

Volume II - A

Technical Specifications

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Preamble

Preamble

The technical specifications contained herein shall be read in conjunction with the other bidding documents as specified in Volume-I.

1 General requirements

The Technical specifications in accordance with which the entire work described hereinafter shall be constructed and completed by the contractor shall comprise of the following:

1.1 Part-I: General technical Specifications

The general technical specifications shall be the "specifications for road and bridge works (fifth revision 2013), issued by the Ministry of Road Transport and Highways, Government of India and published by the Indian Roads Congress, henceforth called MORT&H specifications and deemed to be bound into this document.

2 PART-II specifications for building and miscellaneous works

Technical specifications for building and miscellaneous works shall be the latest "specifications volume I to II, 2019 for civil works and general specifications for electrical works Part I - Internal, PART - II, External for electric work 2023 as published by the Central Public Works Department (CPWD), Government of India" and deemed to be bound into this document.

Section - C1

Technical Specification for Excavation and Filling

Section - C1

Technical specification for excavation and filling

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Section - C1

Technical specification for excavation and filling

1. Scope

- 1.1 This section of the specification covers the technical requirements for excavation and filling for industrial plots in & around structures, buildings, pipes, foundations, trenches, pits, drains, channels, cable ducts, underground facilities & similar works. It also covers filling areas and plinths with selected materials, conveyance and disposal of surplus soils and/or stacking them properly as directed by the Engineer.
- 1.2 The Contractor shall be fully responsible for proper setting out of works, profiling in excavation, stacking, etc., taking adequate safety measures etc. The Contractor shall carry out all works meant within the intent of this specification even if not explicitly mentioned herein. All work shall be executed to the satisfaction of the Engineer.
- 1.3 Existing trees, shrubs, any other plants, pole lines, fences, signs, monuments, buildings, pipelines, drains, sewers, or other surface or subsurface systems/drains/facilities within or adjacent to the works being carried out which are not to be disturbed, shall be protected from damage by the Contractor shall provide and install suitable safeguards approved by the Engineer for this purpose.
- 1.4 During excavation, the Contractor shall take all necessary precautions against soil erosion, water & environmental pollution and where required to undertake additional works to achieve this objective. Before start of operations, the Contractor shall submit to the Engineer for approval, his work plan and the procedure he intends to follow for disposal of waste materials etc. and the schedule for carrying out temporary and permanent control works. However, the approval of the Engineer to such plans and procedures shall not absolve the Contractor of his responsibility for safe and sound work.

2. General requirements

- 2.1 The Contractor shall make his own surveying arrangements for locating the coordinates and positions of all work and establishing the reduced levels (RL's) at these locations based on two reference grid lines and one bench mark which will be furnished by the Owner. The Contractor has to provide at site all the required survey instruments, along with qualified surveyors, to the satisfaction of the Engineer so that the work can be carried out accurately and according to the specification and drawings.
- 2.2 The Contractor shall furnish all skilled and unskilled labour, plant, tools, tackle, equipment, men, materials required for complete execution of the work in accordance with the drawings and as described herein and/or as directed by the Engineer.

IS:4701:	Code of Practice for earth work on canals
IS:9759:	Guide lines for Dewatering during construction.
IS:10379:	Code of practice for field control of moisture and compaction of soils for embankment & sub-grade.
IS:3812	Pulverised fuel ash – specification part 2 for use as admixture in cement mortar and concrete

4. Excavation

- 4.1 Excavation in all types of soils, soft and disintegrated rock (ordinary rock), and hard rock shall be done up to the required level. Excavation shall also include breaking of existing concrete RCC, Masonry work, tar and bitumen surfaces, and paving works etc. In case blasting is required the same shall be subject to the approval of Engineer. Sides and bottoms of excavation shall be cut sharp and true to line and level. Undercutting shall not be permitted. When machines are used for excavation, the last 300 mm before reaching the required level shall be excavated manually or by such equipment that soil at the required final level will be left in its natural condition. Suitability of strata (at the bottom of excavations) for laying the foundation thereon shall be determined by the Engineer.
- 4.2 Excavation for foundations shall be to the bottom of lean concrete and as shown on drawings or as directed by the Engineer. The bottom of all excavations shall be trimmed to required levels and when excavation is carried below such levels, by error, it shall be brought back to specified level by filling with concrete of nominal mix 1:3:6/1:4:8 cement & GGBS(replacement of cement with GGBS): coarse sand: 20mm down aggregates as directed by the Engineer.
- 4.3 The Contractor shall ascertain for himself the nature of materials to be excavated and the difficulties, if any, likely to be encountered in executing this work. Cofferdams, Sheeting, shoring, bracing, maintaining suitable slopes, draining etc. shall be provided and installed by the Contractor, to the satisfaction of the Engineer.
- 4.4 All excavation for installation of underground facilities, such as piping, sewer lines, drain lines, etc. shall be open cuts. For deep and huge excavations and in other excavations, if required by the Engineer, the Contractor shall submit for Engineer's approval (as already mentioned under Clause 1.5) an "Excavation scheme" showing the methodology to be adopted for excavation in order to maintain the stability of side slopes, means for ensuring safety of existing facilities nearby, dewatering as required etc. However, the Contractor shall be fully responsible for the scheme irrespective of any approvals granted. Benching shall be provided for deeper excavation wherever required.

- 4.5 When excavation requires bracing, sheeting or shoring etc., the Contractor shall submit drawings to the Engineer, showing arrangements and details of proposed installation. The Contractor shall also furnish all supporting calculations as called for and shall not proceed until he has received written approval from the Engineer. However, the responsibility for adequacy of such bracing, sheeting, shoring etc. will rest with the Contractor, irrespective of any approval of the Engineer. All precautions shall be taken while excavations near existing structures are to be carried out till the backfilling is completed.
- 4.6 The Contractor shall have to constantly pump out any water collected in excavated pits and other areas due to rain water, ground water, springs etc. and maintain dry working conditions at all times until the excavation, placement of reinforcement, shuttering, concreting, backfilling is completed. The Contractor shall remove all slush/muck from the excavated areas to keep the work area dry. Sludge pumps, if required, shall be employed by the Contractor for this purpose.
- 4.7 The Contractor shall remove all materials arising from excavations from the vicinity of the work either for direct filling, stacking and subsequent filling or for ultimate disposal as directed by the Engineer. In no case shall the excavated soil be stacked within a distance of 1.5m from the edge of excavation or one third the depth of excavation whichever is more. Material to be used for filling shall be kept separately as directed by the Engineer.

5. Filling

5.1 Materials

- a) Materials to be used for filling purposes shall be stone, sand or other inorganic materials and they shall be clean and free from shingle, salts, organic, large roots and excessive amount of sod. Lumps concrete or any other foreign substances which could harm or impair the strength of the substructure in any manner. All clods shall be suitably broken to small pieces. When the material is mostly rock boulders, these shall be broken into pieces not larger than 150mm size. Sand used for filling shall be clean, medium grained and free from impurities. Fines less than 5 microns shall not be more than 20%. In any case, the materials to be used for filling purposes shall have the prior written approval of the Engineer.
- b) If excavated materials are to be used for filling, then the Contractor shall select the materials from the stockpile, load and transport this material and execute the filling. This shall include excavation of earth which may become hard due to laying in stack yard for a long period of time.
- c) In case the materials have to be brought from pits/quarries, then it shall be the Contractor's responsibility for identification of such quarry areas, obtaining approval for

their use from concerned authorities, excavation/quarrying, loading and carriage of such material, unloading and filling at specified locations. The Contractor shall pay any fees, royalties etc. that may have to be paid for utilization of borrow areas.

5.2 Filling procedure

- a) After completion of foundation, footings, walls and other construction below the elevation of the final grades, and prior to filling, all temporary shoring, timber, etc. shall be sequentially removed and the excavation cleaned of all trash, debris and perishable materials. Filling shall begin only with the written approval of the Engineer. Also, areas identified for filling shall be cleared of all soft pockets, vegetation, bushes, slush etc. In case of plinth and similar filling the ground shall be dressed and consolidated by ramming and light rolling.
- b) Fill materials shall not be dropped directly upon or against any structure or facility where there is danger of displacement or damage. Filling shall be started after the concrete/masonry has fully set and shall be carried out in such manner so as not to cause any undue lateral thrust on any part of the structure.
- c) All space between foundation (concrete or masonry) and the sides of excavation shall be filled to the original surface after making allowance for settlement. Fill shall be placed in horizontal layers not exceeding 200mm loose thickness. Each layer shall be watered and compacted with proper moisture content and with such equipment as may be required to obtain a compaction/density as specified. Trucks or heavy equipment for depositing or compacting fill shall not be used within 1.5 metres of building walls, piers or other facilities which may be damaged by their weight or operations. The methods of compaction shall be subject to the approval of the Engineer. Pushing of earth for filling shall not be adopted under any circumstances.
- d) Fill adjacent to pipes shall be free of stones, concrete, etc. and shall be hand placed and compacted uniformly on both sides of the pipe and where practicable up to a minimum depth of 300mm over the top of pipes. While tamping around the pipes, care should be taken to avoid unequal pressure.
- e) Filling shall be accurately finished to line, slope, cross section and grade as shown on the drawings. Finished surface shall be free of irregularities and depressions and shall be within 20mm of the specified level.
- f) Where filling with stone from excavated materials is required, as per design and functional requirements, it shall be from broken pieces of boulders. At first a 75mm thick cushion of selected earth shall be laid over which the 200mm thick graded stones shall be laid in loose layers of 200mm and then the interstices filled with properly graded fine materials consisting of selected earth brought from borrow areas. Each

layer shall be watered and compacted to the required density as per design and functional requirements before the next layer is laid. However, no cushion shall be required where filling is over non-rocky surface.

- g) Where clean stone fill is required as per design and functional requirements it shall consist of clean selected stone metal of 40mm nominal size. It shall be laid in layers not exceeding 150mm (loose) and lightly tamped before the next layer is laid. No compaction shall be required for this type of stone filling.

5.3 **Compaction**

- a) Where compaction of 90% Standard Proctor Density is called for, such compaction shall be by mechanical means but the contractor may be permitted to adopt manual means only if the Engineer finds that the desired compaction is achievable in the field.
- b) Where compaction to 95% Standard Proctor Density is called for, it shall be by mechanical means only. Where access is possible, compaction shall be 12 tonne rollers smooth wheeled, sheep foot or wobbly wheeled and directed by the Engineer. A smaller weight roller may be permitted by the Engineer in special cases, but in any case, not less than 10 passes of the roller will be accepted for each layer. Each layer shall be wetted or the material dried by aeration to a moisture content of 3-5% above the Optimum Moisture Content to be determined by Contractor. Each layer shall be watered, rammed and compacted to the density as specified in the Schedule of Quantities.
- c) For compacting each sand layer, water shall be sprayed over it to flood it and it shall be kept flooded for 24 hours to ensure maximum compaction. Vibro-compactors shall also be used if necessary to obtain the required degree of compaction. Any temporary works required to contain sand under flooded condition shall also be undertaken. The surface of the consolidated sand shall be dressed to required levels or slope.
- d) After the compacted fill has reached the desired level, the surface shall be flooded with water for 24 hours, allowed to dry and then rammed and consolidated to avoid any settlement, at a later date. The compacted surface shall be properly shaped, trimmed and consolidated to an even gradient or level. All soft spots shall be excavated, filled and consolidated.
- e) The degree of compaction of compacted fill in place will be subject to tests in accordance with relevant Indian Standards as desired by the Engineer. As the work progress, the Contractor shall provide the necessary facilities to make such tests. If any test indicates that the compaction achieved is less than the required as per design and functional requirements degree of compaction, the Engineer may require all fill placed subsequent to the last successfully test to be removed and re-compacted by the

Contractor. Compaction procedure shall be amended as necessary to obtain satisfactory results.

- f) When semi-compacted fill is required as per design and functional requirements by the Engineer, the Contractor shall fill up such areas with available earth from stockpiles or borrow pits or directly from excavation without special compaction except that obtained by moving trucks, etc.

6. Sampling testing and quality control

6.1 General

- a) The Contractor shall carry out all sampling and testing in accordance with the relevant Indian Standards and/or International Standards and shall conduct such tests as are called for by the Engineer. Where no specific testing procedure is mentioned, the tests shall be carried out as per the prevalent accepted engineering practice to the directions of the Engineer. Tests shall be done in the field and at a laboratory approved by the Engineer and the Contractor shall submit to the Engineer, the test results in triplicate within three days after completion of a test. The Engineer may, at his discretion, waive some of the stipulations given below, for small and unimportant operations.
- b) Work found unsuitable for acceptance shall be removed and replaced by the Contractor. The work shall be redone as per specification requirement and to the satisfaction of the Engineer.
- c) Only as a very special case and that too in non-critical areas, the Engineer may accept filling work which is marginally unacceptable as per the criteria laid down. For such accepted work, payment shall be made at a reduced rate prorated to the compaction obtained against that stipulated.

6.2 Quality assurance programme

The Contractor shall submit and finalize a detailed field Quality Assurance Programme within 30 days from the date of award of the Contract according to the requirements of the specification. This shall include setting up of a testing laboratory, arrangement of testing apparatus/equipment, deployment of qualified/experienced manpower, preparation of format for record, Field Quality Plan, etc. On finalized field quality plan, the owner shall identify customer hold points beyond which work shall not proceed without written approval from the Engineer.

- 6.3 Frequency of sampling and testing including the methods for conducting the tests are given in **Table-1 of Annexure B**. The testing frequencies set forth are the desirable minimum and the Engineer shall have the full authority to carry out or call for tests as frequently as he may

deem necessary to satisfy himself that the materials and works comply with the appropriate specifications.

6.4 Acceptance criteria

Following acceptance criteria shall be followed.

- a) All individual samples collected and tested should pass without any deviation when only one set of samples is tested.
- b) For re-test of any sample two additional samples shall be collected and tested, and both should pass without any deviation.
- c) Where a large number of samples are tested for a particular test than 9 samples out of every 10 consecutive samples tested shall meet the specification requirement.
- d) Tolerance on finished levels for important filling areas at approved intervals shall be + 20 mm. However, for an unimportant area, tolerance upto + 57 mm shall be acceptable at the discretion of the Engineer. However, these tolerances shall be applicable for localized areas only.

For any other references regarding permissible deviations shall be referred to the tolerance limit enclosed **Annexure F**.

Section - C2

Technical Specifications for Properties, Storage and handling of common building materials

Section - C2

Technical Specification for properties, storage and handling of common building materials

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Section - C2

Technical specification for properties, storage and handling of common building materials

1. Scope

- 1.1 The scope of this section of the specification is to specify the properties, storage and handling of common building materials namely, coarse aggregates, cement, water, sand masonry units, reinforcement and structural steel.
- 1.2 Properties of the materials in general have been discussed. Specific requirements of the materials have been stipulated separately under specification for relevant items of work.

2. General requirements

- 2.1 The work shall include, providing of all necessary plants and equipment, providing adequate engineering supervision and technical personnel, skilled and unskilled labour etc. as required to carry out the entire work as directed by the Engineer to his complete satisfaction.
- 2.2 All materials proposed for use in the work shall conform to the requirements laid down in this section, and also subject to the approval of the Engineer. After specific materials have been accepted, the source of supply of such materials shall not be changed without prior approval of the Engineer.

Approval of any material by the Engineer shall not relieve the Contractor of his responsibility, for the requisite quality and performance of the material used.

- 2.3 Any material considered to be sub-standard, or not upto satisfaction of the Engineer, shall not be used by the Contractor and shall be removed from the site immediately.
- 2.4 Representative samples shall be procured by the Contractor and submitted to the Engineer, for approval before bulk procurement. The representative samples shall be retained by the Engineer for future comparison and reference.

3. Codes and standards

- 3.1 In the event that state, city or other local governmental bodies have requirements more stringent than those set forth in this specification, the former shall govern.
- 3.2 All applicable standards, acts, specifications, codes of practice, hand books, referred to herein shall be the latest editions, including all official amendments and revisions. In case of

discrepancy between this specification and those referred to herein, this specification shall govern.

Any special materials used, but not covered here, shall conform to relevant Indian Standards, if any, or as specified by the Engineer for any special purpose.

3.3 Some of the applicable Indian standards, codes are referred to here below:

IS:226	Specification for structural steel (standard quality).
IS:269	Specification for ordinary Portland cement, 33 grades.
IS:383	Specification for coarse and fine aggregates from natural sources for concrete.
IS:432	Specification for mild steel and medium tensile steel bars and (Parts 1&2) hard-drawn steel wires for concrete reinforcement.
IS:455	Specification for Portland slag cement.
IS:712	Specification for building limes.
IS:1077	Specification for common burnt clay building bricks.
IS:1077	Specification for Burnt clay bricks/Fly ash bricks.
IS:1127	Recommendations for dimensions and workmanship of natural building stones for masonry work.
IS:1129	Recommendation for dressing of natural building stones.
IS:1489	Specification for Portland pozzolana cement (Part-I) Fly ash based (Part-II) Calcined clay based
IS:1542	Specification of sand for plaster.
IS:1566	Specification hard-drawn steel wire fabric for concrete reinforcement.
IS:1597	Code of Practice for construction of Stone masonry, rubble stone masonry.

IS:1786	Specification for high strength deformed bars for concrete reinforcement.
IS:2062	Specification for hot rolled medium and high tensile structural steel.
IS:2116	Specification for sand for masonry mortars.
IS:2386	Testing of aggregates for concrete. (Part I to VIII)
IS:3495	Methods of test of Burnt clay bricks/Fly ash bricks (Part-I to IV)
IS:4031	Methods of physical tests for hydraulic cement.
IS:4032	Methods of chemical analysis of hydraulic cement.
IS:4082	Recommendations on stacking and storage of construction materials at site.
IS:7969	Safety code for handling and storage of building materials.
IS:8112	High strength ordinary Portland cement.
IS:8500	Medium and high strength structural steel.
IS:12269	43/53 grade ordinary Portland cement.
IS:12330	Sulphate resisting Portland cement.
IS:12600	Portland cement, low heat.
IS:12894	Fly Ash Lime Bricks – specification.
IS: 3812-2	Specification for pulverized fuel ash for use as admixture in cement mortar and concrete

4. Burnt clay bricks

- 4.1 Burnt clay bricks, for general masonry work, shall conform to IS:1077 and for face brick work, shall conform to IS:2691. Fly ash lime bricks shall conform to IS:12894

- 4.2 Bricks for general masonry work shall be table moulded /machine made, well burnt without being vitrified, of uniform size, shape, having sharp edges and cherry red colour. These shall be free from cracks, flaws or nodules of free lime and shall emit clear ringing sound (metallic sound) when struck. These shall not show any signs of efflorescence either when dry or subsequent to soaking in water. Fractured surface shall show uniform texture free from girts, lumps, holes etc.
- 4.3 Unless otherwise specified, minimum compressive strength shall correspond to class designation 75 as per IS: 107 with a minimum crushing strength of 75 kg/sq.cm. for general masonry work. However, for non-load bearing walls, bricks pavements, etc. bricks of class designation 50 shall only be used, wherever specified or shown on the drawings. Water absorption after 24 hours immersion shall not exceed 20% by weight for common bricks and 15% for face bricks.
- 4.4 On the basis of finish and dimensional tolerance, the bricks shall be classified as sub class A and B. Dimensional tolerance shall not exceed 3% and 8% of the size, of common bricks for sub-class A & B respectively and 3% for face bricks. All bricks shall have rectangular faces and sharp straight edges. Maximum permissible chip page for the face bricks shall be 6mm at the edges and 10mm for corners. The face bricks shall show no efflorescence after soaking in water and drying in the shade.

For any other references regarding permissible deviations shall be referred to the tolerance limit enclosed **Annexure F**.

- 4.5 The size of the bricks used shall be either modular size as per IS:1077 or locally available conventional size as approved by the Engineer.
- 4.6 Each brick shall have the manufacturer's identification mark clearly marked on the frog. The colour and texture of face bricks shall be limited to the range of samples submitted. Any brick not found upto the satisfaction of the Engineer shall be removed immediately from site by the Contractor.

5. Fly ash bricks

- 5.1 Fly ash bricks (cement bonded) shall be locally made. Bricks shall have smooth rectangular faces with sharp and square corners. Bricks shall be hand or machine moulded and shall be made from the admixture of suitable good quality of fly ash, sand and cement as per the composition mentioned below:

Fly ash : 50-60%
Sand : 32-40%
Cement : 8-12%

5.2 The fly ash bricks will be as per latest relevant IS code. The bricks will be of dimension as per standard clay brick, suitable for making 230mm thick full brick wall, 115mm thick half brick wall and 75mm thick minor partition walls, as applicable, as per drawing/specification/BOQ. A maximum tolerance of (+/-) 2mm shall be allowed as the manufacturing tolerance. The bricks shall have frog of 100 mm in length 40 mm in width and 10 to 20 mm deep of one of its flat sides.

The bricks when tested in accordance with the procedure laid down in IS 3495 (part 2): 1992 after immersion in cold water for 24 hrs, water absorption shall be within 13-15% by weight. Similarly, the porosity of the fly ash bricks shall be within 12-20%. The bricks shall have a minimum crushing strength of 80 Kg/Sqcm.

5.3 Fly ash bricks, for general masonry work, shall conform to IS:2212-1991

5.4 Unless otherwise specified, minimum compressive strength shall correspond to class designation 80 as per IS: 107 with a minimum crushing strength of 80 kg/sq.cm. for general masonry work. However, for non-load bearing walls, bricks pavements, etc. bricks of class designation 50 shall only be used, wherever specified or shown on the drawings. Water absorption after 24 hours immersion shall not exceed 20% by weight for common bricks and 15% for face bricks.

5.5 On the basis of finish and dimensional tolerance, the bricks shall be classified as sub class A and B. Dimensional tolerance shall not exceed 3% and 8% of the size, of common bricks for sub-class A & B respectively. All bricks shall have rectangular faces and sharp straight edges. Maximum permissible chip page for the face bricks shall be 6mm at the edges and 10mm for corners. The face bricks shall show no efflorescence after soaking in water and drying in the shade.

For any other references regarding permissible deviations shall be referred to the tolerance limit enclosed **Annexure F**.

5.6 The size of the bricks used shall be either modular size as per IS:1077 or locally available conventional size as approved by the Engineer.

5.7 Each brick shall have the manufacturer's identification mark clearly marked on the frog. The colour and texture of face bricks shall be limited to the range of samples submitted. Any brick not found upto the satisfaction of the Engineer shall be removed immediately from site by the Contractor.

6. Stones

6.1 All stones shall be from approved quarries. These shall be hard, tough, durable, compact grained, uniform the texture and colour and free from decay, flaws, veins, cracks and sand

holes. The surface of a freshly broken stone shall be bright, clean and sharp and shall show uniformity of texture, without loose grains and free from any dull, chalky or earthy appearance. Stone with round surface shall not be used.

- 6.2 Stones showing mottled colours shall not be used for face work. A stone shall not absorb more than 5% of its weight of water after 24 hours immersion. The type of stone shall be as specified or shown on drawings and/or as instructed by the Engineer. Stones used for masonry work shall conform to IS:1597 (Part – I) No soft stone shall be used for masonry or for filling purpose.
- 6.3 Any stone not found upto the satisfaction of Engineer shall be removed immediately from site by the Contractor.

7. Lime

- 7.1 Lime shall be stone lime and it shall conform to IS:712. Hydrated lime shall be mixed with water to form a putty. This shall be stored with reasonable care to prevent evaporation of water for at least 24 hours before use. Quick lime shall be slaked with enough water to make a cream and then stored with reasonable care to prevent evaporation of water for at least seven days before use. Type of lime to be used for different purposes such as concreting, plastering, white washing etc. shall be according to the satisfaction made hereunder:

Class - A	Eminently hydraulic lime used for structural purposes.
Class - B	Semi-hydraulic lime used for masonry mortars, lime concrete and plaster undercoat
Class - C	Fat lime used for finishing coat in plastering, white washing, composite mortars, etc. and with addition of pozzolanic materials for masonry mortar.
Class - D	Magnesium/dolomite lime used for finishing coat in plastering, whitewashing, etc.
Class - E	Kankar lime used for masonry mortar.
Class - F	Siliceous dolomite lime used for undercoat and finishing coat of plaster

8. Cement and fly ash

- 8.1 Cement shall be ordinary Portland cement, 43/53 grade conforming to IS 8112/12269. The Engineer may permit the use of Portland pozzolana cement conforming to IS:1489 or Portland slag cement conforming to IS:455 or sulphate resistant cement conforming to IS 12330 as per

the specific site condition. However, any lower grade of OPC, PPC and PSC should never be mixed with higher grade cement.

- 8.2 Fly ash is generated by burning of coal in coal fired power plants. It has the characteristic of pozzolanic additive to cement. Continuous research studies by various engineering research laboratories revealed its varied usefulness as an additive for enhancing the various qualities of concrete including its workability, strength and durability if handled and cared properly. Partial replacement of cement with fly ash in concrete save much of the energy required for production of OPC and also facilitates the economical disposal of millions of tons of fly ash.

At present most of the fly ash blended cements commercially produced in India has 18 to 25% fly ash by weight and addition of fly ash to this extent has a beneficial effect on the workability and economy of concrete. It has been found that in order to improve the other qualities of concrete like resistance of sulfate attack and thermal cracking, larger percentage of fly ash is to be used in concrete.

Indian standard specification No. 3812-2003, Specification for Pulverized Fuel Ash, Part 2: For Use as Admixture in Cement Mortar and Concrete [CED 2: Cement and Concrete] covers the extraction and the physical and chemical requirements of pulverized fuel ash for use as admixture in cement mortar and concrete. Fly ash confirming to this standard shall be used in place of cement.

The chemical, physical requirements and testing of fly ash shall be in accordance with the IS 3812-2003

9. Water

- 9.1 Water used for cement concrete, mortar, plaster, grout, curing, washing of coarse aggregate, soaking of bricks, etc. shall be clean and free from injurious amount of oil, acids, alkalis, organic matters or other harmful substances in such amounts that may impair the strength or durability of the structure. Potable water shall generally be considered satisfactory for all masonry and concrete works, including curing. The Contractor shall carry out necessary tests in advance to prove the suitability of the water proposed to be used. As a guide, the following concentrations represent the maximum permissible values:

- a. To neutralize 200 ml sample of water, it should not require more than 2ml of 0.1 normal NaOH.
- b. To neutralize 200 ml sample of water, it should not require more than 10ml of 0.1 normal HCL.
- c. Percentage of solids shall not exceed the following:

i)	Organic	0.02
ii)	Inorganic	0.30
iii)	Sulphates	0.05
iv)	Chlorides	0.10
v)	Suspended matter	0.20

10. Aggregates

- 10.1 Aggregates mean both coarse and fine inert materials used in the preparation of concrete. Aggregates shall consist of natural sands, crushed stone and gravel from a source known to produce satisfactory aggregate for concrete and shall be chemically inert, hard, strong, durable against weathering, of limited porosity and free from such quantities of deleterious materials as may cause corrosion of reinforcement or may impair the strength and / or durability of the concrete. Total percentage of all deleterious materials, including coal, lignite, clay lumps, materials finer than 75 microns, soft fragments and shale but excluding mica shall not exceed 5%. However, for crushed fine aggregate, total percentage of coal and lignite and clay lumps, shall be limited to 2%. Both coarse and fine aggregates shall conform to IS:383 for concrete, shotcreting etc. unless otherwise mentioned.
- 10.2 Sample of aggregates for mix design and determination of their suitability shall be sent to the laboratory well in advance in scheduled placing of concrete. Sampling, testing, and interpretation of test results shall be subject to the approval of the Engineer. Aggregates shall be properly graded.

11. Sand

- 11.1 Sand shall be hard, durable, clean and free from adherent coatings of organic matter and shall not contain clay balls or pellets. The sand shall be free from impurities such as iron pyrites, alkalis, salts, coal, mica, shale, or other laminated materials, in such forms or quantities as to affect adversely the hardening, strength, durability or appearance on mortar, plaster, etc. or to cause corrosion of any metal in contact with such mortar, plaster etc. In no case, the cumulative percentage of Impurities in sand shall be more than 5% by weight. All sand shall be properly graded. Unless otherwise directed by the Engineer, sand for masonry mortars shall conform to IS:2116 and sand for plaster shall conform to IS:1542. Sand, when used as fine aggregate, in concrete, shall conform to IS:383. For filling, medium grained sand (having fines less than 75 microns not exceeding 20%) shall be used.

12. Reinforcement steel, structural steel (including embedded steel) and wire mesh

12.1 Billet: - (Primary steel)

A semi-finished product obtained by forging or rolling, usually square and not exceeding 125 x 125 mm in cross section with rounded corners and is intended for further processing into suitable finished product by forging or re-rolling.

Steel shall be manufactured by open hearth, electric, duplex, basic oxygen or a combination of these processes. In case any other process is employed by the manufacturer, prior approval of the purchaser should be obtained.

The ladle analysis of the material when analyzed in accordance with the various parts of IS: 228, shall be confirmed with IS: 8056-1976- Table 1 (Chemical composition).

Table 1 Chemical composition (As per IS: 8056-1976 clauses 3.1 & 6.1)

Constituent	Percent
Carbon	0.45 to 0.80
Silicon	0.15 to 0.35
Manganese	0.40 to 1.00
Sulphur, Max	0.050
Phosphorus, Max	0.050

In case of continuous cast billets, the billet analysis shall be taken as ladle analysis.

Permissible variation in case of product analysis from the limits specified in IS: 8056-1976 clause-6.1 shall be as follows:

Constituent	Variation over the specified maximum or under the minimum limits in %
Carbon	0.03
Silicon	0.03
Manganese	0.04
Sulphur, Max	0.005
Phosphorus, Max	0.005

Note: Variations shall not be applicable both over and under the specified limits in several determinations in a heat.

Sampling

At least one ladle sample analysis shall be taken per cast.

If required, the samples for product analysis shall be prepared by forging or rolling down to 30-mm round section.

In case of wire rods the test, piece size shall be the size of wire rods.

Drilling shall be taken from the sample representing two-thirds, half and one-third of height from bottom of the billet separately.

In case of continuous cast billets and billets produced from ingots of masses 3 tonnes and more, the sample may be taken from anywhere from the billets.

Freedom from defects

The billets and continuous cast billets shall be free from harmful defects, such as pipe, laminations, segregation, inclusions and cracks.

Subject to agreement between the purchaser and the manufacturer, the billets and continuous cast billets may be supplied with suitable surface dressing.

Billets shall either be supplied free from harmful segregation, piping, cracks, inclusions, and blow-hole by appropriate top and bottom discard and dressing or supplied with suitable surface dressing only, without top and bottom discard if agreed to between the purchaser and the manufacturer, to ensure the requirements of freedom from defects specified in the relevant product specifications.

If agreed to between the purchaser and the manufacturer the following tests may be carried out from the samples prepared under IS: 8056-1976

Dimensions

The size and tolerance of billets shall be subject to agreement between the purchaser and the manufacturer. However, the nominal sizes of billets generally supplied as per guidance given in IS: 8056-1976

The preferred sizes of billets shall be 50, 63, 75, 80, 90, 100 and 125 mm.

The sizes other than those specified may be supplied by agreement between the purchaser and the manufacturer.

A tolerance of the billets shall be confirmed with IS: 8056-1976

The ends of ingots and billets shall be painted with a suitable colour code conforming to IS: 2049-1963.

Each ingot and billet shall be legibly stamped or painted with the cast number, grade and the name or trade-mark of the manufacturer.

The material may also be marked with the IS1 certification mark.

- 12.2 All steel for reinforcement shall be clean and free from loose mill scales, dust, loose rust, oil, grease, paint or other harmful matters which may affect its bond with concrete. Mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement shall conform to grade-1 of IS:432 (Part-1). High strength deformed steel bars shall conform to grade Fe 415 of IS:1786. All steel bars shall be of tested quality. Actual grade and type steel, to be used, shall be as specified or shown on drawings.
- 12.3 Structural steel (including embedded steel) shall be straight, sound, free from twists, cracks, flaws, laminations and all other defects. Structural steel shall be of tested quality conforming to IS:226, IS:2062 or IS:8500. These shall be free from lamination defects. Grade and type of steel to be used shall be as specified.
- 12.4 Hard drawn steel wire fabric shall conform to IS:1566. Wire fabric shall be electrically cross welded.

13. Storage and handling of materials

- 13.1 Generally, all materials shall be stacked and stored by the Contractor as described in IS:4082 unless otherwise mentioned and in a manner affording convenient access for identification and inspection at all times. The storage area and arrangements shall be subject to the approval of the Engineer. Any material rendered unserviceable during the Contractor's custody, shall be replaced or repaired by the Contractor as determined by the Engineer.
- 13.2 All materials shall be so stored as to prevent deterioration or intrusion of foreign matter and to ensure the preservation of their quality and fitness for the work. Any material which has deteriorated or has been damaged or is otherwise considered defective by the Engineer, shall not be used and shall be removed and the cost thereof, shall be realized from the Contractor's dues. The Contractor shall maintain up-to-date accounts of receipts, issue and balance (stock wise) of all materials.
- 13.3 Bricks shall not be dumped at site. These shall be stacked on dry firm ground in regular tiers even as they are unloaded to minimize breakage and defacement of bricks. Bricks of different class, selected for various categories of use in the work, shall be stacked separately. Each stack shall contain equal number of bricks, preferably not more than 3000.
- 13.4 Dressed stone for all facing, paving etc. shall be stored with special care to avoid defacement of faces and edges or damp and rust stains.
- 13.5 Lime shall be stored in weather-proof sheds. Lime which has been damaged by rain, moisture or air slaking, shall not be used. If the lime is supplied as hydrated lime, it shall be stored in the same manner as cement.

13.6 Cement and fly ash

- a. Consignments of cement shall be stored as received and shall be consumed in the order of their delivery. Cement held in storage for more than ninety days shall invariably be tested, and only if test results are satisfactory, the Engineer may consider permitting its use.
- b. Different consignments of different types of cement, i.e. OPC, PPC, PSC shall be stacked separately with clear identifiable stack number.
- c. The cement shall be stored in dry, leak proof and weather proof are closed sheds. Storage under tarpaulins shall not be permitted. The cement bags shall be stored well away from the walls and insulated from the floor, using
- d. Planks etc. to avoid contact with moisture. The cement shall be stacked in easily countable stacks and in a place of easy access so as to facilitate proper inspection and removal on a first in first out basis. Not more than 15 bags shall be stacked in any tier to prevent lumping up under pressure. However, in stacks more than 8 bags high, the cement bags shall be arranged alternately lengthwise and crosswise so as to tie the stacks together and minimize the danger of toppling over. The cement bags shall be gently kept to avoid leakage of cement from the bags. Substandard or partially set cement shall be immediately removed from the site as soon as it is detected.
- e. The Contractor shall make his own arrangements for the storage of adequate quantity of cement. Cement in bulk may be stored in bins or silos which will provide adequate protection against dampness, contamination, etc. The bins or silos, shall be cleaned periodically.
- f. Pulverized fuel ash (Fly ash) shall be stored in accordance with the recommendation given in IS 4082. Additionally, during bulk storage, the fly ash should be suitably covered to avoid getting airborne.
- g. Supplies of pulverized fuel ash (Fly ash) may be made in bulk in suitable quantities or in bags (jute, jute-laminated, multiple paper or polyethylene lined) bearing the net mass (may be 15 kg, 30 kg, 300 kg, 600 kg as agreed by the Contractor)
- h. Pulverized fuel ash in bulk storage for more than 6 months or in bags for more than-3 months after completion of tests, may be re-tested before use and standard. May be rejected, if it fails to conform to any requirements of this standard.
- i. Pulverized fuel ash may be rejected if it does not comply with any of the requirements stipulated in IS 3812 Part 2 of 2003

13.7 Coarse and fine aggregates/sand

- a. Coarse and fine aggregates shall be stacked separately. Contamination with foreign materials and earth during storage and while heaping the materials shall be avoided. Coarse aggregates shall be stacked in layers not exceeding 120 cm in height such that corning and segregation do not occur. Each layer shall cover the entire area of the stockpile before succeeding layers are placed. Segregated aggregates from stock-pile shall be rejected.
- b. Aggregates shall be stored on brick soling or an equivalent platform so that they do not come in contact with dirt, clay, grass or any other injurious substance, at any stage. For lifting aggregates from stockpiles, rakers shall be used. Aggregates of different sizes shall be kept in separate and easily measurable stacks. If so desired by the Engineer, aggregates from different source shall be stacked separately with proper care to prevent intermixing.

13.8 Reinforcement and Structural Steel (including steel required for embedment)

- a. Reinforcement and structural steel (including steel required for embedment) shall be stored consignment wise and size wise, off the ground by at least 150mm and protected by the suitable cover, or as desired by the Engineer. The steel shall be protected from rusting, oil grease and distortions. The reinforcing steel shall be coated with cement wash before stacking to prevent scale and rust, in areas having accelerating corrosion effect like marine atmosphere. The stacks shall be easily measurable. Steel needed for immediate use only shall be removed from storage. Fabricated steel shall be carefully stored to prevent damage, distortion, corrosion and deterioration.
- b. Reinforcement shall be stored according to the diameter, grade and length in such a place as to permit easy approach for inspection and identification.
- c. The area shall be such that water does not accumulate and reinforcement does not get distorted or corroded. It shall not be stacked directly over ground or near any harmful materials. It shall be cleaned of excessive rust before use.
- d. Steel plates of different specifications shall be stacked separately. Steel of IS:2062 and IS:8500 quality shall be given a grade wise, distinctive identification mark. Passage and space between the stacks shall be sufficient for rigging operations.

14. Testing

- 14.1 All materials provided by the Contractor shall be tested for conformity of the specification and the test results shall be submitted to the Engineer for acceptance. In addition to above, the Contractor shall carry out the relevant tests at site as specified under different items of work.

Section - C3

Technical Specification for Cast-in-situ Concrete and Allied works

Section - C3

Technical specification for cast-in-situ concrete and allied works

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Section - C3

Technical specification for cast-in-situ concrete and allied works

Sub-section 1 - Common requirement

1. Scope

- 1.1 The work shall include providing of materials, all necessary plant and equipment, providing adequate engineering supervision and technical personnel, skilled and unskilled labour, etc. as required to carry out the entire work as indicated on the drawings and/or described herein subsequently and/or as directed by the Engineer.
- 1.2 The Contractor shall carry out all works meant within the intent of this specification even if not explicitly mentioned herein. All works shall be executed to the satisfaction of the Engineer.
- 1.3 This specification is divided into 13 sections. The Section – 1 deals with common requirements and the other 12 sections deal with specifications for 12 different items/activities. The stipulations contained in Section-1, '**Common Requirements**' shall form a part of the specifications of 12 different items/activities described in section 2 to 13.

All these eight sections are as follows:

Section – 1	Common requirement
Section – 2	Cast-in-Situ Concrete
Section – 3	Reinforcement
Section – 4	Formwork and staging
Section – 5	Embedded parts
Section – 6	Foundation bolt assembly
Section – 7	Shotcreting
Section – 8	Grouting
Section – 9	Encasement of steel structures/elements
Section – 10	Joints in Concrete
Section – 11	Water proofing/damp proofing of underground concrete structures.
Section – 12	Dismantling/Demolishing works-RCC and PCC.
Section – 13	Cement Additives/Admixtures in concrete.

2. General

- 2.1 Any approval, instructions, permission, checking, review, etc. whatsoever by the Engineer, shall not relieve the Contractor of his responsibility and obligation regarding adequacy, correctness, completeness, safety strength, quality, workmanship, etc.
- 2.2 The Contractor shall make his own surveying arrangements for locating the coordinates and positions of all work and establishing the reduced levels (RLs) at these locations, based on two reference grid lines and one bench mark, which will be furnished by the Owner. The Contractor has to provide at site, faction of the Engineer so that the work can be carried out accurately and according to the specifications and drawings.

3. Codes and standards

- 3.1 All applicable standards, specifications, etc. and codes of practice shall generally be the latest editions, including all applicable official amendments and revisions. A complete set of all these documents shall generally be available at site, with the Contractor.
- 3.2 All work shall be carried out as per the stipulations contained in various sections of these specifications and the latest Indian Standards, Acts, Codes and best practices.
- 3.3 In case of conflict between the stipulations contained in various sections of these specifications and stipulations of Indian Standards, Codes, etc. the requirements of stipulations contained in various sections of these specifications, shall prevail over that of Indian Standards, Codes, etc.
- 3.4 Some of the applicable Indian Standards, Codes, etc. are referred to here below:

IS:73	Specification for paving bitumen
IS:2062	Specification for structural steel
IS:269	Specification for Ordinary Portland cement, 33 grade.
IS:280	Specification of mild steel wire for general engineering purposes
IS:383	Specification for coarse and fine aggregates from natural sources for concrete.
IS:432	Specification for mild steel and medium tensile steel (parts I & II) bars and hard drawn steel wire for concrete reinforcement.
IS:455	Specification for Portland slag cement

IS:456	Code of practice for plain and reinforced concrete.
IS:457	Code of general construction of plain & reinforced concrete for dams & other massive structures.
IS:516	Method of test for strength of concrete
IS:650	Specification for standard sand for testing of cement
IS:702	Specification for industrial bitumen
IS:816	Code of practice for use of metal arc welding for general construction in mild steel.
IS:1199	Method of sampling and analysis of concrete
IS:1200	Method of measurement of building (Part-II and civil engineering works. V, VIII, XVIII)
IS:1367	Technical supply conditions for threaded steel fasteners.
IS:1489	Specification for Portland-pozzolana cement
(Part-I)	Fly ash based
(Part-II)	Calcined clay based
IS:1566	Specification for Hard-drawn steel wire fabric for concrete reinforcement.
IS:1609	Code of practice for laying damp proof treatment using bitumen felts.
IS:1786	Specification for high strength deformed steel bars and wires for concrete reinforcement
IS:1791	General requirements for batch type concrete mixers.
IS:1838(Part 1)	Specification for preformed fillers for expansion joints in concrete pavements and structures (non - extruding and resilient type)
IS:2204	Code of practice for construction of reinforced concrete shell roof.

IS:2210	Criteria for the design of reinforced concrete shell structures and folded plates.
IS:2386	Methods of test of aggregates for (Parts concrete I to VIII)
IS:2438	Specification for roller pan mixer
IS:2502	Code of practice for bending and fixing of bars for concrete reinforcement.
IS:2505	General requirements for concrete vibrators, immersion type.
IS:2506	General requirements for concrete vibrators, screed board type.
IS:2514	Specification for concrete vibrating tables.
IS:2571	Code of practice for laying in-situ cement-concrete flooring.
IS:2645	Specification for Integral cement water proofing compounds.
IS:2722	Specification for portable swing weigh batchers for concrete. (Single and double bucket type)
IS:2750	Specification for Steel scaffoldings
IS:2751	Code of practice for welding of mild steel plain and deformed bars for reinforced concrete structures.
IS:3025	Methods of sampling and test waste water.
IS:3067	Code of practice for general design details and preparatory work for damp proofing & water proofing of buildings.
IS:3150	Specification for hexagonal wire netting for general purposes.
IS:3366	Specification for Pan vibrators.
IS:3370	Code of practice for concrete (Part I structures for the storage of to IV) liquids.)
IS:3384	Specification for bitumen primer for use in water proofing & damp proofing.
IS:3414	Code of practice for design and installation of joints in buildings.

IS:3550	Methods of test for routine control for water used in industry.
IS:3558	Code of practice for use of immersion vibrators for consolidating concrete.
IS:3696	Safety code for scaffolds (Part I ladders & II)
IS: 3812-2	Specification for pulverized fuel ash for use as admixture in cement mortar and concrete
IS:4014	Code of practice for steel tubular scaffolding (Parts I & II)
IS:4031	Methods for physical tests for hydraulic cement.
IS:4130	Safety Code for demolition of buildings.
IS:4326	Code of practice for earthquake resistant design and construction of buildings.
IS:4461	Code of practice for joints in surface hydro-electric power stations.
IS:4656	Specification for form vibrators for concrete.
IS:4925	Specification for batching and mixing plant.
IS:4990	Specification for plywood for concrete shuttering work.
IS:4995	Criteria for design of reinforced concrete bins for the storage of granular and powdery materials. (Parts I & II)
IS:5121	Safety code for piling and other deep foundations.
IS:5256	Code or practice for sealing joints in concrete lining on canals.
IS:5525	Recommendations for detailing of reinforcement in reinforced concrete work.
IS:5624	Specification for foundation bolts.
IS:6461	Glossary of terms relating to cement concrete.

IS:6494	Code of practice for water proofing of underground water reservoirs and swimming pools.
IS:6509	Code of practice for installation of joints in concrete pavements.
IS:7193	Specification for glass fiber base coal-tar pitch and bitumen felts.
IS:7293	Safety code for working with construction machinery.
IS:7861	Code of practice for extreme weather concreting (Parts I&II)
IS:9012	Recommended practice for Shotcreting.
IS:9103	Specification for admixtures for concrete.
IS:9417	Recommendations for welding cold-worked steel bars for reinforced concrete construction.
IS:9595	Recommendations for metal-arc welding of carbon and carbon manganese steels.
IS:10262	Recommended guidelines for concrete mix design.
IS:11384	Code of practice for composite construction in structural steel and concrete.
IS:12118	Specification for two-parts poly sulphide.
IS:12200	Code of practice for provision of water stops at transverse contraction joints in masonry and concrete dams.
IS:12269	43/53 Grade ordinary Portland cement.
IS:12600	Portland cement, low heat.
SP:23	Handbook of concrete mixes
SP:24	Explanatory Handbook on IS:456-1978
SP:34	Handbook on concrete reinforcement and detailing.

4. Sampling, testing and quality assurance

- 4.1 Facilities required for sampling materials, concrete, reinforcement, formwork, etc. in the field and in the laboratory, shall be provided by the Contractor. The Contractor shall carry out all sampling and testing in accordance with the relevant Indian Standards and/or International Standards and this specification. Where no specific testing procedure is mentioned, the tests shall be carried out as per the prevalent accepted engineering practice to the directions of the Engineer. Tests shall be done in the field in the presence of the Engineer or his authorized representative and at a laboratory, approved by the Engineer, and the Contractor shall submit to the Engineer the test results in triplicate within three days after completion of any test.
- 4.2 The Contractor shall maintain records of all inspection and testing, which shall be made available to the Engineer. The Engineer at his discretion, may waive some of the stipulations for small and unimportant concreting operations and other works.
- 4.3 Work found unsuitable for acceptance shall be removed and replaced by the Contractor. The work shall be redone as per specification requirements and to the satisfaction of the Engineer at no extra cost to the Owner.
- 4.4 **Quality assurance programme**
- a) The Contractor shall submit and finalize a detailed field Quality Assurance Programme within 30 days from the date of award of the contract, before commencement of work at site, according to the requirements of the specification. This shall include setting up of a testing laboratory, arrangement of testing apparatus/equipment, deployment of qualified/experienced manpower, preparation of format for record, field quality plan, etc. On finalized field quality plan, the Owner shall identify, customer hold points, beyond which work shall not proceed without written approval from the Engineer. The testing apparatus/equipment installed in the field laboratory shall be calibrated /corrected by the authorized persons as frequently as possible to give accurate testing results.
- b) Frequency of sampling and testing, etc. and Acceptance Criteria are given in respective sections. However, the testing frequencies set forth are the desirable minimum and the Engineer shall have the full authority to carry out or call for tests as frequently as he may deem necessary to satisfy himself that the materials and works comply with the appropriate specifications.

Sub-section 2 – Cast-in-situ concrete

1. Scope

This section of the specification deals with plain or reinforced cement concrete for general use and in structures and covers the requirements for concrete, materials, their properties, storage, handling, grading, mix design, strength and quality, pouring at all levels, testing, casting, protecting, curing, finishing, etc.

2. General requirement

- 2.1 The provision of IS:456 shall be followed as general guidance, along with all other relevant Indian Standards, unless otherwise specifically mentioned.
- 2.2 Before starting a concrete pour, the Contractor shall obtain the approval of the Engineer on a 'Pour Card' maintained for this purpose. He shall obtain complete instructions about the materials and proportions, water cement ratio, etc. to be used, slump/workability, number of test cubes/samples to be taken, type of finishing to be done, any admixture to be added, any limitation on size of pour and location for interruption of a pour in case of premature stopping of pour, etc.
- 2.3 The mixers and weigh-batchers, shall be maintained in clean and serviceable condition. Accuracy of all equipment shall be periodically checked. All concrete shall be mixed in mechanically operated batch mixers complying with IS:1791 and these shall be of approved make, with suitable provision for correctly controlling the water delivered to the drum. Weigh batchers shall conform to IS:2722 and shall be capable of controlling the weights to within one percent of the desired value.
- 2.4 The Contractor's procedures for casting massive concrete sections (as noted on the drawings or as identified by the Engineer) shall take account of the release of the heat of hydration, drying shrinkage behavior. The procedures shall be such that cracking or loss of strength of the concrete from these effects is prevented. At least one week before commencing the construction of any massive concrete section, the Contractor shall submit, for approval of the Engineer, detailed proposals for placing the concrete together with supporting calculations to demonstrate the suitability of the methods.

3. Materials

- 3.1 In general, all the materials used in the manufacture of concrete shall be in accordance with the Technical specification for properties, storage and handling of common building materials, (vide module C2) which shall be deemed to form a part of this specification.

3.2 The Engineer shall have the right to inspect the sources of materials, method of procurement and storage of materials, method of procurement and storage of materials, quality control procedures, etc.

3.3 Cement

The cement used shall be the Ordinary Portland cement conforming to IS:269 or Portland Pozzolana cement conforming to IS:1489 or Portland slag cement conforming to IS:455 or any other type of cement, specified in IS:456 with the prior approval of the Engineer. However, any special type of cement such as High strength cement or sulphate resisting cement, may be used under special circumstances.

3.4 Aggregates

- a) For reinforced concrete work, aggregates conforming to IS:383 & IS:2386 having a maximum size of 20 mm shall be used. For certain reinforced concrete works, aggregates having a maximum size other than 20 mm size shall also be used as called for in the drawings. However, for lean concrete provided as mud mat below structural concrete, maximum size upto 40 mm shall be used.
- b) Aggregates (coarse or fine) with a specific gravity below 2.6 shall not be used without special permission of the Engineer. Machine-made sand will be acceptable provided the constituent (rock/gravel) is sound, hard, dense and is acceptable to the Engineer. Sand, natural gravel and crushed rock shall be prepared for use by such screening or washing, or both, as necessary to remove all objectionable foreign matter.
- c) **Type of aggregates:** Petro graphic examination shall be carried out to ascertain the structure and rock type of aggregate including presence of strained quartz and other reactive minerals. Moreover, in case the coarse aggregate sample is of composite nature, the proportions (by weight) of different rock types in the composite sample and petrographic evaluation of each rock should also be ascertained. While determining different rock type is in the composite sample, special emphasis should be given on identification of known reactive rocks like chalcedony, opal etc. and procedure laid down in IS:2430 for sampling of aggregates may be followed. The sample should not contain weathered rock and reduced to required quantity by quartering and coning.

The results of petro graphic test, shall be submitted to the Engineer. The Engineer shall review the results on consultation with some specialist agencies, if required, to determine potential activity of the aggregate (siliceous minerals) which may lead to reaction of silica in aggregate with the alkalis of cement. In additional, potential of some aggregate like lime stone to residual expansion due to repeated temperature cycle is also to be reviewed. Further, the Contractor shall submit the results of Alkali aggregates reactivity carried out as per IS:2386 (Pt. VII).

In case of any apprehension about the properties of the aggregate, the Engineer shall ask the Contractor to send samples of coarse and fine aggregate to any of the established research laboratory including National Council for, Cement and Building Materials (NCB), Ballabgarh for further testing. However, the Owner shall fix the agency and bear the cost of such testing.

In case, it is established from the tests that the aggregates contain reactive silica which would react with alkalis of the cement, the Contractor shall be asked to change the source of supply of the aggregate and take additional measures as suggested. In case aggregates indicate residual expansion, under repeated temperature cycle test, the material shall not be used for concreting of equipment foundations which are likely to be subjected under repeated temperature cycle. The Contractor shall use different type of aggregate as approved by the Engineer.

3.5 Admixtures

Admixtures in concrete for promoting workability, improving strength, entraining air for similar purposes may be used only after the written permission from the Engineer is obtained. These shall be free from injurious amount of chloride, etc. Addition of admixtures should not reduce the specified strength or durability of concrete and should not have detrimental effect on reinforcement. The admixtures shall conform to IS:9103 and shall be of proven make and from a reputed manufacturer. Calcium chloride as accelerating admixture is not permitted to be used other than in mass concrete works. The Contractor shall produce latest test results carried out at approved Government Test Houses for the approval of the Engineer, before use details of admixtures have been covered under Section – 13.

4. Water

- 4.1 Water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalis, sugar, organic materials or other substances that may be deleterious to concrete or steel. Potable water is generally considered satisfactory for mixing concrete. The maximum permissible values of impurities shall be as given in clause no. 4.3 of IS:456-1978.
- 4.2 In case of doubt regarding development of strength, the suitability of water for making concrete shall be ascertained by the compressive strength and initial setting time tests specified in IS:456.
- 4.3 Average 28 days compressive strength of atleast three 150 mm concrete cubes prepared with water proposed to be used shall not be less than 90% of the average strength of three similar concrete cubes prepared with distilled water. The cubes shall be prepared, cured and tested in accordance with IS:456.

- 4.4 The initial setting time of a concrete test block made with the appropriate cement and the water proposed to be used shall not be less than 30 minutes and shall not differ by ± 30 minutes from the initial setting time of control test block prepared with the same cement and distilled water. The test shall be carried out as per IS:4031.
- 4.5 Where concrete, made from water, proposed to be used does not satisfy the above requirements and/or contains an excess of acid, alkali, sugar, salt or other deleterious substances, then the Engineer may refuse to permit its use. Sea water shall not be used for curing besides mixing in concrete.

5. Grades of concrete

All concrete shall be “design mix concrete” as defined in IS:456, unless a nominal mix concrete such as 1:2:4, 1:3:6, 1:4:8 or 1:5:10 proportion is specified. The proportion referred to is by weight (mass). The grades for ‘design mix’ concrete shall be designated M-15, M-20, etc. as specified in IS:456. (Replacement of cement with GGBS shall be considered):

5.1 Nominal mix concrete

- a) Nominal mix concrete shall be used only for plain Cement concrete works and where shown on drawings or specifically allowed by the Engineer. Such concrete shall not require preparation of trial mixes and all such concrete shall be mixed in a mechanical mixer. Proportions for nominal mix concrete shall be according to Table-3 of IS:456-1978. In addition, standard proportion by volume shall be used wherever specified.
- b) In proportioning concrete, the cement & GGBS shall be measured by (mass) weight. The quantities of fine and coarse aggregates may be determined by volume (for corresponding weight) but preferably by weight. If fine aggregates are moist, the amount of surface water shall be determined. Also an allowance shall be made for bulking in case of volume batching, in accordance with IS:2386 (Part-III). Allowance shall also be made for surface water present in the aggregates, when computing the water requirement. All the above data shall be maintained properly, to the satisfaction of the Engineer.
- c) The recommended maximum water cement ratios are specified in **Table 1**.

Table 1: Recommended water – Cement ratio

Nominal mix concrete	Quantity of water per 50 Kg. of cement (max.)
1:5:10	60 litres
1:4:8	45 litres
Nominal mix concrete	Quantity of water per 50 Kg. of cement (max.)
1:3:6	34 litres
1:2:4	32 litres

- d) Nominal mix concrete 1:5:10 shall correspond to grade M5, 1:4:8 shall correspond to grade M7.5, 1:3:6 to grade M10 and 1:2:4 to grade M15 of IS:456.
- e) If Nominal mix concrete made in accordance with specified proportions does not yield the specified strength of the corresponding grade and fails to satisfy the requirements of “acceptance criteria for concrete” as specified in IS:456. Such concrete shall be treated in the following manner:
- i) In case the Engineer is satisfied that lower strength of concrete is attributed to material and workmanship of the Contractor, then such concrete shall be replaced by concrete of specified strength. The Engineer may however, also accept such lower strength concrete but such lower strength concrete shall be classified as belonging to the appropriate lower grade proportion.
 - ii) In case the Engineer is satisfied that lower strength of concrete is not attributable to the Contractor, he may direct in writing to increase the cement content to obtain specified strength. Such extra cement shall also be considered for reconciliation purposes. The use of richer mix shall be continued until the Engineer instructs otherwise.
- f) Nominal mix proportion shall not be classified as higher grade proportion either on the ground that the test strengths are higher than the minimum specified or in the case where the Engineer directs use of additional cement over the quantity specified for the particular mix proportion to achieve the minimum specified strength.

5.2 Design mix concrete

- a) Design mix concrete shall be used on all concrete works, except where specified otherwise or specially permitted by the Engineer. The mix shall be designed for all grades of concrete except those specified under Nominal Mix Concrete (replacement of cement with GGBS) such as to obtain for works cubes, the required workability and the characteristic strength not less than the appropriate values given in Table 2. Using Standard Deviation specified in IS:10262 corresponding to good quality control, the Minimum value of target strength of design mix of various grades of concrete shall be as per Table 2.

However, the Engineer may allow to change the target strength values based on adequate numbers of works test results.

Table 2: Grades of concrete

Compressive strength of a 15-cm cube at 28 days (N/Sq.mm)

Grade designation of concrete	Preliminary test strength (target of trial mix)	Characteristic strength on strength works cubes
M 15	20.8	15
M 20	27.6	20
M 25	33.7	25
M 30	39.9	30
M 35	45.4	35
M 40	49.25	40

- b) In proportioning concrete, the quantity of cement, GGBS and aggregates shall be determined by mass. However, only in some exceptional cases including concreting in some isolated areas, the Engineer may allow the quantity of aggregates to be determined by an equivalent volume basis after the relationship between weight and volume is well established by trials and the same shall be verified frequently. Water shall be either measured by volume in calibrated tanks or weighed. All measuring equipment at site, shall be maintained in a clean and serviceable condition, and their accuracy shall be periodically checked.
- c) To keep the water-cement ratio to the designed value, allowance shall be made for the moisture contents in both fine and coarse aggregates and determination of the same in accordance with IS:2386 Part (III) shall be made as frequently as directed by the Engineer.

In some of the structures, water-cement ratio shall be restricted even below 0.45. To increase the workability, plasticizer may have to be used in such cases. Trial mix shall be carried out accordingly.

- d) With the permission of the Engineer, for any of the above-mentioned grades of concrete, if the water quantity has to be increased, proportionately cement quantity shall also be increased, to keep the ratio of water to cement same as adopted in Preliminary tests for the corresponding grade of concrete. The extra cement required on account of this shall also be considered for reconciliation purposes.

5.3 Mix design

- a) IS:10262 shall be followed as general guidance for mix design. Preliminary tests/trial mix, as specified or as required by the Engineer, shall be carried out sufficiently ahead of the actual commencement of the work with different grades of concrete made from representative samples of aggregates and cement & GGBS expected to be used on the works. These tests are to be conducted to arrive at the grading of aggregates, water cement ratio, workability and the quantity of cement required to give Preliminary (target) compressive strengths as specified in Table-2.
- b) Minimum cement contents, from durability consideration, or different exposures and sulphate attack shall be as given in Table-19 and 20 of IS:456. In case, higher value is obtained from trial mix from strength consideration, same shall be considered.
- c) At least four trial mixes are to be made and minimum. Six test cubes taken for each trial mix noting the slump for each type of mix. The cubes shall then be properly cured and three cubes for each mix shall be tested in a laboratory (approved by the Engineer) at 7 days and others at 28 days and others at 28 days for obtaining the compressive strength. The test reports shall be submitted to the Engineer. The design mix particulars shall indicate, with the help of graphs and curves etc. the extent of variation in the grading of aggregates which can be allowed. While designing mixes, over wet mixes shall be avoided. For chimney, natural draft cooling tower, etc. where assessment of early strength is required, the concrete cubes shall also be tested for early age strength at 1 day and 3 days for establishing the values.
- d) The Contractor shall submit the test reports of mix design to the Engineer for his view, indicating design criteria, analysis and proportioning of materials, etc. On the basis of the above test reports, a mix proportion by mass and the water cement ratio, shall be determined by the Contractor such that concrete prepared with this mix yield the desired characteristic strength and shall have suitable workability. The mix design to be adopted on the works shall be subject to the approval of the Engineer. The proportions, once decided for different grades of concrete, shall be adhered to, during all concreting operations as long as the quality of the materials does not change. If,

however, at any time, the quality of materials being used has changed from those for Preliminary mix design, or there is a change either in the required strength of concrete, or water cement ratio or workability, the Contractor shall have to make similar trial mixes and Preliminary tests to ascertain the revised mix proportions and water cement ratio to be used for obtaining the desired strength and consistency.

- e) In the situations, like casting of piles, where the compaction of concrete is not possible by vibration, the method of compacting concrete cubes of Preliminary/ trial mixes and work tests shall be in the same manner as the method of compacting concrete at site is proposed.

5.4 Workability of concrete

- a) The workability of concrete shall be checked at frequent intervals. The workability of concrete measured in accordance with IS:1199 for every sample taken for testing shall be recorded with the corresponding cube test result.
- b) The degree of workability necessary to allow the concrete to be well compacted and to be worked into the corners of formwork and round the reinforcement to give the required surface finish shall depend on the type and nature of the structure and shall be based on experience and tests. The suggested ranges of values of workability for concrete for some placing conditions, measured in accordance with IS:1199 as stipulated under clause No. 6.0 of IS:456, are given below in Table-3, for guidance only. In addition, in some special cases like casting of pile, very high degree of workability (up to 180 mm slump) shall be used.

Table 3: Limits of workability

Placing	Degree of workability	Value of workability
Concreting of shallow sections with vibration factor	Very Low	20-10 seconds, Vee-bee time or 0.75-0.80 compacting.
Concreting of lightly reinforced section with vibration	Low	10-5 seconds, Vee-bee time or 0.80-0.85 compacting factor.
Concreting of lightly reinforced section without vibration, or heavily reinforced sections with vibration	Medium	5-2 seconds, Vee-bee time or 0.85-0.92 compacting factor or

Placing	Degree of workability	Value of workability
Concreting of heavily reinforced sections without vibration	High	25-75mm, slump for 20 mm aggregate (for smaller aggregate the values will be lower). Above 0.92 compacting factor or 75-125 mm slump for 20 mm aggregate (for smaller aggregate the values will be lower)

Note: Notwithstanding the values given above, the slump to be maintained for work in progress shall be as per directions of the Engineer.

5.5 Mixing of concrete

- a) Concrete shall be mixed in a mechanical mixer conforming to IS:1791. However, mixing shall preferably be done at a single central batching plant, conforming to IS:4925, situated within the area allocated for the Contractor's particular use as shown on the drawing or as directed by the Engineer. The plant shall have a mechanically operated mixer of an approved size and type, capable of ensuring a uniform distribution of the materials throughout the mass and the mass is uniform in colour and consistency.
- b) Water shall not be added into the drum of the mixer, until all the cement and aggregates constituting the batch are already in the drum and dry mixed for at least one minute and are uniformly distributed. Water shall then be added and mixing of each batch shall be continued until there is a uniform distribution of the materials and the mass but in no case shall mixing be done for less than two minutes and for at least 40 revolutions after all the water and materials are in the drum. When absorbent aggregates are used or when the mix is very dry, the mixing time shall be extended as directed by the Engineer. Mixers shall not be loaded above their rated capacity as this prevents thorough mixing.
- c) The entire contents of the drum shall be discharged before the ingredients for the next batch are fed into the drum. No partly set or remixed or excessively wet concrete shall be used and it shall be immediately removed from site. Each time if the work stops for more than 30 minutes, the mixer shall be thoroughly cleaned and when the next mixing commences, the first batch shall have 10% additional cement.
- d) In exceptional circumstances and/or work in remote areas, hand mixing may be allowed by the Engineer, subject to adding 10% extra cement which shall be considered for reconciliation purposes. The mixing shall be carried out on watertight

platform and mixing shall be continued till a uniform colour and consistency of the mix is achieved.

5.6 Concrete conveying

- a) Concrete shall be handled and conveyed as rapidly as practicable, from the place of mixing to the place of final laying, by approved means, before the initial setting of the cement starts. Concrete shall be conveyed in such a way that there is no segregation or loss of any of the ingredients and maintaining the required workability. If segregation does occur during transport, the concrete shall be remixed.

During very hot or cold weather, if directed by the Engineer, concrete shall be transported in deep containers which will reduce the rate of water loss by evaporation in hot weather and heat loss in cold weather, at no extra cost to the Owner.

- b) Conveying equipment for concrete shall be mortar tight, well maintained and thoroughly cleaned before commencement of concrete mixing. Such equipment shall be kept free from set concrete. Chutes shall not be used for transport of concrete without the written permission of the Engineer. The chute in case permitted to be used shall be of such size and design as to ensure practically continuous flow. Slope of the chute shall be so adjusted that the concrete flow without the use of an excessive quantity of water and without segregation of its ingredients. The delivery end of the chute shall be as close as possible to the point of deposit.
- c) Concrete may be conveyed and placed by mechanically operated equipment, e.g. pumps or pneumatic placers only with the written permission of the Engineer, who shall also review the entire scheme for which comprehensive details shall be furnished by the Contractor.

5.7 Concrete placing

- a) Concrete shall be placed and compacted in its final position before the cement reaches the initial set and normally concrete shall be compacted in its final position within minutes of leaving the mixer.
- b) Where direct placement is not possible, the Contractor shall provide suitable arrangements such as chutes, tremie, elephant trunks, etc. to confine the movement of concrete as directed by the Engineer. Concrete shall not be dropped from a height or handled in a manner which may cause segregation.
- c) If concrete is placed by pumping, the consistency shall be the minimum necessary for such conveyance of concrete. Before commencement of regular pumping, the

pipeline shall be lubricated by cement mortar (1:2), and once pumping commences, stoppages shall be avoided.

- d) Concrete shall not be placed in foundations on soft areas or where there is standing water or debris. Such soft areas shall be removed and filled with 1:4:8/1:3:6 nominal mix concrete, as directed by the Engineer.

For rock surfaces, it shall be ensured that the rock is not unsound. On sloping rock faces, rough steps or benches shall be formed and concrete shall not be placed on a sloping rock surface. Prior to pouring concrete, the rock surface shall be cleaned with a high - pressure water and air jet and kept wet for three hours. Also, before placing concrete, water shall be removed from depressions, the rock surface shall be dried and a 10mm thick cement sand mortar (1:6) layer shall be placed and worked into all crevices, cracks, depression, etc.

- e) The placing of concrete shall be a continuous operation with no interruption in excess of 30 minutes between the placing of continuous portions of concrete. Concrete shall be placed in continuous horizontal layers of 150 mm or higher thickness as directed by the Engineer and thoroughly compacted before placing next layer. The thickness of each layer shall be such that it will be deposited before the previous layer has stiffened. When placing concrete through reinforcing steel, care shall be taken to prevent segregation of the coarse aggregates.
- f) Approval by the Engineer of any of the materials and/or work as required herein shall not relieve the Contractor of his obligation to produce finished concrete in accordance with the drawings and specifications. Slots, openings, holes, pockets, etc. shall be provided in the concrete as directed by the Engineer.
- g) Slabs, beams and similar members shall normally be poured in one operation. In special circumstances, with the approval of the Engineer, these can be poured in horizontal layers, but it must be ensured that the under layer is not already hardened. Bleeding of under layer, if any, shall be effectively removed. Molding, throating, drip course, etc. shall be poured as shown on the drawings or as desired by the Engineer.
- h) After the concrete has been placed, it shall be spaded and thoroughly compacted by approved mechanical vibrators to a maximum subsidence without segregation and thoroughly worked around reinforcement or other embedded fixtures into the correct form and shape. Hand tamping in some cases may be allowed subject to the approval of the Engineer. Care must be taken to ensure that the inserts, fixtures, reinforcement and formwork are not displaced or disturbed during placing of concrete.
- i) Whenever vibration has to be applied externally, the design of formwork and the disposition of vibrators shall receive special consideration to ensure efficient compaction and to avoid surface blemishes. Surface vibrators and form attached

vibrator shall not be permitted under normal conditions. Their use shall require written approval of the Engineer.

- j) Vibrators shall penetrate both the layer poured and the under layer to ensure good bond homogeneity and to prevent the formation of cold joints. Immersion vibrators shall not be allowed to come in contact with steel reinforcement after start of initial set. Also, they shall not be allowed to come in contact with forms or finished surfaces.
- k) Immersion vibrators shall have a 'no load' frequency, amplitude and acceleration as per IS:2505 depending upon the size of the vibrator. Immersion vibrators shall be operated by experienced men. These vibrators shall be immersed not more than 450 mm apart and withdrawn when air bubbles cease to come to the surface. Such vibrators shall in no case be used to push concrete inside the forms and vibrators shall be withdrawn slowly.
- l) No concrete shall be placed in wet weather or on a water covered surface. If there have been any signs of washing of cement or sand, the concrete shall be entirely removed immediately. Suitable precautions shall be taken in advance to guard against possible rains before leaving the fresh concrete unattended.
- m) Mass concrete shall be poured in lifts not exceeding 1.0 m in height unless otherwise indicated on drawings or as directed by the Engineer. Horizontal lift shall not be more than 150 cm in thickness, according to provision of IS:457.
- n) Formwork and reinforcement shall be approved in writing by the Engineer before concrete is placed. Concrete shall be placed only after all preparations for casting have been approved by the Engineer and approval given to proceed with the casting in writing on pour card to be maintained by the Contractor for this purpose and to be submitted along with the Contractor's bills.
- o) Concrete, when deposited, shall have a temperature of not less than 5 degrees Centigrade and not more than 40 degrees Centigrade. When depositing concrete in very hot weather, precautions shall be taken so that the temperature of wet concrete does not exceed 40 degrees Centigrade while placing. This shall be achieved by stacking aggregates under the shade and keeping them moist, starting curing before concrete dries out, etc. However, before mixing / placing concrete, when the above temperature conditions vary on either side, approval of the Engineer shall be obtained for the method of execution.

5.8 Protection and curing of concrete

- a) Newly place concrete shall be protected by approved means from rain, sun and wind. Concrete placed below ground level, shall be protected from falling earth, during and

after placing. Concrete placed in ground containing any deleterious substances, shall be kept free from contact with such ground or with water draining from such ground, during placing of concrete and for a period of atleast three days or as otherwise instructed by the Engineer.

- b) The ground water around newly poured concrete shall be kept down to an approved level by pumping or other approved means of drainage. Adequate steps shall be taken to prevent floatation or flooding. Steps, as approved by the Engineer, shall be taken to protect immature concrete from damage by debris, excessive loading, vibration, abrasion, mixing with earth or other deleterious materials, etc. that may impair the strength and durability of the concrete.
- c) As soon as the concrete had hardened sufficiently for the surface not to be marked, it shall be kept in a damp or wet condition by pounding or by covering with a layer of sacking, canvas, hessian or similar materials and kept continuously wet for atleast seven days after final setting. This period may be extended, at the discretion of the Engineer, upto fourteen days. Curing of horizontal surfaces exposed to drying winds shall begin immediately after the concrete has hardened. Concrete slabs and floors shall be cured for the periods mentioned above by flooding with water of minimum 25mm depth.
- d) Approved curing compounds may be used in lieu of moist curing with the permission of the Engineer. However, such permission may be granted only in specific cases. Such compounds shall be applied to all exposed surfaces of the concrete, as soon as possible after the concrete has set.
- e) Quantity of water applied shall be such as to prevent erosion of freshly placed concrete.

5.9 Construction joints

- a) When work has to be interrupted, the concrete shall be rebated and/or keyed at the joint to such shape and size as may be required by the Engineer or as shown on the drawings. All vertical construction joints shall be made with stop boards, which are rigidly fixed and slotted to allow for the passage of the reinforcing steel. In the case of water retaining structures, basements, tunnels, etc. water stop of approved material shall be provided, if so specified on the drawings or as directed by the Engineer.
- b) Construction joints shall be located as shown or described on the drawings. Where it is not described, the joints shall be in accordance with the following guidelines.

- i) In a column, the joints shall be formed about 75 mm below the lowest soffit of the beams framing into it, including haunches, if any. In flat slab construction, the joint shall be 75 mm below the soffit of the column capital.
- ii) Concrete in a beam shall be placed throughout without a joint. If unavoidable, the joint shall be vertical and within the middle-third of the span. When a beam intersects a girder, the joints in the girder shall be given an offset equal to a distance twice the width of the beam and additional reinforcement provided for shear. The joints shall be vertical throughout the full thickness of the concrete member with suitable shear key wherever shown on the drawing.
- iii) A joint in a suspended floor slab shall be vertical at one quarter points of the span and at right angle of the principal reinforcement.
- iv) Construction joints in equipment foundations shall not be provided without specific concurrence of the Engineer.
- v) Vertical construction joints in water retaining structures shall not be permitted unless shown on the drawings.

However, if the Contractor desires any adjustments in the location of construction joints (to suit site conditions) from those shown on drawings or from those explained above, he shall obtain prior approval from the Engineer.

- c) Before fresh concrete is placed, the cement skin of the partially hardened concrete which was poured earlier shall be thoroughly removed and the surface made rough and aggregate exposed, by wire brushing, hacking, water jetting, air jetting or any other method as directed by the Engineer. The rough surface shall be thoroughly wetted for about 1/2 hour and shall be dried and coated with 10 to 15 mm thick layer of 1:1 freshly mixed cement and sand slurry. Special care shall be taken to see that the first layer of concrete placed after a construction joint is thoroughly rammed against the existing layer.
- d) In forming a joint, concrete shall not be allowed to slope away to a thin edge. The locations of construction joints shall be planned by the contractor well in advance of pouring and they will have to be approved by the Engineer. The Contractor's proposals shall include atleast the location of construction joints, the sequence of pouring, formwork details and their stripping times.
- e) Where the concrete has not fully hardened, all laitance shall be removed by scrubbing the wet surface with wire or bristle brushes. Care being taken to avoid dislodgement of particles of aggregates. The surface shall be thoroughly wetted and all free water removed. The surface shall then be coated with neat cement slurry. On this surface, a

layer of concrete not exceeding 150 mm in thickness shall first be placed shall be well rammed against old work, particular attention being to corners and close spots. Work thereafter, shall proceed in the normal way.

- f) For multiple lift work a suitable gap shall be maintained between setting of the earlier placed concrete and the commencement of concrete pour. After depositing concrete in columns, piers or walked time gap of minimum 4 hours, preferably 24 hours shall be maintained before depositing concrete in beams, girders or slabs, supported there in order to avoid cracking due to settlement.

5.10 **Work in extreme weather conditions**

During hot weather (atmospheric temperature above 40 degrees centigrade) or cold weather (atmospheric temp at 5 degree centigrade and below) the concreting shall be done as per the procedures and precautions set out in IS:7868 (Parts I and II).

5.11 **Cleaning and finishing of concrete**

- a) All concrete surfaces shall have an even and clean finish free from honeycombs, air bubbles, fins or other blemishes unmarred, reasonable smooth. The formwork joint marks on concrete work exposed to view shall be rubbed with carborandum stone and defects patched up with paste of cement sand mortar (1:2) and cured. The finish shall be made to the satisfaction of the Engineer. Concrete surfaces to be subsequently plastered or where brick work is to be built against them, shall be adequately hacked as soon as the form is stripped off so that proper bond can develop.
- b) Immediately after removal of forms, the concrete shall be inspected and defective areas as pointed out by the Engineer shall be removed partially or entirely as directed. Holes, left by form bolts, etc. shall be filled-up and made good with cement sand mortar of approved mix. All superficial defects such as honeycombing, rough patches, etc. shall be similarly made good. If the defective area is at a vulnerable location, e.g. at the ends of beams & columns etc. then it may be necessary to cut out the member completely or in part and reconstruct as directed by the Engineer. If epoxies have to be used, the same shall be subject to the approval of the Engineer. Poured concrete affected by faulty formwork shall be removed totally and replaced. If so directed, the Contractor shall have to resort to grouting / shotcreting.
- c) A smooth finish shall be obtained with the use of forms having smooth and even surfaces and edges. Panels and form linings shall be of uniform size and be as large as practicable and installed with closed joints. Upon removal of forms, the joint marks shall be smoothed off and all blemishes, projections etc. removed leaving the surfaces reasonably smooth and unmarred.

- d) Where integral cement concrete finish is called for, the surface shall be compacted and then floated and treated with a straight edge and any high and low spots eliminated. The work shall be carried out as per IS:2571

6. Sampling, testing and quality assurance including construction tolerances

6.1 General

- a) Concrete cubes for works tests shall be cured under laboratory conditions, except when in the opinion of the Engineer, extreme weather conditions prevail at which time, these may require curing under job conditions.
- b) For the purposes of statistical analysis, any substandard cube result, which in the opinion of the Engineer, is due to improper sampling, molding or testing shall be discarded and a dummy result shall be substituted. The value of a dummy result shall be equivalent to the average value of the cubes from the same grade of concrete tested immediately before and after the discarded result. The number of such substandard cubes shall not exceed 5%.
- c) If the 'strength' of the laboratory controlled cubes, for any portion of the concrete work, falls below the compressive strength specified, the Engineer shall have the right to order a change in the proportions or the water content for the remaining portion of the surface.
- d) If the 'strength' of the works cured test cubes falls below the specified strength, the Engineer shall have the right to require provisions for temperature and moisture control during the period of curing as necessary to secure the required strength, and may require retest in accordance with the standard method of securing, preparing and testing specimens from hardened concrete for compressive and flexural strengths, or load tests to be made on the portion of the building so affected. All such tests shall be made at the Contractor's expense.
- e) Unacceptable concrete work shall be dismantled by the Contractor and replaced by fresh work, meeting the specification requirements. In the course of dismantling, if any damage is done to the embedded items or adjacent structures, the same shall be made good, by the Contractor, to the satisfaction of the Engineer, at no extra cost to the Owner.
- f) Only as a very special case and that too in non-critical areas, the Engineer may accept concrete work which is marginally unacceptable as per the criteria laid down in IS:456. For such accepted work, payment shall be made at a reduced rate prorata to the concrete cube strength obtained, against that stipulated.

- g) Before placing concrete, the inside of forms shall be checked to ensure that they are clean and thoroughly wetted or adequately treated. So as to prevent absorption of water from the concrete.
- h) Ultrasonic tests on the foundations of major equipment to ascertain the quality and grade of concreting shall be carried out. The Owner shall arrange for the specialized agency for conducting the test at his cost. The Contractor shall provide all the necessary facilities and arrangement for conducting the test at site in terms of access, scaffolding etc. In case of any defects, the Contractor shall rectify the same as directed by the Engineer.
- i) Rebound hammer test shall be carried out for ascertaining the quality of concrete work, as directed by the Engineer.
- j) Test shall be conducted for the water tightness of the liquid retaining structures as per IS:3370 and IS:6494. The details and sequence of tests shall be as given hereunder:
 - i) All arrangements, including supply of water for testing purposes, shall be kept ready when the tank is nearing completion.
 - ii) Water supply to the tank shall be in stages of 300 to 450 mm height in order to check the water tightness of the tank and location of leakage of various levels.
 - iii) The permissible drop in level in 24 hours shall be 6 mm in case of covered reservoir/tank and 12 mm in the case of open reservoir/tank.
 - iv) The leakage points shall be marked and separately treated after dewatering.
 - v) The reservoir/tank shall be retested for water tightness after rectification.

For basement type structures like cable vault, track-hopper, tunnel, neutralizing pit, etc. the Contractor shall examine the water tightness against ingress of sub-soil water.

Frequency of sampling and testing including the methods of conducting the tests shall be as given in **Table – 2 of Annexure B**.

6.2 Sampling of concrete

Samples from fresh concrete shall be taken according to IS:1199 and tested as per IS:516.

- a) Normally only compressive test shall be performed but the Engineer may require other tests to be performed in accordance with IS:516.

b) i) **Trial Mixes:**

At least four trial mixes shall be made with; min. 6 test cubes for each mix.

ii) **Works Tests:**

The min. frequency of sampling of concrete of each grade shall be according to clause 14.2.2 of IS:456-1978. However, after getting continuous satisfactory results and in the case of voluminous concrete works, the Engineer, may at his discretion reduce the frequency of sampling as follows.

For each grade of concrete, and for each 8 hours (shift) of work or part thereof, at least one sample consisting of six specimens shall be taken from each 150 cum. Of concrete or part thereof, 3 specimens shall be tested at 7 days and remaining 3 shall be tested at 28 days. However, in all cases, the 28 days compressive strength shall alone be the criterion for acceptance or rejection.

c) To control the consistency of concrete from every mixing, slump tests and compaction factor tests in accordance with IS:1199 shall be carried out by the Contractor every two hours or as directed by the Engineer. Slumps corresponding to the test specimens shall be recorded for reference.

d) The strength of sample shall be the average of the strength of three specimens. The individual variation should not be more than $\pm 15\%$ of the average.

6.3 **Unless otherwise specified, the tolerance in construction shall be as follows:**

Description of Item/ Structural element	Permissible Deviation in mm
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The dimensions of concrete as cast when compared with those on the drawings shall be within the tolerance given below:

Faces of concrete in foundations and structural members against which backfill is placed.	+ 25	- 10
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Description of Item/ Structural element	Permissible Deviation in mm
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Location of footing

(for RCC framed structures only). Eccentricity of footing	+ 25	- 25
	2% of footing width of direction of misplacement but limiting to 50mm.	
Top surface of slabs and of concrete to receive base plates to be grouted.	+ 5	- 5
Alignment of beams, lintels, columns, walls, slabs and similar structural elements.	+ 5	- 5
Deviation from specified dimensions of cross-sections of columns and beams.	+ 12	- 6
Alignment of holding down bolts without sleeves.	+ 1.5	- 1.5
Alignment of holding down bolts with sleeves.	+ 5	- 5
Level of holding down bolt assemblies.	+ 10	- 10
Embedded parts (in any direction).	+ 5	- 5

**Description of Item/
Structural element**

**Permissible
Deviation in mm**

Centres of packets or holes with greatest lateral dimension not exceeding 150 mm. Variation in steps:	+ 10	- 10
Riser	+ 1.5	- 1.5
Tread Plumb	+ 3.0	- 3.0
	3 mm for every metre subject to a maximum of 10mm.	

6.4 Acceptance criteria

The acceptance criteria of concrete shall be in accordance with IS:456. However, in exceptional circumstances, the Engineer may, at his discretion, accept a concrete of lower strength than that specified at reduced rates. The concrete shall be deemed to comply with the strength requirements if:

- a) Every sample has a test strength not less than the characteristic value or
- b) The strength of one or more samples, though less than the characteristic value, in each case is not less than the greater of:
 - i) The characteristic strength minus 1.35 times the Standard Deviation and
 - ii) 0.80 times the characteristic strength; average strength of all the samples, is not less than the characteristic strength + $[1.65 - 1.65 / \text{square root of (No. of samples)}]$ times the standard deviation.

6.5 Load test

If any work is found unacceptable whereupon the Engineer requires its removal and reconstruction, the Contractor may request that it should be load tested in accordance with the provision of clause no. 16.50 of IS:456-1978 as given below:

- a) The test load shall be 125 percent of the maximum superimposed load for which the structure or element was designed. This load shall not be applied earlier than 28 days after the effective hardening of concrete. This test load shall be maintained for 24 hours and during the entire duration of the test, struts, strong enough to take the whole superimposed, dead and other loads shall be placed in position, leaving a small gap under the members.
- b) The maximum deflection shall be measured after the test load is in position for 24 hours. Thereafter, the test load shall be removed.
- c) If 24 hours after the removal of the load, the structure does not show a recovery of atleast 75 percent of the maximum deflection, registered as in (b) above, the test shall be repeated after a lapse of 72 hours. The structure shall be considered to have failed to pass the test if the recovery after the second test is not at least 80 percent of the maximum deflection during the second test.
- d) If the maximum deflection in mm, shown during 24 hours under load, is less than $40 l^2 / D$, where l is the effective span in metres and D is overall depth of the section in mm, it is not necessary for the recovery to be measured and the recovery position of the above mentioned clause 10.5 I will not apply.

Sub-section 3 – Reinforcement

1. Scope

1.1 This section of the specification deals with reinforcement for all reinforced concrete works and covers the requirement of materials, their properties, storage, handling, furnishing of bar bending schedules and the cleaning, bending, binding and placing of reinforcement with suitable cover blocks. This shall also include the supply of reinforcement, wherever required.

2. General requirements

2.1 The Contractor shall prepare and furnish to the Engineer, bar bending schedules for all RCC works for his review and approval. No work shall commence without the approval of bar bending schedule by the Engineer, in writing.

2.2 The Contractor shall have to obtain prior written approval from the Engineer, if he desires any adjustments in diameter or spacing of reinforcement. However, the Contractor shall modify the bar bending schedule, when a particular type and size of reinforcement would not be available, with the approval of the Engineer.

3. Materials

3.1 All steel for reinforced concrete works shall be in accordance with Technical Specification for Properties, Storage and Handling of common Building Materials, (vide module C2) which shall be deemed to form the part of this Specification.

3.2 All bars shall be thoroughly cleaned before being fabricated. Pitted and defective bars shall not be used.

4. Bending and placing

4.1 Bending

a) Reinforcing bars supplied bent or in coils, shall be straightened before these are cut to size. Straightening of bars shall be done in cold and without damaging the bars. This is to be considered as a part of reinforcement bending and fabrication work.

b) Unless otherwise specified, reinforcing steel shall be bent in accordance with procedure specified in IS:2502 and/or as approved by the Engineer. Bends and shapes shall comply strictly with the dimensions shown on the approved bar bending schedules and they shall be rechecked by the Contractor before bending and he shall be entirely responsible for their correctness. Bars correctly bent, shall only be used. Unless specified otherwise

or directed by the Engineer, the detailing of reinforcement shall be in accordance with IS:5525 and SP:34.

- c) No reinforcement shall be bent, when in position in the work without approval of the Engineer, whether or not it is partially embedded in concrete. Where the reinforcement bars are bent aside, at construction taken to ensure that, at no time, the radius of the bend is less than 4 times the bar diameters for plain mild steel or 6 times the bar diameters for deformed bars. Care shall also be taken while bending back bars, to ensure that the concrete around the bar is not damaged.
- d) Welding of bars to obtain continually shall not be allowed, particularly for cold twisted bars, unless specifically approved by the Engineer. If welding is approved, the work shall be carried out as per IS:2751 and IS:9417, according to the best practice and as directed by the Engineer.

4.2 **Placing in position**

- a) All reinforcement shall be accurately fixed and maintained in position as shown on the drawings by such approved means as steel chairs, and/or concrete spacer blocks as per IS:2502. Bars intended to be in contact at crossing points by two numbers annealed steel wire of 0.9 mm to 1.6 mm size conforming to IS:280 in such a manner that they do not slip over each at the time of fixing & concreting. The tying of bars shall be in crisscross manner.
- b) Binders shall tightly embrace the bars with which these are intended to be in contact and shall be securely held. The vertical distance between successive layers of bars shall be maintained by provision of spacer bars. These shall be so spaced that the main bars do not sag perceptively between adjacent spacers.

Bundled bars shall be provided wherever shown on the drawing to facilitate concreting. Location of laps and development lengths, shall be as indicated on the drawings.

- c) The placing of reinforcement shall be completed well in advance of concrete pouring. Just prior to concrete pouring, the reinforcement shall be checked by the Engineer, for accuracy of placement and cleanliness. Necessary corrections, as directed by the Engineer shall be carried out. Care shall be taken to ensure that projecting ends of ties and other embedded metal do not encroach into the concrete cover. Where concrete blocks are used for ensuring the cover and positioning of reinforcement, these shall be made of mortar 1:2 (1 cement: 2 sand) by volume and cured for at least seven days. The sizes and locations of the concrete blocks shall be approved by the Engineer. The 28 days crushing strength of cover blocks shall be atleast equal to the specified strength of concrete in which the blocks will be embedded.

- d) Laps and anchorage length of reinforcing bars shall be in accordance with IS:456, unless otherwise specified. If the bars in a lap are not of the same diameter, the smaller diameter will guide the lap length. Laps shall be staggered as far as practicable and as directed by the Engineer and not more than 50% of bars shall be lapped at a particular section. Mechanical connections, for splicing reinforcement bars in congested locations may be used by the Contractor, only if approved by the Engineer. Reinforcement bars shall not be lapped unless the length required exceeds the maximum available lengths of bars at site.

5. Cover to reinforcement

- a) Unless shown otherwise on the drawings, minimum clear concrete cover for reinforcement (exclusive of plaster or other finishes) shall be as follows: -
- At each end of a reinforcing bar, not less than 25 mm, nor less than twice the bar diameter.
 - For a longitudinal reinforcing bar in a column, 40 mm or bar diameter whichever is more. 25 mm cover may be adopted for columns of minimum dimension 200 mm or under and with longitudinal reinforcement diameter not exceeding 12 mm.
 - For longitudinal reinforcing bars in a beam, not less than 25 mm or less than the bar diameter.
 - For reinforcement in slabs and walls; not exposed to weather or ground not less than 15 mm nor less than the bar diameter.
 - For bottom reinforcement in footings: 75 mm, if concrete is laid against the ground or 40 mm if laid on a layer of lean concrete.
 - For retaining walls, grade beams, top and sides of footings and similar surfaces exposed to weather or ground; 50 mm for bars larger than 16 mm and 40 mm for bars upto 16 mm.
 - For concrete members exposed to the action of harmful chemicals, acids, alkalis, atmosphere, sulphurous smoke, sea water etc., the cover shall be as shown on the drawings.
 - For liquid retaining structures; 40 mm or diameter of main bars, whichever is larger. This shall be increased to 50 mm in case of sea water or corrosive environment.
- b) Clean distance between reinforcing bars shall be in accordance with IS:456 or as shown on drawings.

6. Sampling, testing and quality assurance

6.1 General

Sample bent bars shall be checked to ensure that they conform to the bar bending schedules. Reinforcement in position shall be checked for proper positioning, and rigidity, cover, spacing

of bars, placement of chairs and spacers, etc. Also, it shall be checked that all bars at crossings are properly tied.

6.2 Tolerance

Tolerance in construction, unless otherwise specified or as approved by the Engineer shall be as follows:

Description of item/Structural element	Permissible Deviation in mm (Max.)	
Placing of reinforcement		
For effective depth 200 mm or less	+10	-5
For effective depth more than 200 mm	+15	-10
Cover to reinforcement		-5
Cutting of reinforcement		
When minimum length specified	+75	-
When maximum length specified	-	-50
When maximum or minimum length not specified	+75	-25

Note: For any other references regarding permissible deviations shall be referred to the tolerance limit enclosed **Annexure F**.

6.3 Frequency of sampling and testing of reinforcement work shall be as given in **Table -2** of **Annexure B**.

Sub-section 4 - Formwork and staging

1. Scope

This section of the specification deals with the requirements for the supply, erection, dismantling of formwork and staging required for cast-in-situ concrete works including for making pockets/block outs.

2. General conditions

The Contractor shall supply, fabricate, erect and dismantle (after use) all staging that is required for all activities covered under the specifications. He shall prepare the scheme and submit along with the supporting calculations for approval of the Engineer.

3. Materials

Formwork shall compose of steel, best quality wood or non-absorbent type plywood. Timber shall be free from significant knots and shall be of medium grain as far as possible and hard woods shall be used as caps and wedges under or over posts. Timber shall be well seasoned, free from sap, shakes, worm holes, warps or other surface defects and shall have smooth finish.

Staging, unless specified otherwise, shall generally be of mild steel tubes, steel beams and channels etc. or strong sal ballies 150 mm in diameter or above. Bamboos, small diameter ballies etc., shall not be used unless approved by the Engineer in specific cases.

4. Classification of formwork

a) Ordinary

This shall be used in places where ordinary surface finish is required and shall compose of steel and/or approved good quality seasoned wood. Plywood shuttering can also be used by the Contractor.

b) Plywood

This shall be used in exposed surfaces as shown on drawings or as directed by the Engineer where a specially good finish is required. Such surfaces shall be formed using approved brand of heavy quality water resistant plywood to produce a perfectly leveled, uniform and smooth surface. Reuse of such forms may be permitted only after inspection and approval by the Engineer, for each such reuse.

c) Formwork for shell roofs

For this item, the detailed design of formwork shall be submitted by the Contractor to the Engineer, well in advance, for his approval. Units of shell forms may be used

repeatedly but prior approval shall be required for each repetition. Extra care shall be taken to keep correct levels and profiles.

5. Quality of formwork and staging

- 5.1 Formwork shall consist of all materials required for forming the boxing to pour concrete, including steel/wood/plywood forms, ties, anchors, hangers, inserts, etc. Formwork shall be so constructed that vertical and horizontal adjustments can be made as required. The design and engineering of formwork including staging as well as its erection and dismantling shall be the responsibility of the Contractor.
- 5.2 The staging shall be true and rigid and thoroughly braced in both directions as well as cross braced, strutted and propped such that it will not deform unduly under weight of concrete and other loads due to men, equipment, etc. Vertical member or props should not be supported on an unpropped lower suspended floor or beam unless it is ensured by the Contractor that the lower floor or beam can safely carry the loads. No propping shall take place until the Engineer's approval has been given to the Contractor's scheme submitted along with supporting calculations.
- 5.3 The forms and staging shall be sufficiently strong to carry without under deformation, the dead weight of the concrete as liquid as well as anticipated working loads. Where the concrete is vibrated, the formwork shall be strong enough to withstand the effects of vibration, without appreciable deflection, bulging, distortion or loosening of its components. The joints in the formwork shall be sufficiently tight to prevent any leakage of mortar. The formwork shall be such as to ensure a smooth uniform surface free from honeycombs, air bubbles, bulges, fins and other blemishes. Any blemish or defect found on the surface of the concrete, must be brought to the notice of the Engineer immediately and rectified as directed by him.
- 5.4 To achieve the desired rigidity, ample studs, braces, bolts, spacer blocks, wires, clamps, ties, straps, shores, etc. Shall be used to hold the form in proper position without undue distortion. These shall be approved by the Engineer but they must in no way impair the strength of concrete or leave stains or marks on the finished surface. Where there are chances of these fixtures being embedded, only mild steel or concrete of adequate strength shall be used. Bolts passing completely through liquid and or earth retaining walls/slabs, basement walls etc. For the purpose of securing and aligning the formwork, shall not be permitted.
- 5.5 For exposed interior and exterior concrete surfaces of beams and columns, plywood or other approved forms thoroughly cleaned and tied together with approved corrosion resistant devices shall be used. Rigid care shall be exercised ensuring that all column forms are plumb and true and thoroughly cross braced to keep them so.

- 5.6 Beveled strips 25x25 mm shall be provided to form angles and in corners of columns and beam boxes for chamfering of corners if shown on drawings or directed by the Engineer. Temporary openings for cleaning, inspection and for pouring concrete shall be provided at the base of vertical forms and at other places, where these are necessary and as may be directed by the Engineer. The temporary openings shall be so formed that they can be conveniently closed rigidly when required and must not leave any mark on the concrete.
- 5.7 If it is so desired by the Engineer, the Contractor shall prepare, before commencement of the actual work, designs and drawings for formwork and staging and get them approved by the Engineer. Formwork shall be so designed and positioned that it can be removed without damage to concrete.
- 5.8 The Contractor shall maintain necessary camber in centering for all floor slabs and beams in all spanning directions, so as to offset the deflection and assume correct shape. The camber shall have the crown of not less than 8 mm for every 5 metres span unless otherwise shown on the drawings. For cantilever, camber at free end shall be 1 in 100.
- 5.9 The Contractor shall provide the shuttering for complete stretch of work upto expansion joints for the structures like shell, folded plate etc. and/or as directed by the Engineer.

6. Cleaning and treatment of forms

- 6.1 All forms shall be thoroughly cleaned of old concrete, wood shavings, saw dust, dirt and dust sticking to them before these are fixed in position. All rubbish, loose concrete, chippings, shavings, saw dust etc. shall be scrupulously removed from the interior of the forms before concrete is poured. Wire brushes, brooms, compressed air jet and/or water jet etc. shall be kept handy for cleaning, if directed by the Engineer.
- 6.2 Before formwork is placed in position, the form surfaces that will be in contact with concrete shall be treated with approved non-staining oil or composition which is insoluble in water and not injurious to concrete. Care shall be taken that the oil or composition does not come in contact with reinforcing steel or stain the concrete surfaces. Burnt oil shall not be allowed to be used specially where the concrete surface will require finishing and/or plaster.

7. Removal of forms

- 7.1 The Contractor shall begin the removal of formwork only after the approval of the Engineer. He shall place on record the dates on which the concrete is placed in different parts of the work and the dates of the removal of formwork therefrom. This record shall be checked and countersigned by the Engineer. The Contractor shall be responsible for the safe removal of formwork but the Engineer may delay the time of removal if he considers it necessary. Any work showing signs of damage through premature removal of formwork, shall be entirely removed and reconstructed by the Contractor at no extra cost to the Owner.

7.2 The formwork shall be so designed and erected that the forms for slabs and the sides of beams, columns and walls may be removed first, leaving the beam bottoms and their supports in position. Re-propping of beams shall not be done except with the approval of the Engineer. Formwork for columns and walls at each stage of concreting shall be erected only upto the particular lift of construction. Wedges, spacer bolts, clamps or other suitable means shall be provided to allow accurate adjustment of the formwork and to allow it to be removed gradually without jerking the concrete.

7.3 Forms of various types of structural components shall, under normal circumstances, not be removed before the minimum periods specified in Cl. 10.3 of IS:456-1978, which shall also be subject to the approval of the Engineer. However, in any case formwork shall not be struck until the concrete has reached strength, atleast twice that of the stress to which the concrete may be subjected to at the time of removal of forms.

In normal circumstances and where ordinary Portland cement is used, forms may generally be removed after the expiry of the following periods, according to clause no. 10.3 of IS:456-1978.

i.	Walls, columns and vertical faces of all structural members as directed by the Engineer.	1 to 2 days
ii.	Slabs (Props left under)	3 days
iii.	Beam soffits (props left under)	7 days
iv.	Removal of props under slabs	
	Spanning up to 4.5 m	7 days
	Spanning up to 4.5 m	14 days
v.	Removal of props under beams	
	Spanning up to 6 m	14 days
	Spanning over 6 m	21 days
vi.	Cantilever slabs	14 days

7.4 The number of props left under, their sizes and disposition shall be such as to be able to safely carry the full dead load of the slab, beam or arch as the case may be together with any live load likely to occur during curing or further construction.

7.5 Where the shape of the element is such that the formwork has reentrant angles, the formwork shall be removed as soon as possible after the concrete has set, to avoid shrinkage cracking occurring due to the restraint imposed.

7.6 In case of cantilever slabs, the removal of forms shall begin from the outer edge and proceed towards the support, where as in the case of slabs supported on two/four sides, the removal of forms shall begin from centre to supports.

- 7.7 The formwork shall be so made as to produce a finished concrete, true to shape, lines, plumb and to dimensions as shown on the drawings. The Engineer may call for finished work at any time to set standards of workmanship. Once approved, these will become the accepted Sample.
- 7.8 In case PPC/PSC is used instead of OPC, the removal of shuttering/support shall be after 50% more time from that being applied for OPC, unless otherwise permitted by the Engineer. For concrete temperature above 40 °C, stripping time shall be increased.
- 7.9 In case of special structures, such as shells, folded plates, etc., the sequence of removal of forms shall be as per drawings or as directed by the Engineer.

8. Reuse of forms

Before reuse, all forms shall be thoroughly scraped, cleaned, all nails and adhering substances removed, holes and leaks satisfactorily plugged, joints examined and where necessary repaired and inside surfaces treated as specified herein before. Formwork shall not be used/re-used, if declared unfit or unserviceable by the Engineer.

9. Testing and quality assurance (including dimension tolerance)

9.1 General

Staging shall be checked for its soundness as a whole and for adequacy of the joints and its foundations. All joints shall be either vertical or horizontal and shall be such as to avoid loss of liquid through the formwork.

9.2 Dimensional tolerance for formwork

Levels and heights	± 6 mm
Plumb	3 mm for every metre subject to a maximum of 10mm.
Unevenness of any surfaces	± 3 mm
Length or breadth	± 12 mm
Diagonals	± 15 mm

In case of inclined surfaces like track hopper wall, folded plates etc., the deviation in the alignment of inclined surfaces, shall not exceed 3 mm with reference to the theoretical alignment, for a length of 1000 mm measured vertically, subject to a maximum of 10 mm.

In addition to above, requirement of clause no. 10.3 shall be complied with, which shall be the final acceptance criteria of concrete work.

- 9.3 Frequency of sampling and testing of work, shall be as given in **Table - 2 of Annexure B**

Sub-section 5 - Embedded parts

1. Scope

This section of specification deals with the supply, fabrication (where called for) and/or erection of embedded steel parts and PVC pipes

2. General requirements

2.1 Embedded steel parts shall be furnished by the Owner for transportation & erection by the Contractor or supplied, fabricated and erected by the Contractor as stipulated. If supplied by the Owner, these parts shall be furnished anywhere within the project area and the Contractor shall transport the same to the work site.

- a) Embedded steel parts supplied, fabricated and erected by the Contractor shall include items such as, but not limited to, foundation grillages, anchor bolts, pipe sleeves, equipment mounting plates, steel pieces properly welded with necessary lugs as shown on the drawings, auxiliary framing for equipment supports, pesty plugs for door and window frames, dowel bars for concrete work, miscellaneous frames, etc.
- b) Embedded steel parts supplied, fabricated/erected by the Contractor shall also include items such as, but not limited to plate inserts, edge protection angles, rolled sections with or without properly welded lugs.
- c) Cold work deformed steel bars shall not be used for lugs.

3. Materials

The materials shall be in accordance with the relevant clauses of Technical Specification for 'Properties, Storage and Handling of Common Building Materials (vide module C2), which shall be deemed to form a part of this specification. Mild steel pipes shall conform to IS:1161. Unless otherwise specified, medium class pipes shall be provided/ PVC pipes shall conform to IS:4985. Minimum pressure rating shall be 2 Kgf/cm².

4. Fabrication, erection etc.

4.1 The Contractor shall fabricate, transport to site and erect accurately in position all embedded steel parts either by welding, bolting or any other means as approved by the Engineer. Exposed surfaces of embedded parts other than holding down bolts, unless otherwise stated, are to be painted with two coats of approved anticorrosive paint (as per IS:2074) and/or bituminous paint as directed. The threads of holding down bolts shall be greased and protected with waterproof tape.

- 4.2 During erection, the Contractor shall provide necessary strong temporary bracings and supports to ensure proper installation of the embedded parts which shall be erected at the true locations as shown on the drawings and these shall be in plumb and level (unless otherwise shown on drawings). The Contractor shall furnish the Engineer with fabrication and assembly drawings prepared for embedded steel parts showing the erection procedure, for major items, wherever necessary.
- 4.3 Fabrication & erection shall be carried out as per IS:800. Welding rods & site /field welding shall conform to IS:816 and IS:9595. IS:7634 (part-III) shall be followed for PVC pipe works.

Sub-section 6 - Foundation bolt assembly

1. Scope

This section of the specification deals with the requirements of supply, fabrication and erection of foundation bolt assembly etc.

2. General requirements

Supply, fabrication, erection and installation of Foundation bolt assembly shall comprise of foundations bolts, stiffener plates, washers, nuts, lock nuts, pipe sleeves etc.

3. Materials

3.1 Foundation bolts shall generally conform to IS:5624. Mild steel bars used for the fabrication of bolt assembly shall conform to grade-I of IS:432, IS:226, IS:2062 or any other material including high carbon/high tensile steel as specified.

3.2 Hexagonal nuts and lock nuts shall conform to IS:1363 & IS:1364 upto M 36 dia and IS:3138 and M 42 to M 150 dia.

3.3 Flat plain washers shall be of mild steel and punched/machined type conforming to IS:5369.

3.4 Steel pipe sleeves shall conform, to Medium class of IS:1161.

4. Fabrication, erection, etc.

4.1 The fabrication and erection of bolt assemblies shall include threading, cutting, grinding, drilling, welding, etc., complete. All bolts, bolts assemblies, etc. shall be fabricated by the Contractor to the correct dimensions and shapes as shown on drawings, supplied by the Engineer. The bolts shall have coarse pitch screw thread in the diameter range, 8 to 64 and 6 mm pitch screw for diameter > 64 mm as per IS: 4218.

4.2 For fabrication of any particular size of bolt indicated on the drawing, the diameter of the threaded portion of the bolt shall be considered as the diameter of the bolt.

4.3 Every bolt shall be provided with steel washer, under the nut. The washer shall be flat and min. outside circle have a diameter 2.50 times that of the bolt and of suitable thickness. All nuts shall be of steel with well formed hexagonal heads unless specified otherwise, forged from solid metal and shall be dipped in hot boiled linseed oil as soon as these are made. The nuts shall fit good on the bolts.

- 4.4 During erection, the Contractor shall provide necessary template, temporary bracings, supports, etc. to ensure proper positioning of the assemblies and holding them firmly until they are cast/grouted and the grouted has set. All materials shall be erected in plump and in level (unless otherwise specified) and at true locations as shown on the drawings. Threads shall be protected by using PVC taps.
- 4.5 Fabrication & erection shall be carried out as per IS:800. Welding shall conform to IS:816 and 9595.

Sub-section 7 - Shotcreting

1. Scope

This section of the specification deals with the requirements of furnishing and placement of shotcreting.

2. General requirements

2.1 Generally, shotcreting shall be done in accordance with IS:9012.

2.2 Reinforcement for shotcreting shall be as detailed below, unless specified otherwise.

a) Reinforcement in one direction consisting of 6 mm M.S. bars at 750 mm c/c shall be connected to the lugs of fastening of the wire fabric. This shall be used in case of 50 mm or above thick shotcreting.

b) Wire fabric conforming to IS:1566 shall be used as reinforcement and shall consist of wire, 3 mm diameter, spaced 50 mm both ways and shall be electrically cross welded. Wire fabric shall be securely tied to 6 mm bars for 50 mm (min) thickness. Adjacent sheet of wire fabric shall be lapped at least 100 mm tied.

c) Clear cover to reinforcement mesh shall not be less than 15 mm.

2.3 This work shall be executed only by experienced operators, approved by the Engineer.

2.4 Minimum thickness shotcreting shall be 50 mm. for abrasion resistant and 25 mm for ordinary surface protection work.

3. Materials

3.1 Generally, the materials shall be in accordance with the relevant clauses of Technical Specification for properties. Storage and Handling of common Building Material, which shall be deemed to form a part of this Specification.

a) Fine aggregates shall consist of natural sand or crushed stone from a known source and shall be strong, hard, coarse, sharp chemically inert, clean and free from any coating. It shall be free from clay, coal or coal residue, organic or any other impurities that may impair the strength or durability of the concrete and shall conform to IS:383.

- b) Fine aggregate (sand) shall be well graded and particles shall range in size within the following limits. The Engineer, may approve the use of any other grading as per the requirements of IS:9012.

IS sieve designation	Percentage passing by weight
10 mm	100
4.75 mm	90 – 100
2.36 mm	60 – 95
1.18 mm	45 – 80
600 microns	35 – 60
300 microns	8 – 30
150 microns	0 – 10

- c) The fineness modules shall be preferably between 2.5 & 3.3. Any other value can be used, with prior approval of the Engineer.

3.2 Water shall be clean & free deleterious matter and shall have same properties, stipulated for use in concrete work.

3.3 Set accelerating and water proofing shotcreting admixtures of approved make shall be used wherever required.

4. Application

4.1 After the placement of reinforcement and/or welded mesh and not more than six hours prior to the application of shotcrete, the surface shall be thoroughly cleaned of all loose material and dirt. The Contractor shall properly prepare the surfaces, reinforcement and/or welded mesh to receive the shotcrete. Cleaned surfaces shall be wetted not more than one hour prior to shotcreting.

4.2 The mix as placed on surface shall one part cement to three parts approved sand by volume. Cement and sand shall be dry mixed; no water shall be added after mixing and before using in the gun. The quantity of water when added, shall be only that which is sufficient to hydrate the cement. For average atmospheric conditions, the water cement ratio for shotcrete in place shall be between 0.35 and 0.5. Suitable admixture shall be used wherever required.

4.3 A uniform pressure of not less than 2.5 Kg/cm² at the nozzle shall be maintained. Necessary adjustments shall be made to ensure this pressure, taking into account the length of hose and height of the place to be shotcreted.

4.4 The application shall proceed in an upward direction. Beams, stiffener and intermediate walls, if any, shall be wrapped with wire fabric and completely covered with shotcreting. All

rebound shall be removed from the area of application as the work progresses and such rebound material shall not be reused.

5. Curing

As soon as the freshly shotcreted surface shows the first dry patches, a fine spray of water shall be applied to keep it moist. After the surface has hardened, it shall be kept continuously moist for minimum seven days. If there is extreme heat, especially when accompanied by hot winds, the shotcreted surface, immediately upon completion, shall be covered with burlap of similar covering, which must be kept continuously moist for 14 days after shotcreting. The temperature of the lining shall not be permitted to exceed 38 Degrees Centigrade during placing and curing.

Sub-section 8 - Grouting

1. Scope

This section of the specification deals with the requirements of furnishing and placement of grout in block outs and foundation bolt holes and underpinning of base plates. In case special type of grouting is required for the machine base plate, the contractor shall submit the details of the same and get it approved from the Engineer.

2. General requirements

- 2.1 The space between the top surface of the foundation and the underside of the base plate shall be filled with appropriate grout.
- 2.2 Crushing strength of grout shall be one grade higher than the foundation concrete. Minimum crushing strength shall be 25N/sq.mm. Unless otherwise specified.
- 2.3 The contact area between the grout and base plate shall not be less than 80%.

3. Materials

- 3.1 Cement shall be Ordinary Portland Cement slag cement or Pozzolana Portland Cement conforming to IS:269, 455 and 1489 respectively.
- 3.2 Sand shall be clean and well graded conforming to IS 383. For flow able grout, sand conforming to zone-4 grade shall be used. Coarse aggregate wherever used shall also conform to IS:383.
- 3.3 Clean potable water as recommended for concrete mix shall be used.

3.4 Admixtures

- a) Non-shrink admixtures of approved make shall be used.
- b) Plasticizer conforming to IS:9103 shall be used to increase the workability, wherever required.

4. Mixing and placing

4.1 Type of mix

There shall generally be following three types grout mix:

- i) Ready mixed non-shrink cementations grout

- ii) Cement-Sand Grout: The proportion of cement to sand shall generally be 1:2, unless otherwise specified.
- iii) Cement Aggregate Grout: The approximate proportions of cement, sand and coarse aggregate shall be 1:1:25:2, with a maximum size of aggregate as 10 mm. This mix shall generally be used for grout thickness above 40 mm for dry pack application.

4.2 **Mixing**

Depending upon the case of placement and method of application, there shall be following three grout consistencies.

a) Fluid mix:

Water-cement ratio shall be 0.6 (max.) may be added to increase workability, wherever required. This grout mix shall be suitable for application with low pressure grouting equipment or self flowing and suitable for grouting of pockets/block outs, etc.

b) Plastic mix:

Water-Cement ratio shall be about 0.5. This grout mix shall be suitable for application with trowel or rod.

c) Stiff mix:

Water-cement ratio shall generally be 0.4. This grout mix shall be suitable for dry-pack application. The consistency should allow pressurizing into firm hard ball without cracking.

4.3 **Placing**

The block outs, bolts holes etc. which have to be grouted, shall be cleaned thoroughly by use of compressed air just prior to taking up the grouting operations.

- 4.4 Cement, sand, aggregate, and non-shrink admixture of approved quality and proven make shall be first blended thoroughly in the required proportion as per manufacturer's specifications. Grout shall then be prepared by mixing this admixture with water. Any grout which has been mixed for a period longer than half an hour shall not be used on the work.

- 4.5 Immediately after preparation, a group of suitable mix shall be poured into the block outs, pockets and bolt holes either from the sides or through the holes provided for this purpose in the base plate, by using special equipment for pressure grouting. It shall be ensured by Roding and by tapping of bolts that the block out is completely filled without leaving any voids. The pouring shall cease as soon as each hole is filled and any excess grout found on the surface of the concrete foundation shall be completely removed and the surface dried.

- 4.6 The space between the top surface of the foundation concrete and the underside of the base plate shall be filled with appropriate grout type. Grouting, once commenced, shall be done continuously. Grout shall be worked from one end to the other (to prevent air entrapment) and until the grout oozes out through the grout holes provided in the base plates.
- 4.7 In case of stiff mix, the space between the top surface of foundation concrete and the underside of the base plate shall be dry packed by firmly pressing or ramming into place against fixed supports.
- 4.8 When it is clear that the centre of base has been properly filled, the grout outside the base plate shall be briefly rammed to ensure compaction below the edges. Shims provided for the alignment of plant bases shall be positioned at the edges of the base to permit subsequent removal which shall take place not less than 7 days after the grouting has been executed. The resulting cavities shall be made good with the same grade of grout as has been used for grouting under the rest of the base plate.
- 4.9 **Curing**

The work shall be cured for a period of at least 7 days commencing 24 hours after the completion of the grouting. The curing shall be done by covering the surfaces with wet gunny bags and flooding.

Sub-section 9 - Encasement of steel structures / elements

1. Scope

This section of specification deals with the requirement for encasement of steel work in concrete with necessary formwork, placing, finishing and curing, complete as per drawings and specifications.

2. General requirements

- 2.1 All concrete work, reinforcement, formwork & staging work shall be done as per stipulations of section 2, 3 and 4 of this specification.
- 2.2 The reinforcement to be provided for encasement of steel elements shall be mild steel bars or in the form of wire netting. Such reinforcement shall be kept 20 mm away from the steel member and held securely to it.
- 2.3 The minimum grade of concrete to be used for encasing shall be M-20 unless specified. The aggregate to be used in concrete shall be 12.5 mm maximum size unless specified otherwise. In case of box type steel sections, encasement shall be done with cement, sand mortar (1:4) with thickness of 50mm over 0.9 mm size wire netting conforming to IS:3150, or as shown on the drawings.
- 2.4 In the case of encasement of beams with concrete, if the gap between the edge of the shuttering and flange is hardly sufficient for placing the concrete, the workability of the concrete shall be increased suitably by increasing the water-cement ratio.
- 2.5 Minimum cover for concrete encasement shall be 50 mm

3. Materials

The materials shall be in accordance with the relevant clauses of Technical Specification for Properties, Storage and handling of common Building Materials which shall be deemed to form the part of this specification.

4. Wire netting

Hexagonal wire netting shall be 0.9 mm dia and 19 mm aperture size, conforming to IS:3150.

Sub-section 10 - Joints in concrete

1. Scope

This section of the specification deals with the requirement of furnishing and installing of joints including joint filler materials, water bars, resilient pads type vibration damping material in an around the side of concrete works etc.

2. General requirements

Details of joints shall be as approved by Engineer or as per approved drawings. Where necessary or / and specified, joints shall be made water tight by use of water stops.

3. Classification of joints

From the point of view of utility, the joints as provided may be classified as below:

a) Construction joints

Construction joints are produced by placing fresh concrete against surface of hardened concrete. Construction joints are generally, but not necessarily, vertical or horizontal. Requirements of construction joints shall be as per clause specified elsewhere.

b) Contraction joints

These are provided to eliminate tensile stresses due to shrinkage and are commonly used where temperature variations are small and where there is no likelihood of expansion, such as spaces below water and earth levels and unexposed to atmosphere. At contraction joints, the reinforcement is discontinued and bond is not allowed to develop between the joint faces, thereby introducing a structural discontinuity. A contraction joint also serves as a construction joint so far as break in the pouring of concrete is concerned.

c) Expansion joints

These are provided either to completely eliminate or to significantly reduce comprehensive stresses in concrete that would otherwise result from thermal expansion and might crush, buckle or crack part of the structure. Expansion joints serve the purpose of contraction and also construction joints.

d) **Control joints**

At places where cracking is inevitable, places of weakness are introduced by the provision of control joints so that the cracking takes place along these joints instead of allowing it to develop in a haphazard manner.

e) **Separation joints**

The places where the expansion of the structure is not expected but they are required to be kept structurally separate so that stresses, vibrations, etc. are not transferred, a separation joint should be provided. Like expansion joint, a gap is provided in separation joint also, but this is not expected to be used by the expansion of members. In case, no gap is required, the separation joint can be obtained by using an approved alkathene sheet stuck on the surface against which concrete shall be placed.

f) **Settlement joints**

Structures, which are likely to settle with respect to the adjacent structures, shall be separated by a settlement joint so that the adverse effects of differential settlement are obviated. It is like an expansion joint but with a different sealing arrangement.

4. Materials

4.1 Joint filler

a) **Bitumen board:**

The bitumen impregnated fiber board; a preformed material shall be used as joint filler which shall fill space between the concrete surfaces at the joints. The minimum thickness of board shall be 12 mm and the material shall conform to IS:1838.

b) **Expanded polystyrene:**

The expanded polystyrene slab shall be of fire retarding grade (type-2) conforming to IS:4671. Density of material shall not be less than 25 kg/cum.

4.2 Water stops

a) Water stops shall be provided at the joints as a continuous diaphragm to contain the filler material and/or to exclude passage of water or any other material into or out of the structure.

b) The water stops shall be either metallic like Copper, or non-metallic like P.V.C. the material is to be procured from reputed manufacturers having proven records of

satisfactory supply of water Stops of similar make and shape of other jobs. Only PVC water stop shall be used, unless, otherwise, specifically approved by the Engineer.

c) Non-metallic Water Stop:

These will be normally in PVC and can be of shape having any combination of the following features:

- i) Plain
- ii) Central Bulb
- iii) Dumb-bell or flattened ends
- iv) Ribbed and Corrugated Wings
- v) V-shaped
- vi) Kicker type (Externally placed)

Water bars shall generally meet the stipulations of IS:12200. The minimum thickness of PVC Water Stops shall be 5 mm and the minimum width 225 mm, unless otherwise specified in the schedule of items. However, for some non-critical areas 150 mm wide and 5 mm thick water stop can be used. The actual size and the shape will be as shown on drawings and/or as directed by the Engineer. The material should be of good quality Polyvinyl Chloride, highly resistant to tearing, abrasion and corrosion as well as to chemicals likely to come in contact with during use. The performance requirements shall generally be as follows:

Sp. Gr	:	1.3 to 1.4
Shore hardness	:	60A to 80A
Tensile strength	:	116kgf / cm ² min.
Max. Safe continuous temp.	:	70 - degree C.
Ultimate elongation	:	Not less than 300%
Tear resistance	:	45kgf / cm ² min.
Stiffness in flexure	:	25kgf / cm ² min.
Accelerated extraction		
i) Tensile strength	:	110kgf / cm ²
ii) Ultimate elongation	:	250%
iii) Water absorption in 7 days	:	5% (max.)
Effect of Alkali		
	:	7 days
a) Weight increase	:	0.25% max.
b) Weight decrease	:	0.10% max.
c) Hardness change	:	+ 5 %
Effect of Alkali		
	:	28 days
a) Weight increase	:	0.40% max.
b) Weight decrease	:	0.30% max.
c) Dimension change	:	+1%

4.3 Sealing compound

a) Bitumen sealing compound:

The bitumen sealing compound shall be from approved manufacturer and shall conform to the requirements of IS:1834. For joints in concrete lining on canals/reservoirs, sealing compound conforming to IS:5256 shall be used.

b) Polysulphide sealing compound:

This shall be two-part polysulphide sealant and shall be from approved manufacturer, conforming to IS:12118. Materials shall consist of polysulphide polymer and a curing agent. Gun grade material shall be used unless otherwise specified. The application of the sealant shall be strictly followed as per manufacturer's guidelines.

4.4 Metal cover strips

Metal cover strips shall be made from aluminium or mild steel sections as shown on drawings. The min. thickness of aluminium strips shall be 3 mm and that of mild steel 6 mm. Aluminium alloy strip shall be corrosion resistant grade 31000 as per IS:737. Mild Steel shall conform to IS:226 or IS:2062.

4.5 Resilient pads

i) The vibration damping material shall be resilient rubber pads made up of natural or synthetic rubber and shall have the following physical properties

- a) Shore 'A' durometer hardness : 50 (+) / (-) 5
- b) Min. elongation : 450%
- c) Ultimate min. tensile strength : 145 kg/sq.cm
- d) Rubber pads shall not absorb more than 10% of weight of water in a 7 days test.

ii) The minimum thickness of the resilient pads shall be 12 mm.

5. Installation

5.1 Bitumen board / Expand polystyrene

The bitumen impregnated fiber board may be secured to vertical concrete by nails in the first placed concrete. The joint filler shall be coated on both faces with coal-tar pitch conforming to IS:216 or bitumen grade conforming to IS:73 or IS:702.

i) Water stops shall not have any longitudinal joints and shall be procured and installed in largest practicable lengths having a minimum number of transverse joints. The

jointing procedure shall be as per the manufacturer's recommendations and shall be reviewed and approved by the Engineer. Suitable field splicing kit including heater shall be used for this purpose. The edges shall be neatly crimped and bent to ensure proper bond with the concrete.

- ii) As Non-metallic Water Stops can be easily handled in very large lengths unlike metal strips, transverse joints will be allowed only under unavoidable circumstances and with the specific approval of the Engineer. The method of forming these joints, laps etc. shall be as specified by the Manufacturer and/or approved by the Engineer, taking particular care to match the centre and the edges accurately.
- iii) Particular care shall be taken for the correct positioning of the water stops to prevent any faulty installation which may result in joint leakage.

Adequate provisions shall be made to support the water stops during the progress of work and to ensure their proper embedment in the concrete. The symmetrical halves of the water stops shall be equally divided between the concrete pours adjacent to the joints.

Max. Density and imperviousness of the concrete shall be ensured by thoroughly working in the vicinity of joints. However, particular care should be exercised in use of vibrators in the proximity of joints to avoid dislodging of the water stops.

iv) **Splices**

Splices in the continuity of intersections of runs of water stops shall be jointed as per manufacturer's stipulations depending on the type of water stops used. In case of a cross section, overlapping must not be done but, instead factory made cross joint should be used. It is essential that the material is not damaged during the splicing operation and that the continuity of the entire water stops across the section be maintained.

v) **Inspection**

All water stops installations shall be subject to inspection and approval by the Engineer, before concreting operations, encasing water stops, are performed.

5.2 **Sealing compound**

When directed, the gap in joints shall be thoroughly cleaned and sealing compound laid as per manufacturer's specification and approved drawings. Primer shall be applied wherever required. For reservoir/canal lining, procedure as stipulated under clause 9.0 of IS:5256-1969 shall be followed.

5.3 Metal cover strips

The metal cover strips shall be pinned (using stainless steel) at one end and slotted at the other end. Exposed surface of mild steel shall be painted with two coats of approved anti-corrosive paint (as per IS:2074) and/or bituminous paint. Welding of aluminium shall be in accordance with IS:2812.

6. Resilient pads:

The resilient pads shall be installed around the foundation or at other locations as shown on the drawings. The pads shall be installed in position by sticking the same to the foundations by using approved glue.

Sub-section 11 Waterproofing / damp proofing of underground concrete structures

1. Scope

This section of specification deals with the retirements of all works for completing waterproofing/damp proofing of underground concrete structure. This shall include water retaining and basement type structures.

2. General requirements

2.1 As a general guidance, the provisions of IS: 6494 shall be followed unless otherwise mentioned.

The Contractor shall do the proper concreting so that concrete is water tight in itself without any waterproofing treatment. The waterproofing treatment shall be provided in exceptional cases, as additional precaution, as shown on the drawings or directed by the Engineer.

2.2 The work of waterproofing / damp proofing of underground concrete structures by course of bitumen felt, blown bitumen or any other operations shall be entrusted by the Contractor to one of the well known expert agencies approved by the Engineer.

2.3 Actual type of waterproofing treatment to be provided for particular structure, shall be as shown on the drawings or directed by the Engineer.

3. Bitumen felt treatment

3.1 Materials

- a) The materials shall be in accordance with the relevant clauses of Technical specification for properties, Storage and Handling of Common building materials
- b) The bitumen felt shall conform to IS: 1322 and the workmanship to IS: 1609 and IS: 3067. The bitumen felt shall be hessian based. Bitumen primer shall conform to IS: 3384. The bonding materials shall consist of blown type bitumen conforming to IS: 702 or residual bitumen conforming to IS: 73 or a mixture of the two, to withstand local conditions of prevailing temperature gradient of surface. The contractor shall satisfy the Engineer that the bonding materials proposed to be used are suitable for the particular job.

3.2 Installation

- a) Waterproofing / Damp proofing for horizontal surfaces, unless specified otherwise with two layers of felt on which subsequently concrete shall be placed, shall be provided with the following treatments:
- i) A minimum of 12mm thick plaster 1:4 (1 cement: 4 sand) with waterproofing admixture / additives over PCC
 - ii) One coat of bitumen primer @ 0.4 kg/Sqm min.
 - iii) One layer of hot applied bitumen @ 1.5kg/sq.m. min.
 - iv) One layer of self finished felt (type – 3, grade II as per IS: 1322).
 - v) One layer of hot applied bitumen @ 1.5 kg/Sqm min.
 - vi) One layer of self finished felt (type – 3, grade – II as per IS: 1322).
 - vii) One layer of hot applied bitumen @ 1.5 kg/Sqm min.
 - viii) A minimum of 12mm thick plaster 1:4 (1 cement: 4 sand).
- b) Water proofing / Damp proofing for other surfaces (including vertical) unless specified otherwise, with two layers of felt shall be provided with following treatments:
- i) One coat of bitumen primer @ 0.4 kg/Sqm min.
 - ii) One layer of hot applied bitumen @ 1.5 kg/Sqm min.
 - iii) One layer of self finished felt (type – 3, grade – II as per IS: 1322).
 - iv) One layer of hot applied bitumen @ 1.5 kg/Sqm min.
 - v) One layer of self finished felt (type – 3, grade II as per IS: 1322).
 - vi) One layer of hot applied bitumen @ 1.5 kg/Sqm min.
 - vii) A minimum 25mm thick plaster 1:4 (1cement: 4 stand).
 - viii) Half brick masonry work in cement mortar 1:4 (1 cement: 4 sand) using bricks of class designation 75, unless otherwise specified.

4. Miscellaneous treatment

4.1 Plastering treatment

After the side walls are constructed and allowed to undergo the specified curing, the surface of the walls and the flooring should be made rough with a hacking tool, washed clean with water and wire brushed so as to remove all the loose material, and a waterproof cement plaster 1:3 mix, with suitable proportion of an integral waterproofing compound shall be applied in two coats, the first coat being 12mm thick and the next 10mm thick. The second coat shall be applied after allowing a time interval of at least 24 hrs for the first coat to harden. Hexagonal galvanized netting of 0.90mm dia, 19 mm aperture size shall be used in the plastering. The netting shall be fixed with the help of MS Screws, fixed with the help of fibrous plugs provided before application of first layer of plaster.

4.2 Hot applied bitumen treatment

The external concrete of plastered surface shall be carefully cleaned, cured and allowed to dry for some time before the application of a coat of hot bitumen of the industrial grade 85/25 conforming to IS: 702 against ground water seepage. Rate of application of bitumen shall not be less than 1.7 kg/Sqm and it should be heated to about 120 C before application. Anti-stripping compound shall be added. Anti-stripping and adhesion improving agent shall be 100% mixable in bitumen. The stripping and adhesion improving agent shall be 100% mixable in bitumen. The stripping value tested as per IS: 6241 should be nil when recommended quantity of anti-stripping compound is mixed. Nominal mix proportion of the compound shall be 1 percent by weight of bitumen. However, actual mix proportion shall be as per manufacturer's recommendation.

4.3 Polymer modified cementitious coating treatment

a) Materials

- i) Modified liquid polymer blend shall be a dispersion containing 100% acrylic based polymer solids.
- ii) Portland cement based dry powder
- iii) Clean, fine specially prepared quartz sand approximately 0.6 mm size.

b) Mixing

The liquid polymer shall be stirred well and cement base powder shall then be added slowly to make a slurry mix. For preparation of brush topping mix, quartz sand shall be added slowly and mixed well till a homogenous mixture is obtained. The mix shall be used within half an hour of the preparation. Addition of quartz sand may not be necessary, in case dry power contains the same.

c) Properties of the coating

- i) It must adhere to the wet surface
- ii) It should develop adequate bond strength with the concrete surface, not less than 2 N / Sqm
- iii) Co-efficient of permeability shall be about 5 x 10 Cms
- iv) Water absorption after continuous soaking shall not be more than 1%.
- v) The materials shall be permeable under water vapor.
- vi) The material shall be resistant to acids and alkalis' present in the soil and underground water with normal pH value between 4 and 14.
- vii) The co-efficient of thermal expansion of the material shall be close to that of concrete.

d) Application

The concrete surface shall be cleaned and made free from grease, oils or loosely adhered particles. The surface shall be damp without any free water.

- i) For slurry mix: a minimum of 2 coats shall be applied on the surface. The first coat being applied when the surface is still damp and left to harden for 4 to 6 hours. After 4 to 6 hours of the application of second coat, it shall be finished by rubbing down with a soft dry sponge. The coverage shall not be less than 1.1kg/sq.m in the 2 coats. A lap of 75mm shall be provided at the joints.

The coating shall be air dried for 4 to 6 hours and, thereafter, cured for 7 days after the application of last coat.

- ii) For brush topping mix: This shall be applied in two coats. A primary coat of slurry mix can also be first applied on the surface as first coat. After the coating has dried up, a coat of brush topping mix shall be applied over it with a push broom or any other similar brush. It shall be left in broom finished condition. The nominal thickness shall be 1.5mm and minimum thickness shall be 1.0mm. A lap of 75mm shall be provided at the joints. It shall be ensured that no pinhole exists and re-brushing shall be done to cover the pinholes if any.

The coating shall be air dried for 4 to 6 hours and thereafter cured for 7 days after application of last coat.

5. Chemical injection treatment

Wherever shown on the drawing or directed by the Engineer, min 12mm dia (N.B.) threaded nozzle of suitable length, shall be provided over the surface and along the construction joint line in a grid pattern at a spacing not exceeding 1.5m c/c before concreting operation. Adequate precaution shall be taken to keep the nozzles plugged at both ends to prevent them from getting closed by concrete.

For fixing of any nozzle in set concrete suitable size hole shall be drilled, preferably by using percussive hammer drill electrically operated, in grid pattern and grouting nozzle shall be fixed in these holes.

After the nozzles are fully set, neat cement slurry admixed with water soluble non-shrink polymer/monomer based chemical shall be injected through the network of nozzles with low pressure grout pumps at a pressure of about 2.0 kg/sq.cm. Water cement ratio of the slurry shall not be more than 1:2. The resultant solution shall not have viscosity greater than 1:2 centipoises. Plasticizing agent shall be added wherever required. The grouting shall be started at very low pressure and increased gradually to a required pressure. The grouting shall continue till the hole refuses to take any further grout, even at an increased pressure. Applied pressure shall not be more than the designed strength of the concrete. After completion of grouting operation, the nozzles shall be sealed properly to the satisfaction of the Engineer.

Sub-section 12 - Dismantling / demolishing work - RCC and PCC

1. Scope

This section of specification deals with the requirements of dismantling / demolishing RCC and / or PCC work

2. General requirements

- 2.1 The dismantling implies, carefully taking up or down and removing without damage, this shall consist of dismantling one or more parts of a structure. This includes chipping work, making holes/ opening etc in concrete members according to the required shape, size and profile at all elevations.
- 2.2 The term demolition implies, taking up or down or breaking up of a structure / member in part or full as specified or shown on drawings or as directed by the Engineer
- 2.3 In a structure / member, both dismantling and demolishing work may be involved. In such case, the portion of work treated as demolishing shall be as shown on the drawing or as decided by the Engineer
- 2.4 All materials obtained from the demolition/dismantling work shall be the property of the owner, unless otherwise specified.
- 2.5 All serviceable materials obtained, shall be separated out and stacked properly upto a lead of 500 metres or shall be returned to NTPC stores and all unserviceable materials, rubbish etc shall be disposed off as directed by the Engineer upto a lead of 2 Kms.
- 2.6 The dismantling / demolishing operations shall be carried out in proper sequence so that the serviceable material can be salvaged, without being damaged during the process of work.
- 2.7 Necessary propping, shoring and under pinning shall be provided for the safety of the adjoining work or property which is to be left intact, before dismantling / demolishing work

3. Safety

- 3.1 All demolition work shall be carried out in conformity with the local safety regulations, extreme caution being exercised to avoid damage to the work and the equipment, which are to be left intact. Necessary precautions shall be taken to keep the dust nuisance down. Safety requirements in IS: 4130 shall also be followed.
- 3.2 As and where necessary, the dismantled / demolished materials shall be lowered to the ground and not thrown and then properly stacked as directed by the Engineer. Wherever required, temporary enclosures shall be erected to minimize the dust or moisture infiltration.

Sub-section 13 - Cement additives / admixtures in concrete

1. Scope

This section of specification deals with the requirements of furnishing, placing and mixing cement additives / admixtures, in all kinds of cement concrete, (plain or reinforced) for all kinds of structures at all levels.

2. General requirements

- 2.1 The Contractor shall furnish all labour and equipment to place and mix waterproofing cement additive and cement plasticizer in concrete of any grade and cement mortar. Thereafter he shall carry out the work as specified earlier in relevant clauses of this specification for concrete and hence complete the work as indicated on the drawing and as per the specification listed hereunder.
- 2.2 Waterproofing additive and other types of admixtures shall be as far as possible, free from aggressive chemical like chloride, sulphide etc., which can cause corrosion of steel reinforcement in RCC.
- 2.3 The Contractor shall have the services of the manufacturer's supervisor, at no extra cost to the owner, to supervise the work, if directed by the Engineer.
- 2.4 Admixtures in concrete for promoting workability, improving strength, entraining air or for similar purposes may be used only after the written permission from the Engineer, is obtained. Addition to admixtures shall not reduce the specified strength or durability of concrete in any case. The admixtures shall conform to IS: 9103 and shall be of proven make and from a reputed manufacturer. Calcium chloride shall not be permitted to be used other than in mass (plain) concrete works.

3. Materials

- 3.1 Waterproof cement additive shall conform to IS: 2645 and shall be of proven make and from a reputed manufacturer.
- 3.2 Admixtures in concrete shall conform to IS: 9103 and shall be of proven make and from a reputed manufacturer. In addition, for plasticizer cum waterproofing compound materials shall meet the permeability requirements as per IS: 2645. Similarly, for plasticizer cum retarder admixture material shall satisfy the setting time requirements of retarder and other properties of plasticizer as per IS: 9103.

4. Mixing

- 4.1 Admixtures / waterproofing additive shall be used at the rate specified by the manufacturer or as indicated on the drawings and shall be mixed with water, as required by the Engineer.
- 4.2 Samples of concrete in which admixture and / or waterproofing cement additive is added shall be tested for water proofness, workability, compressive strength, water absorption, density, setting time, etc., the results shall conform to relevant IS specifications.

Sub-section 14 - Slab on grade

1. Scope

This section of specification deals with carrying out the work of “slab on grade”. In all medium duty industrial floors

2. General requirements

- 2.1 The contractor shall furnish all material/ labour and equipment. The specifications covered under section C-3, sub section 1 to 13 for cast in situ concrete and allied works shall generally be applicable unless otherwise specified here under.
- 2.2 The work includes right from preparation of sub grade to completing and curing slab on grade in all respects to the satisfaction of the Engineer.

3. Materials

- (a) Materials for filling shall be crushed stone dust, sand or other inorganic materials and they shall be clean and free from shingle, salts, organic matters, roots and excessive amount of sod, concrete or any other foreign substances which could harm or impair the strength of the substructure in any manner.
- (b) Stones for Granular sub base shall be broken stones to gauge not exceeding 63 mm and shall be free from dust, organic matters etc.
- (c) Maximum size of 40 mm stone aggregate shall be used for concrete.
- (d) Cement shall be ordinary Portland cement conforming to IS:269, Grade 43
- (e) Admixtures in concrete for improving workability, strength etc may be used only after the written permission from the Engineer.
- (f) Water shall be clean, free from injurious matters. Potable water is generally considered satisfactory.
- (g) Reinforcing steel bars shall conform to grade 1 of IS:432 (part 1)
- (h) Polysulphide sealant shall conform to IS 12118 Gun Grade.
- (i) Concrete curing compound shall be CONCURE WB of M/s. Fosroc Chemicals (India) Ltd., or equivalent.

4. Laying of slab on grade

- i) Uneven (but fairly level) sub grade shall be dressed, leveled by necessary Excavation / Scraping / Filling, watered, rolled by 10T roller and consolidated to desired level.
- ii) On consolidated sub grade, two layers of granular sub base each of 75 mm thickness shall be laid Total consolidated thickness of sub base shall be 150 mm. Refer specification No.C-1.6.0 – Granular Sub Base (Hard core)
- iii) On consolidated sub base water proof paper shall be placed with minimum 150mm overlaps on all sides.
- iv) Concrete grade M20, 150 mm thick shall be poured in strips as per drawing and as directed by the Engineer.

The strips shall be prepared by placing formwork in straight line and level. Each strip may be of size 4-metre-wide x 20 meter long alternate strips shall be cast by leaving 24 hours interval in between.

Form work shall be strong enough to hold the screed vibrator.

The concrete shall be vibrated by screed vibrator / surface vibrator and when it becomes touch dry it shall be machine trowel led to smooth uniform level surface. Ramp surfaces shall then be “**Broom Finished**”.

Under no circumstances dry cement or cement slurry shall be separately spread on concrete at any time.

Special care shall be taken to pour and vibrate the concrete along the form work to avoid any segregation of aggregate and honey combing.

- v) 24 hours after concreting, the form work shall be removed and immediately the grooves of size 10mm x 50mm as shown on the drawing shall be cut in concrete at an interval of about 4.0 metres or as shown on the drawing.

The grooves shall be cleaned and concrete surface shall then be sprayed by water based concrete curing compound as specified. The grooves shall be filled up by poly sulphide sealant after fourteen days.

- vi) Dowels shall be provided along transverse and longitudinal construction joints as shown on the drawing.

- vii) Any expansion / contraction joints in slab on grade shall be provided at locations and as per the details indicated on the drawing.

5. Acceptance criteria

All finished surface shall be smooth, uniform and at desired line and level within a tolerance of ± 3.0 mm. It shall be free from cracks and warping.

Technical Specification for Bridges

The following clauses in MoRTH shall also be read as part of technical specification for bridges.

Section 1500 **Formwork**

Clause 1501 **Description**

The Clause shall read as below.

The Contractor shall prepare a formwork mobilization and utilization plan and submit the plan for Engineer's approval at least 28 days before the commencement of construction of structures. The requirement of formwork shall be worked out considering the overall construction program of all the structures to be cast in one or more stages, as specified in the drawings. The plan shall take into account the time required for erection of formwork, retention in position, stripping, and removal and subsequent use in the next and subsequent structures.

Notwithstanding Engineer's approval of mobilization plan, if due to any reason, Contractor has to arrange additional formwork, to meet the requirements of the construction program, it shall be done by the Contractor without any extra cost to the Employer.

Clause 1502 **Materials**

This Clause shall read as under:

"All materials shall comply with the requirements of IRC-87.

Material and components used for formwork shall be examined for damage or excessive deterioration before use/reuse and shall be used only if found suitable after necessary repairs.

Only steel formwork shall be used. The steel used for forms shall be of such thickness that the forms remain true to shape. All bolts should be countersunk. The use of approved internal steel ties or plastic spacers shall be permitted. Structural steel tubes used as support for forms shall have a minimum wall thickness of 4 mm."

Clause 1504 Workmanship

Sub-Clause 1504.1 Add the following at the end of Clause 1504.1

The loading from the formwork shall be distributed to the soil or the permanent works below (e.g. pile cap) in such a manner that any total or differential settlement are within acceptable limits. Subsoil characteristics shall be taken into account while designing the staging to avoid untoward failures. All the pipes etc. Used for staging shall be free from kinks, bends etc.

Clause 1506 Precautions

Add the following as items of this clause:

- Adequate support against sideway and lateral loads due to construction operations and wind shall be provided.
- In case cantilevers are supported directly from the ground, the supports for cantilevers shall be removed simultaneously with main supports only after approval for the same from the Engineer.
- Forms shall be rigid and of adequate section to reduce deflections. Forms shall have sufficient rigidity to resist horizontal pressures caused by flowing concrete resulting from use of super plasticizers. The formwork shall resist the lateral pressure caused due to fast rate of placement by concrete pumps.

Clause 1509 Re-use of formwork

This Clause shall read as under:

"After forms are stripped, all materials shall be examined for any damage and damaged pieces, if any, shall be removed either as rejected or for rectification if possible. The materials found fit to be reused shall be thoroughly cleaned. Holes bored through sheathing for form ties shall be plugged by driving in common corks or foamed plastics. Patching plaster may also be used to fill small holes. After cleaning and before re-fixing, each formwork shall be got approved from the Engineer.

Formwork and staging shall be so used as to ensure quality of the exposed surface. However, if in the opinion of the Engineer, any particular panel/member has become unsatisfactory for use at any stage, the same will be rejected and removed from site.

All bent steel props shall be straightened before reuse. The maximum deviation from straightness shall not exceed 1/600 of length. However the maximum number of users shall be limited to 20 times since only steel formwork is to be used. The maximum permissible axial loads in used props shall be suitably reduced depending upon their condition.”

Clause 1510 Specialized Formwork

Replace the words ‘slip-form work’ by ‘climbing formwork’ in the first sentence of this clause.

The first sentence of Para 2 of this clause shall read as follows: Slip forming is not permitted.

Replace the word “plywood” by “marine plywood” in the fourth paragraph of this clause.

Section 1600 Steel Reinforcement (Un-tensioned)

Clause 1602 General

Paragraph 2 of Clause 1602 shall read as follows:

“Reinforcements shall be thermos Mechanically Treated (TMT) deformed bars of grade Fe 550/550D conforming to IS: 1786. Only uncoated steel shall be used as reinforcement”.

Clause 1604 Bending of reinforcement

Para 1 of Clause 1604 shall be read as follows:

The reinforcement shown on the drawings shall be considered merely symbolic representations of the shape and position and shall not be used by the Contractors to justify any deviation from the stipulated requirements. Bar bending schedules and any supplementary drawings as may be required shall be furnished by the Contractor and got approved by the Engineer before start of work. The bending schedules shall state the number, shape and length of bar and weight in respect of each type. System of bar referencing should be coherent and systematic. A separate bar bending schedule shall be prepared for auxiliary bars like spacers, chairs etc.

Clause 1605 Placing of reinforcement

Paragraph (c) (i) of Clause 1605 shall be read as follows:

Cover blocks shall be made of concrete or cement mortar with the same durability properties as the surrounding concrete and with the same type of constituents. In visible surfaces, the cover blocks shall be of the same colour and texture as the surrounding concrete. The Contractor's proposal for cover blocks shall be submitted to the Engineer for acceptance.

Add the following as sub Para (f) to this Clause:

Tolerances:

1. Tolerance of cover: Deviation shall not exceed + 10 mm No negative tolerance is allowed.
2. Tolerance in position: Tolerance for deviation from the positions shown in the drawings shall not exceed the following:

Structural depth d (mm)	Tolerance (mm)
$d < 1000$	<10
$1000 < d < 2000$	< 0.01d
$2000 < d$	< 20

Clause 1606 Bar Splices

Sub-Clause 1606.1 First sentence of Clause 1606.1 shall read as follows:

To the extent possible, all reinforcement shall be furnished in full lengths as indicated in drawings.

Add the following as paragraph 2 of Clause 1606.1:

The location of joints in continuous reinforcing bars, not shown in drawings, shall be submitted to the Engineer for acceptance. If nothing contrary has been specified, the number of bars to be joined in any cross-section shall not exceed one-third of the total.

Sub-Clause 1606.2 Welding

Sub-Clause 1606.2.1 Add the following at the end of the paragraph.

In prestressed concrete members, when welding of un-tensioned reinforcement is permitted by the Engineer, it shall be carried out before insertion of the pre-stressing tendons/sheathing.

Clause 1607 Testing and acceptance

Add the following as the last paragraph of Clause 1607:

Manufacturer's test certificate regarding compliance with Indian Standards for each lot of steel shall be obtained and submitted to the Engineer. If required by the Engineer, the Contractor shall carry out confirmatory tests in the presence of a person approved by the Engineer. Cost of these tests shall be borne by the Contractor. The sampling and testing procedure shall be as laid down in IS: 1786. However, if any test piece selected from a lot fails, no re – testing shall be done and the lot rejected.

Section 1700 Structural concrete

Clause 1703 Grades of concrete

Add the following at the end of this Clause:

The concrete mixes leaner than M15 shall be called as nominal mix concrete.

“Nominal mix concrete is for which, concrete is not to be designed by tests and in which the proportions of materials are in accordance with the drawing and the specification clause mentioned below:

- i) All the materials for this concrete shall conform to section 1000 of MORT & H.
- ii) Minimum cement content and maximum water cement ratio for above said nominal mix concrete shall conform to clause 1703.2 Table 1700-3(A) of MORT & H.
- iii) Mixing of above said nominal mix concrete shall conform to Clause 1708 of MORT & H.
- iv) Transporting, Placing and Compaction of above said nominal mix concrete should conform to clause 1709 of MORT & H”.

Clause 1704 Proportioning of concrete

Add the following at the end of this Clause:

“In proportioning concrete, the quantity of both cement and aggregate shall be determined by weight. Where the weight of cement is determined by accepting the manufacturer’s weight per bag, a reasonable number of bags shall be weighed separately to check the net weight. Where cement is weighed from bulk stock at site and not by bag, it shall be weighed separately from the aggregates. Water shall either be measured by volume in calibrated tanks or weighed. All measuring equipment shall be maintained in a clean and serviceable condition. Their accuracy shall be periodically checked.

It is most important to keep the specified water-cement ratio constant and at its correct value. To this end, moisture content in both fine and coarse aggregates shall be determined as frequently as possible; frequency for a given job being determined by the Engineer according to the weather conditions. The amount of mixing water shall then be adjusted to compensate for variations in the moisture content. The determination of moisture content in the aggregates shall be done as per IS: 2386 (Part III). Suitable adjustments shall also be made in the weight of aggregates to allow for the variation in weight of aggregates due to variation in their moisture content.”

Sub-Clause 1704.4 Additional Requirements

In Para (a) substitute "0.06%" for "0.1%"; "0.06%" for "0.2%"; and "0.1%" for "0.3% for the three items respectively.

Sub-Clause 1704.6 Add the following as clause 1704.6:

Materials for pumped concrete:

Materials for pumped concrete shall be batched consistently and uniformly. Maximum size of aggregate shall not exceed one-third of the internal diameter of the pipe.

Grading of aggregate shall be continuous and shall have sufficient ultra fine materials (materials finer than 0.25 mm). Proportion of fine aggregates passing through 0.25mm shall be between 15 and 30% and that passing through 0.125 mm sieve shall not be less than 5% of the total volume of aggregate. Admixtures to increase workability can be added. When pumping long distances and in hot weather set-retarding admixtures can be used. Fluid mixes can be pumped satisfactorily after adding palsticisers and super plasticisers. Suitability of such concrete shall be verified by trial mixes and by performing pumping test.

Clause 1705 Admixtures

This Clause shall read as under:

"Duly tested admixtures/additives conforming to IS: 6925 and IS: 9103 (without replacement of cement) may be used subject to satisfactory proven use, with the approval of the Engineer. Admixtures generating Hydrogen or Nitrogen and containing chlorides, nitrates, sulphides, sulphates and any other material liable to affect the steel or concrete shall not be permitted.

The general requirements, physical and chemical requirements shall be as per Clause 1012."

Clause 1706 Size of coarse aggregate

Table 1700-7 shall be modified as given below:

Components	Maximum nominal size of Coarse aggregate (mm)
a. RCC Well Curb.	20
b. RCC / PCC well staining, PCC below foundations and approach slab, annular filling around foundations.	40
c. Well cap or pile cap; solid wall type abutments, piers, median walls, splayed wing walls and their foundations.	40
d. RCC works in T-beam and slab / solid slab / voided slab and box girder superstructure, wearing coat, kerb, crash barrier, approach slab, dirt walls, coping on masonry wing walls, hollow abutments and piers pier / abutment caps, pedestals, dirt walls, piles, all components of counterfort type abutments, columns, cantilever return walls etc.	20
e. All PSC works	20
f. Any other item	As specified by the Engineer

Clause 1707 Equipment

Para 1 of this Clause shall read as under:

“Unless specified otherwise, equipment for production, transportation and compaction of concrete shall be as under:

- a) For production of concrete: Batching and mixing of the concrete shall be done in a concrete batching and mixing plant fully automatic of a minimum capacity of 40 cum/hour. The plant shall be approved by the Engineer.”

Paragraph 3 of this clause shall read as follows:

“The accuracy of measuring devices shall fall within the following limits:

Measurement of Cement in each batch.	±	1% of the quantity of cement
Measurement of Water in each batch.	±	1% of the quantity of water
Measurement of Aggregate	±	2% of the quantity of Aggregate in each batch.
Measurement of Admixture	±	1% of the quantity of Admixture in each batch.

Paragraph 3(b) & 3(c) shall remain unchanged.

Add the following paragraph at the end of the clause: Batching, mixing transportation and placing concrete.

Once the concreting of a section is started, it has to be completed as a continuous operation. Before starting an important placement, the Contractor shall submit to the Engineer an equipment list to ensure that sufficient equipment is available for batching, mixing, transporting and placing concrete and once the concreting of a section is started, it can be completed as a continuous operation within a reasonable time.

Clause 1708 Transporting, placing and compaction of concrete

Add the following paragraph at the end of the clause:

For Placing Concrete with Pumps: Pipe Lines from the pump to the placing area should be laid out with a minimum of bends. For large concrete placements standby pumps shall be available. Suitable valves (air release valves shutoff, valves etc.) shall be provided as per the site needs. The pumping of concrete shall be preceded by a priming mix to lubricate the pump and pipeline. A rich mix of creamy consistency shall be required for lubricating the pipelines; continuous pumping shall be done to the extent possible. After concrete has been placed the lines all related equipment shall be cleaned immediately. A plug sponge ball shall be inserted in the end near the pump and shall be forced through the line by either water or air pressure. Pipes for pumping should not be made from materials, which can harm concrete; aluminium alloy pipelines shall not be used.

Clause 1709 Construction joint (Refer Appendix 1700/1, Preparation of the surface of the joint)

In the first paragraph, add after the words “the surface shall be roughened” the words “the coarse aggregate shall be made visible to a depth of 5 mm to 10 mm”.

In the third paragraph under the heading “Preparation of the Surface of the Joint” add the following at the end of paragraph.

“Bush hammering is not permitted since it loosens the coarse aggregate and results in extensive micro cracks.”

Concreting of Joints:

Under the heading “Concreting of Joints”, add the following at the end of sub-Para 3”.

“At vertical construction joints, a fine mesh on the inner surface of the stopping board shall be placed, if directed by the Engineer, to facilitate removal of laitance.”

Clause 1711 Adverse weather conditions

Sub -Clause 1711.2 Hot Weather Conditions

Add the following at the end of paragraph 1 of the above clause:

Where the Contractor proposes to use ice to cool the concrete or mixing water or any of the ingredients, the Contractor shall provide a refrigeration plant to avoid use of contaminated ice.

Placement of concrete shall not be permitted when day temperature exceeds 40°C.

Clause 1712 Protection and curing

Sub-Clause 1712.1 Water curing

Add the following at the end of Para I:

Water sprinklers or perforated pipes shall be used for curing of concrete for all major bridges, ROB's and grade separators. Such arrangement must be in place & tested before concreting for its proper functioning and shall be maintained for a minimum period of 14 days after concreting.

Approved concrete curing compounds should be preferred where water curing cannot be done reliably.

Clause 1716 Tolerances

Add the following at the end of Clause:

"In the absence of any information in drawings or specifications, for particular cases, the following limitations shall apply.

Dimension (mm) 'a'	Tolerances (mm) ' $\delta a = (a \text{ nominal} - a \text{ actual})$ '
$a \leq 200$	$ \delta a < 5$
$200 < a < 2000$	$ \delta a < 3.5 + 0.0075a$
$2000 < a$	$ \delta a < 16.5 + 0.001a$