)
Gammon Engineers & Contractors Pvt Ltd, Mumbai	Shri S. W. Deshpande Shri Mukund C. Butala (*Alternate*)
Government College of Engineering, Pune	Dr Namdeo A. Hedaoo
Hindustan Construction Company Ltd, Mumbai	Shri Satish Kumar Sharma Shri Mukesh Valecha (*Alternate*)
Indian Concrete Institute, Chennai	Representative
Indian Institute of Technology Delhi, New Delhi	Dr Dipti Ranjan Sahoo Dr Shashank Bishnoi (*Alternate*)
Indian Institute of Technology Roorkee, Roorkee	Dr Ashok K. Jain
Military Engineer Services, Engineer-in-Chief's Branch, Integrated HQ of MoD (Army), New Delhi	Shri J. B. Sharma Shri Yogesh K. Singhal (*Alternate)*

Organization	*Representative(s)*
National Council for Cement and Building Materials, Ballabgarh	SHRI V. V. ARORA SHRI T. V. G. REDDY (*Alternate*)
Tata Consulting Engineers Limited, Mumbai	SHRI S. M. PALEKAR SHRI S. KRISHNA (*Alternate*)
In personal capacity (*Grace Villa, Kadamankulam P.O., Thiruvalla 689 583*)	SHRI JOSE KURIAN
In personal capacity (*A2B/37A, Ekta Apartments*, *Paschim Vihar, New Delhi*)	SHRI ARVIND KUMAR
In personal capacity (*Flat No. 220, Ankur Apartments, Mother Dairy Road, Patparganj, Delhi*)	DR V. THIRUVENGADAM
In personal capacity (*K-L/2, Kavi Nagar, Ghaziabad*)	DR A. K. MITTAL
In personal capacity (*House No. 2103, Sector 7D, Faridabad*)	SHRI HARISH KUMAR JULKA
In personal capacity (*EA-92, Maya Enclave, Hari Nagar, New Delhi*)	SHRI R. C. WASON

(*Continued from second cover*)

g) The clause on ‘cylindrical prestressed tanks’ has been modified to include guidance on radial tensile stress

h) The title of the standard has been modified to address the actual coverage.

In the formulation of this standard, assistance has been derived from the BS 8007 : 1987 Code of practice for design of concrete structures for retaining aqueous liquids, issued by British Standards Institute (BSI).

The composition of 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.

Bureau of Indian Standards

BIS is a statutory institution established under the *Bureau of Indian Standards Act*, 2016 to promote harmonious development of the activities of standardization, marking and quality certification of goods and attending to connected matters in the country.

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 02 (13640).

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.gov.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	: Plot No. 4-A, Sector 27-B, Madhya Marg CHANDIGARH 160019	265 0206 265 0290
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. BENGALURU. BHOPAL. BHUBANESHWAR. COIMBATORE. DEHRADUN. DURGAPUR. FARIDABAD. GHAZIABAD. GUWAHATI. HYDERABAD. JAIPUR. JAMMU. JAMSHEDPUR. KOCHI. LUCKNOW. NAGPUR. PARWANOO. PATNA. PUNE. RAIPUR. RAJKOT. VISAKHAPATNAM.

Published by BIS, New Delhi