

Materials for Structures

1000

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1001. GENERAL

Materials to be used in the work shall conform to the specifications mentioned on the drawings, the requirements laid down in this section and specifications for relevant items of work covered under these specifications.

If any material, not covered in these specifications, is required to be used in the work, it shall conform to relevant Indian Standards, if there are any, or to the requirements specified by the Engineer.

1002. SOURCES OF MATERIAL

The Contractor shall notify the Engineer of his proposed sources of materials prior to delivery. If it is found after trial that sources of supply previously approved do not produce uniform and satisfactory products, or if the product from any other source proves unacceptable at any time, the Contractor shall furnish acceptable material from other sources at his own expense.

1003. BRICKS

Burnt clay bricks shall conform to the requirements of IS:1077, except that the minimum compressive strength when tested flat shall not be less than 8.4 MPa for individual bricks and 10.5 MPa for average of 5 specimens. They shall be free from cracks and flaws and nodules of free lime. The brick shall have smooth rectangular faces with sharp corners and emit a clear ringing sound when struck. The size may be according to local practice with a tolerance of ± 5 per cent.

1004. STONES

Stones shall be of the type specified. It shall be hard, sound, free from cracks, decay and weathering and shall be freshly quarried from an approved quarry. Stone with round surface shall not be used.

The stones, when immersed in water for 24 hours, shall not absorb water by more than 5 per cent of their dry weight when tested in accordance with IS:1124.

The length of stones shall not exceed 3 times its height nor shall they be less than twice its height plus one joint. No stone shall be less in width than the height and width on the base shall not be greater than three-fourth of the thickness of the wall nor less than 150 mm.

1005. CAST IRON

Cast iron shall conform to IS:210. The grade number of the material shall not be less than 14.

1006. CEMENT

Cement to be used in the works shall be any of the following types with the prior approval of the Engineer :

- a) Ordinary Portland Cement, 33 Grade, conforming to IS:269.
- b) Rapid Hardening Portland Cement, conforming to IS:8041.
- c) Ordinary Portland Cement, 43 Grade, conforming to IS:8112.
- d) Ordinary Portland Cement, 53 Grade, conforming to IS:12269.
- e) Sulphate Resistant Portland Cement, conforming to IS:12330.

Cement conforming to IS:269 shall be used only after ensuring that the minimum required design strength can be achieved without exceeding the maximum permissible cement content of 540 kg/cu.m. of concrete.

Cement conforming to IS:8112 and IS:12269 may be used provided the minimum cement content mentioned elsewhere from durability considerations is not reduced. From strength considerations, these cements shall be used with a certain caution as high early strengths of cement in the 1 to 28-day range can be achieved by finer grinding and higher constituent ratio of C_3S/C_2S , where C_3S is Tricalcium Silicate and C_2S is Dicalcium Silicate. In such cements, the further growth of strength beyond say 4 weeks may be much lower than that traditionally expected. Therefore, further strength tests shall be carried out for 56 and 90 days to fine tune the mix design from strength considerations.

Cement conforming to IS:12330 shall be used when sodium sulphate and magnesium sulphate are present in large enough concentration to be aggressive to concrete. The recommended threshold values as per IS:456 are sulphate concentration in excess of 0.2 per cent in soil sub-strata or 300 ppm (0.03per cent) in ground water. Tests to confirm actual values of sulphate concentration are essential when the structure is located near the sea coast, chemical factories, agricultural land using chemical fertilizers and sites where there are effluent discharges or where soluble sulphate bearing ground water level is high. Cement conforming to IS:12330 shall be carefully selected from strength considerations to ensure that the minimum required design strength can be achieved without exceeding the maximum permissible cement content of 540 kg/cu.m. of concrete.

Cement conforming to IS:8041 shall be used only for precast concrete products after specific approval of the Engineer.

Total chloride content in cement shall in no case exceed 0.05 per cent by mass of cement. Also, total sulphur content calculated as sulphuric anhydride (SO_3) shall in no case exceed 2.5 per cent and 3.0 per cent when tri-calcium aluminate per cent by mass is upto 5 or greater than 5 respectively.

1007. COARSE AGGREGATES

For plain and reinforced cement concrete (PCC and RCC) or prestressed concrete (PSC) works, coarse aggregate shall consist of clean, hard, strong, dense, non-porous and durable pieces of crushed stone, crushed gravel, natural gravel or a suitable combination thereof or other approved inert material. They shall not consist pieces of disintegrated stones, soft, flaky, elongated particles, salt, alkali, vegetable matter or other deleterious materials in such quantities as to reduce the strength and durability of the concrete, or to attack the steel reinforcement. Coarse aggregate having positive alkali-silica reaction shall not be used. All coarse aggregates shall conform to IS:383 and tests for conformity shall be carried out as per IS:2386, Parts I to VIII.

The contractor shall submit for the approval of the Engineer, the entire information indicated in Appendix A of IS:383.

Maximum nominal size of coarse aggregate for various structural components in PCC, RCC or PSC, shall conform to Section 1700.

The maximum value for flakiness index for coarse aggregate shall not exceed 35 per cent. The coarse aggregate shall satisfy the following requirements of grading :

TABLE 1000-1 REQUIREMENTS OF COARSE AGGREGATE

IS Sieve Size	Per cent by Weight Passing the Sieve		
	40mm	20mm	12.5mm
63 mm	100	—	—
40 mm	95-100	100	—
20 mm	30-70	95-100	100
12.5 mm	—	—	90-100
10 mm	10-35	25-55	40-85
4.75 mm	0-5	0-10	0-10

1008. SAND/FINE AGGREGATES

For masonry work, sand shall conform to the requirements of IS:2116.

For plain and reinforced cement concrete (PCC and RCC) or prestressed concrete (PSC) works, fine aggregate shall consist of clean, hard, strong and durable pieces of crushed stone, crushed gravel, or a suitable combination of natural sand, crushed stone or gravel. They shall not contain dust, lumps, soft or flaky, materials, mica or other deleterious materials in such quantities as to reduce the strength and durability of the concrete, or to attack the embedded steel. Motorised sand washing machines should be used to remove impurities from sand. Fine aggregate having positive alkali-silica reaction shall not be used. All fine aggregates shall conform to IS:383 and tests for conformity shall be carried out as per IS:2386, (Parts I to VIII). The Contractor shall submit to the Engineer the entire information indicated in Appendix A of IS:383. The fineness modulus of fine aggregate shall neither be less than 2.0 nor greater than 3.5.

Sand/fine aggregate for structural concrete shall conform to the following grading requirements :

TABLE 1000-2

IS Sieve Size	Per cent by Weight Passing the Sieve		
	Zone I	Zone II	Zone III
10 mm	100	100	100
4.75 mm	90-100	90-100	90-100
2.36 mm	60-95	75-100	85-100
1.18 mm	30-70	55-90	75-100
600 micron	15-34	35-59	60-79
300 micron	5-20	8-30	12-40
150 micron	0-10	0-10	0-10

1009. STEEL

1009.1. Cast Steel

The use of cast steel shall be limited to bearings and other similar parts. Steel for castings shall conform to Grade 280-520N of IS:1030. In case where subsequent welding is unavoidable in the relevant cast steel components, the letter N at the end of the grade designation of the steel casting shall be replaced by letter W. 0.3 per cent to 0.5 per cent copper may be added to increase the corrosion resistance properties.

1009.2. Steel for Prestressing

The prestressing steel shall conform to either of the following :

- (a) Plain hard drawn steel wire conforming to IS:1785 (Part I) and IS:1785 (Part II).
- (b) Cold drawn indented wire conforming to IS:6003
- (c) High tensile steel bar conforming to IS:2090
- (d) Uncoated stress relieved strands conforming to IS:6006.

1009.3. Reinforcement / Untensioned Steel

For plain and reinforced cement concrete (PCC and RCC) or prestressed concrete (PSC) works, the reinforcement / untensioned steel as the case may be shall consist of the following grades of reinforcing bars.

TABLE 1000-3

Grade Designation	Bar Type conforming to governing IS Specification	Characteristic Strength f_y MPa	Elastic Modulus GPa
S 240	IS:432 Part I Mild Steel Bar	240	200
S 415	IS:1786 High Yield Strength Deformed Bars (HYSD)	415	200

Other grades of bars conforming to IS:432 and IS:1786 shall not be permitted.

All steel shall be procured from original producers, no re-rolled steel shall be incorporated in the work.

Only new steel shall be delivered to the site. Every bar shall be inspected before assembling on the work and defective, brittle or burnt bar shall be discarded. Cracked ends of bars shall be discarded.

Fusion-bonded epoxy coated reinforcing bars shall meet the requirements of IS:13620. Additional requirements for the use of such reinforcement bars have been given below :

- (a) Patch up materials shall be procured in sealed containers with certificates from the agency who has supplied the fusion bonded epoxy bars.
- (b) PVC coated G.I. binding wires of 18G shall only be used in conjunction with fusion bonded epoxy bars.
- (c) Chairs for supporting the reinforcement shall also be of fusion bonded epoxy coated bars.
- (d) The cut ends and damaged portions shall be touched up with repair patch up material.

- (e) The bars shall be cut by saw-cutting rather than flame cutting.
- (f) While bending the bars, the pins of work benches shall be provided with PVC or plastic sleeves.
- (g) The coated steel shall not be directly exposed to sun rays or rains and shall be protected with opaque polyethelene sheets or such other approved materials.
- (h) While concreting, the workmen or trolleys shall not directly move on coated bars but can move on wooden planks placed on the bars.

When specified in the contract, protective coating prescribed by CECRI shall be provided in conformance to specifications given in *Appendix 1000/I*. The CECRI coating process shall be allowed to be implemented at the site of works provided a representative of the Institute is present throughout the duration of the coating process who shall certify that the materials and workmanship are in accordance with prescribed specifications developed by the Institute.

1009.4. Grey Iron Castings

Grey Iron castings to be used for bearings shall have the following minimum properties :

(i) Minimum ultimate tensile strength	370 MPa
(ii) Modulus of Elasticity	147000 MPa
(iii) Brinell Hardness	230 MPa
(iv) Shear Strength	370 MPa
(v) Compressive Strength	1370 MPa

The testing shall be as specified in IS:210.

1009.5. Steel Forgings

Forged steel pins shall comply with clause 3, 3A or 4 of IS:1875 and steel forgings shall comply with clause 3, 3A or 4 of IS:2004. Raw materials of the forging will be taken as per IS:1875 with minimum reduction ratio of 1.8:1. Alternatively, if forging is made from ingot, a minimum reduction ratio between the ingot and forging will be 4:1. Forging shall be normalised.

1009.6. Structural Steel

Unless otherwise permitted herein, all structural steel shall before fabrication comply with the requirements of the following Indian Standards:

IS:226	:	Structural Steel (Standard Quality)
IS:961	:	Structural Steel (High Tensile)
IS:2062	:	Weldable Structural Steel
IS:8500	:	Weldable Structural Steel (medium & high strength qualities)

IS:1148	:	Hot rolled rivet bars (upto 40mm dia) for structural purposes
IS:1149	:	High tensile rivet bars for structural purposes
IS:1161	:	Steel tubes for structural purposes
IS:4923	:	Hollow Steel sections for structural use
IS:11587	:	Structural weather resistant steel
IS:808	:	Specifications for Rolled Steel Beam, Channel and Angle Sections
IS:1239	:	Mild Steel Tubes
IS:1730	:	Dimension for Steel Plate, sheet and strip for structural and general engineering purposes
IS:1731	:	Dimension for Steel flats for structural and general engineering purposes
IS:1732	:	Dimension for round and square steel bars for structural and general engineering purposes
IS:1852	:	Rolling and cutting tolerances for hot rolled steel products

The use of structural steel not covered by the above standards may be permitted with the specific approval of the authority. Refer to Section 1900 for further details.

1009.7. Stainless Steel

Stainless steel shall be austenitic chromium-nickel steel, possessing rust, acid and heat resistant properties conforming to IS:6603 and IS:6911. Mechanical properties/grade for such stainless steel shall be as specified by the accepting authority, but in no case be inferior to mild steel. Generally, stainless steel is available as per AISI grades. AISI 304 which is equivalent to grade 04Cr18Ni110 of IS:6911 satisfies the requirements of mechanical properties of structural steel. Other grades of stainless steel for specific purposes may be provided as per specific requirements. For application in adverse/ corrosive environment, stainless steel shall conform to AISI 316L or 02G17 Ni Mo2 of IS:6911.

1010. WATER

Water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel. Potable water is generally considered satisfactory for mixing concrete. Mixing and curing with sea water shall not be permitted. As a guide, the following concentrations represent the maximum permissible values :

- (a) To neutralise 200 ml sample of water, using phenolphthalein as an indicator, it should not require more than 2 ml of 0.1 normal NaOH.
- (b) To neutralise 200 ml sample of water, using methyl orange as an indicator, it should not require more than 10 ml of 0.1 normal HCl.

- (c) The permissible limits for solids shall be as follows when tested in accordance with IS:3025 :

	Permissible Limits (max)
Organic	200 mg/lit
Inorganic	3000 mg/lit
Sulphates (SO ₄)	500 mg/lit
Chlorides (Cl)	500 mg/lit *
Suspended matter	2000 mg/lit

* In case of structures of lengths 30m and below, the permissible limit of chlorides may be increased upto 1000 mg/lit.

All samples of water (including potable water) shall be tested and suitable measures taken where necessary to ensure conformity of the water to the requirements stated herein.

- (d) The pH value shall not be less than 6.

1011. TIMBER

The timber used for structural purposes shall conform to IS:883.

1012. CONCRETE ADMIXTURES

1012.1. General

Admixtures are materials added to the concrete before or during mixing with a view to modify one or more of the properties of concrete in the plastic or hardened state.

Concrete admixtures are proprietary items of manufacture and shall be obtained only from established manufacturers with proven track record, quality assurance and full fledged laboratory facilities for the manufacture and testing of concrete.

The contractor shall provide the following information concerning each admixture after obtaining the same from the manufacturer :

- Normal dosage and detrimental effects, if any, of under dosage and over dosage.
- The chemical names of the main ingredients in the admixtures.
- The chloride content, if any, expressed as a percentage by the weight of the admixture.
- Values of dry material content, ash content and relative density of the admixture which can be used for Uniformity Tests.
- Whether or not the admixture leads to the entrainment of air when used as per the manufacturer's recommended dosage, and if so to what extent.
- Where two or more admixtures are proposed to be used in any one mix, confirmation as to their compatibility.
- There would be no increase in risk of corrosion of the reinforcement or other embedments as a result of using the admixture.

1012.2. Physical and Chemical Requirements

Admixtures shall conform to the requirements of IS:9103. In addition, the following conditions shall be satisfied :

- (a) "Plasticisers" and "Super-Plasticisers" shall meet the requirements indicated for "Water reducing Admixture".
- (b) Except where resistance to freezing and thawing and to disruptive action of de-icing salts is necessary, the air content of freshly mixed concrete in accordance with the pressure method given in IS:1199 shall not be more than 2 per cent higher than that of the corresponding control mix and in any case not more than 3 per cent of the test mix.
- (c) The chloride content of the admixture shall not exceed 0.2 per cent when tested in accordance with IS:6925. In addition, the maximum permissible limit of chloride content of all the constituents as indicated in Section 1700 shall also be observed.
- (d) Uniformity tests on the admixtures are essential to compare qualitatively the composition of different samples taken from batch to batch or from the same batch at different times.

The tests that shall be performed along with permissible variations in the same are indicated below :

- Dry Material Content : to be within 3 per cent and 5 per cent of liquid and solid admixtures respectively of the value stated by the manufacturer.
- Ash content : to be within 1 per cent of the value stated by the manufacturer.

Relative Density (for liquid admixtures) : to be within 2 per cent of the value stated by the manufacturer.

- (e) All tests relating to the concretes admixtures shall be conducted periodically at an independent laboratory and compared with the data given by the manufacturer.

1013. REINFORCED CONCRETE PIPES

Reinforced concrete pipes for highway structures shall be of NP4 type conforming to the requirements of IS:458.

1014. STORAGE OF MATERIALS

1014.1. General

All materials may be stored at proper places so as to prevent their deterioration or intrusion by foreign matter and to ensure their satisfactory quality and fitness for the work. The storage space must also permit easy inspection, removal and restorage of the materials. All such materials even though stored in approved godowns/places, must be subjected to acceptance test prior to their immediate use.

1014.2. Brick

Bricks shall not be dumped at site. They shall be stacked in regular

tiers as they are unloaded, to minimise breakage and defacement. The supply of bricks shall be available at site at any time. Bricks selected for use in different situations shall be stacked separately.

1014.3. Aggregates

Aggregate stockpiles may be made on ground that is denuded of vegetation, is hard and well drained. If necessary, the ground shall be covered with 50 mm plank.

Coarse aggregates, unless otherwise agreed by the Engineer in writing, shall be delivered to the site in separate sizes (2 sizes when nominal size is 25 mm or less and 3 sizes when the nominal size is 32 mm or more). Aggregates placed directly on the ground shall not be removed from the stockpile within 30 cm of the ground until the final cleaning up of the work, and then only the clean aggregate will be permitted to be used.

In the case of fine aggregates, these shall be deposited at the mixing site not less than 8 hours before use and shall have been tested and approved by the Engineer.

1014.4. Cement

Cement shall be transported, handled and stored on the site in such a manner as to avoid deterioration or contamination. Cement shall be stored above ground level in perfectly dry and water-tight sheds and shall be stacked not more than eight bags high. Wherever bulk storage containers are used their capacity should be sufficient to cater to the requirement at site and should be cleaned at least once every 3 to 4 months.

Each consignment shall be stored separately so that it may be readily identified and inspected and cement shall be used in the sequence in which it is delivered at site. Any consignment or part of a consignment of cement which had deteriorated in any way, during storage, shall not be used in the works and shall be removed from the site by the Contractor without charge to the Employer.

The Contractor shall prepare and maintain proper records on site in respect of delivery, handling, storage and use of cement and these records shall be available for inspection by the Engineer at all times.

The Contractor shall make a monthly return to the Engineer on the date corresponding to the interim certificate date, showing the quantities of cement received and issued during the month and in stock at the end of the month.

1014.5. Reinforcement /Untensioned Steel

The reinforcement bars, when delivered on the job, shall be stored above the surface of the ground upon platforms, skids, or other supports, and shall be protected from mechanical injury and from deterioration by exposure.

1014.6. Prestressing Materials

All prestressing steel, sheathing, anchorages and sleeves or coupling must be protected during transportation, handling and storage. The prestressing steel, sheathing and other accessories must be stored under cover from rain or damp ground and protected from the ambient atmosphere if it is likely to be aggressive. Storage at site must be kept to the absolute minimum.

- (a) **Tendon** : Wire, strand and bar from which tendons are to be fabricated shall be stored about 300mm above the ground in a suitably covered and closed space so as to avoid direct climatic influences and to protect them from splashes from any other materials and from the cutting operation of an oxy-acetylene torch or arc welding process in the vicinity. Under no circumstances, tendon material shall be subjected to any welding operation or on site heat treatment or metallic coating such as galvanising. Storage facilities and the procedures for transporting material into or out of store, shall be such that the material does not become kinked or notched. Wire or strand shall be stored in large diameter coils which enable the tendons to be laid out straight. As a guide, for wires above 5mm dia, coils of about 2m dia without breaks or joints shall be obtained from manufacturer and stored. Protective wrapping for tendons shall be chemically neutral. All prestressing steel must be provided with temporary protection during storage.
- (b) **Anchorage Components** : The handling and storing procedures shall maintain the anchorage components in a condition in which they can subsequently perform their function to an adequate degree. Components shall be handled and stored so that mechanical damage and detrimental corrosion are prevented. The corrosion of the gripping and securing system shall be prevented. The use of correctly formulated oils and greases or of other corrosion preventing material is recommended where prolonged storage is required. Such protective material shall be guaranteed by the producer to be non-aggressive and non-degrading.

Prestressing steel shall be stored in a closed store having single door with double locking arrangements and no windows. Also the air inside the store shall be kept dry as far as possible by using various means to the satisfaction of the Engineer. Also instrument measuring the air humidity shall be installed inside the store. This is with a view to eliminating the possibility of initial rusting of prestressing steel during storage. The prestressing steel shall be coated with water solvable-grease. The prestressing steel should be absolutely clean and without any signs of rust.

All prestressing steel shall be stored at least 30 cm above ground level and it shall be invariably wrapped by protective cover of tar paper or polythene or any other approved material.

The Contractor should see that prestressing steel shall be used within 3 months of its manufacture. He should chalk out his programme in this respect precisely, so as to avoid initial corrosion before placing in position.

1014.7. Water

Water shall be stored in containers/tanks covered at top and cleaned at regular intervals in order to prevent intrusion by foreign matter or growth of organic matter. Water from shallow, muddy or marshy surface shall not be permitted. The intake pipe shall be enclosed to exclude silt, mud, grass and other solid materials and there shall be a minimum depth of 0.60 m of water below the intake at all times.

1015. TESTS AND STANDARD OF ACCEPTANCE

All materials, even though stored in an approved manner shall be subjected to an acceptance test prior to their immediate use.

Independent testing of cement for every consignment shall be done by the Contractor at site in the laboratory approved by the Engineer before use. Any cement with lower quality than those shown in manufacturer's certificate shall be debarred from use. In case of imported cement, the same series of tests shall be carried out before acceptance.

1015.1. Testing and Approval of Material

The Contractor shall furnish test certificates from the manufacturer/supplier of materials along with each batch of material(s) delivered to site.

The Contractor shall set up a field laboratory with necessary equipment for testing of all materials, finished products used in the construction as per requirements of conditions of contract and the relevant specifications. The testing of all the materials shall be carried out by the Engineer or his representative for which the Contractor shall make all the necessary arrangements and bear the entire cost.

Tests which cannot be carried out in the field laboratory have to be got done at the Contractor's cost at any recognised laboratory / testing establishments approved by the Engineer.

1015.2. Sampling of Materials

Samples provided to the Engineer or his representative for their retention are to be in labelled boxes suitable for storage.

Samples required for approval and testing must be supplied well in advance by at least 48 hours or minimum period required for carrying out relevant tests to allow for testing and approval. Delay to works arising from the late submission of samples will not be acceptable as a reason for delay in the completion of the works.

If materials are brought from abroad, the cost of sampling/testing whether in India or abroad shall be borne by the Contractor.

1015.3. Rejection of Materials not Conforming to the Specifications

Any stack or batch of material(s) of which sample(s) does not conform to the prescribed tests and quality shall be rejected by the Engineer or his representative and such materials shall be removed from site by the Contractor at his own cost. Such rejected materials shall not be made acceptable by any modifications.

1015.4. Testing and Approval of Plant and Equipment

All plants and equipment used for preparing, testing and production of materials for incorporation into the permanent works shall be in accordance with manufacturer's specifications and shall be got approved by the Engineer before use.
