

# AXIS CONSULTANTS

<b><u>STANDARD CIVIL ENGINEERING SPECIFICATION</u></b>		
<b>ISSUED: 15-09-2012</b>	<b>GENERAL CONCRETE SPECIFICATION</b>	<b>REV. - 0</b>

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## 1.0 **SCOPE**

This specification covers the general requirements for concrete to be used on jobs, including requirements in regard to quality, handling, storage of materials, proportioning, batching, mixing, placing of concrete, curing, protecting, repairing, finishing, stacking the members, erection of members and testing of concrete.

## 2.0 **APPLICABLE CODES**

**Note:** - Wherever reference is made to IS Codes, on any page of this Technical Specification (including annexures), applicable year of publication of IS Code is as stated below.

The Indian Standard Codes applicable to this section shall include but not limited to the following:

IS 383-1970	:	Coarse and fine aggregates from natural source for concrete.
IS 455-1989	:	Portland slag cement
IS 456-1978	:	Code of practice for plain and reinforced concrete.
IS 516-1959	:	Method of test for strength of concrete.
IS 1199-1959	:	Methods of sampling and analysis of concrete.
IS 1343-1980	:	Code of practice for prestressed concrete.
IS 1489 (Part 1) - 1991	:	Portland Pozzolana Cement Part 1 – Flyash based
IS 1489 (Part 2) - 1991	:	Portland Pozzolana Cement Part 2 – Calcined Clay based
IS 1791-1985	:	Batch type concrete mixer.
IS 2386 (Part 1) To (Part 8)-1963	:	Methods of test for aggregate for concrete.
IS 2430-1986	:	Methods of sampling of aggregate for concrete.
IS 2505-1992	:	Concrete vibrators - immersion type – General Requirement
IS 2645- 1975	:	Integral cement waterproofing compounds.
IS 2722-1964	:	Portable swing weigh batcher for concrete (Single and double bucket type)
IS 3025 (Part 1) To (Part 49)	:	Methods of sampling and test (physical and chemical) for water and waste water.
IS 3366-1965	:	Pan vibrators.

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- IS 3370 (Part 1)- : Code of practice for concrete structures for the storage of liquids : Part  
1 1965 General requirements.
- IS 3370 (Part 2)- : Code of practice for concrete structures for the storage of liquids : Part  
2 1965 Reinforced concrete structures.
- IS 3370 (Part 3)- : Code of practice for concrete structures for the storage of liquids : Part  
3 1967 Prestressed concrete structures.
- IS 3370 (Part 4)- : Code of practice for concrete structures for the storage of liquids : Part  
4 1967 Design tables.
- IS 4082-1996 : Stacking and storage of construction materials and components at site  
- Recommendations
- IS 4656-1968 : Form vibrators for concrete.
- IS 4925-1968 : Concrete batching and mixing plant.
- IS 6452-1989 : Specification for high alumina cement for structural work.
- IS 7861 (Part 1)- : Code of practice for extreme weather concreting : Part 1  
1975 Recommended practice for hot weather concreting.
- IS 7861 (Part 2)- : Code of practice for extreme weather concreting : Part 2  
1981 Recommended practice for cold weather concreting.
- IS 8112-1989 : 43 grade ordinary Portland cement
- IS 9013-1978 : Method of making, curing and determining compressive strength of  
accelerated cured concrete test specimen.
- IS 10262- 1982 : Recommended guidelines for concrete mix design.
- IS 12330- 1988 : Sulphate Resisting Portland Cement

### **3.0 PRIORITY OF REQUIREMENTS**

In case of any variation and discrepancy in condition between the special conditions, this specification and codes, order of priority shall be as under :-

- (1) Special conditions
- (2) This specification
- (3) Codes

### **4.0 GENERAL**

Engineer-in-Charge shall have the right at all times to inspect all operations, including the sources of materials, procurement, layout and storage of materials, concrete batching equipment, and the quality control system. Such an inspection shall be arranged and Engineer-in-Charge's approval obtained, prior to starting of concrete work. This shall,

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however, not relieve CONTRACTOR of any of his responsibilities. All materials, which do not conform to this specification, shall be rejected.

## 5.0 MATERIALS

### 5.1 Cement

Cement shall be ordinary portland cement with a 7 days strength of not less than 220kg/cm<sup>2</sup> conforming to IS: 8112, or Portland slag cement conforming to IS 455, unless otherwise specified.

#### 5.1.1 Storage at Site

- (a) The storage of cement at the site of work shall be at CONTRACTOR's expense and shall meet the requirements of IS 4082. The cement shall be stored above ground in a suitable weather tight building or godown and in such a manner as to permit easy access for proper inspection and also to prevent deterioration due to moisture. Storage under tarpaulins shall not be permitted. In the event of any damage occurring to the quality of cement due to faulty storage or on account of negligence on the part of the CONTRACTOR, such damages shall be borne by the CONTRACTOR himself. Engineer-in-Charge shall approve storage arrangement.
- (b) All approved and accepted cement shall be arranged in batches with type, brand and date of receipt prominently displayed on them. A maximum of eight bags shall be stacked one over the other. Cement bags shall be used in the same order as received. The CONTRACTOR shall maintain a register, on day to day basis, giving the details of the receipt, consumption, source of supply and type of cement etc. The register shall always be accessible to the Engineer-in-Charge for verification.

#### 5.1.2 Tests after Delivery

Each consignment of cement supplied by OWNER/BHEL or CONTRACTOR shall, after delivery at site and at the discretion of the Engineer-in-Charge, be subjected to any or all of the tests and analyses, required by the relevant Indian Standard Codes. In case the cement is supplied by the OWNER/BHEL, the CONTRACTOR shall get himself satisfied regarding its quality before using the same in his works at his own expense. The CONTRACTOR shall carry out and bear the cost of all tests and analyses required to ensure quality of cement before using in actual works, irrespective of the fact whether the cement is supplied by the OWNER/BHEL or procured by him.

#### 5.1.3 Rejection

The Engineer-in-Charge may reject at his discretion any cement, notwithstanding the manufacturer's certificate or failing to meet the requirements of relevant IS Codes for testing of cement. He may similarly reject any cement which has deteriorated owing to inadequate protection from moisture or due to intrusion of foreign matter or any other cause. Any cement which is considered defective, shall not be used and shall be promptly removed from the site by the CONTRACTOR at no extra cost to OWNER/BHEL.

### 5.2 Aggregates

Aggregate shall consist of natural sand, crushed stone and gravel and shall be chemically inert, strong, hard, clean, durable against weathering, limited porosity, free from deleterious

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materials and conform to IS 383. When directed by Engineer-in-Charge, they shall be washed and screened.

Sampling and testing shall be as per IS 2386 under the supervision of Engineer-in-Charge. The cost of all tests, sampling etc. shall be borne by CONTRACTOR.

All coarse and fine aggregates shall be stacked separately and shall avoid contamination with foreign material. Segregated aggregates shall be rejected.

## 5.2.1 Fine Aggregate

Fine aggregates shall be sharp and durable. The total percentage by weight of deleterious substances in sand shall not exceed 5% for uncrushed sand and 2% for crushed sand. The grading shall be as per IS 383. The fineness modulus shall be between 2.2 and 3.2.

## 5.2.2 Coarse Aggregate

Coarse aggregate shall be with granular or crystalline surface, shall be free from elongated, flaky or laminated pieces and shall be graded aggregate as per IS 383.

Total percentage of deleterious substances in the coarse aggregate shall not exceed 5% for both crushed and uncrushed aggregates.

Unless otherwise specifically stated on the drawings, the maximum size of coarse aggregate shall be 20 mm, but in no case greater than 1/4 of the minimum thickness of the member.

## 5.2.3 Sampling and Testing

The CONTRACTOR shall carry out all tests including mix designs of concrete, at his own expense, at the start of work as well as during any stage of construction as required by the Engineer-in-Charge. Test shall be carried out in accordance with IS 516 and IS 2386. Testing shall be carried out from laboratories approved by the Engineer-in-Charge. The method of sampling shall be in accordance with the requirements given in IS 2430.

## 5.2.4 Storage of Aggregates

- (a) Storage of all types of aggregates at site of work shall be at CONTRACTOR's expense and shall be stored as specified in IS 4082. Aggregates shall in no case be stored near to the excavated earth or directly over ground surface.
- (b) The CONTRACTOR shall maintain sufficient quantities of aggregates, near the place of work, required for the continuity of the work. Each type and grade of aggregate shall be stored separately on hard, firm surface having adequate slope for drainage of water.
- (c) Aggregates delivered at site in wet condition or becoming wet due to rain or any other means, shall not be used for at least 24 hours. The CONTRACTOR shall obtain prior approval of the Engineer-in-Charge for the use of such aggregates and shall adjust the water content in accordance with IS 2386 to achieve the desired mix.

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### 5.3 Water

Water used for both mixing and curing shall be as per IS 456. Potable water is generally satisfactory. Where water contains an excess of acid, alkali, sugar or salt, Engineer-in-Charge may refuse to permit its use. The CONTRACTOR shall make adequate arrangement to store sufficient water at works for all construction activities.

Test on water samples shall be carried out in accordance with IS 3025 and they shall fulfill all the guidelines and requirements given in IS 456.

## 6.0 **TYPES OF CONCRETE**

### 6.1 General

Unless otherwise specified or mentioned in drawings, all leveling concrete, lean concrete and filling concrete shall be "NOMINAL MIX CONCRETE" and all structural concrete shall be of "DESIGN MIX CONCRETE" as defined in IS 456. However all concrete works of grade M5, M7.5 and M10 shall always be NOMINAL MIX CONCRETE.

### 6.2 Nominal Mix Concrete

Nominal Mix Concrete shall be prepared without preliminary test, by adopting the proportions of materials as specified in Table I. Only graded coarse aggregates shall be used.

All the requirements of IS 456 for nominal mix concrete shall also apply.

Nominal mix concrete specified by volumetric batching shall be as per table below :

**TABLE I**

Concrete Mix	Cement (kg)	Sand (Litres)	Coarse Aggregate (Litres)	Quantity of water max (Litres)
1:5:10 (M5)	50	175	350	60
1:4:8 (M7.5)	50	140	280	45
1:3:6 (M10)	50	105	210	34
1:2:4 (M15)	50	70	140	32
1:1.5:3 (M20)	50	53	106	30

**NOTE:**

The ratio of fine to coarse aggregate shall generally be 1:2, but subject to a lower limit of 1:2.5 and an upper limit of 1:1.5. As the grading of the fine aggregates become finer and the maximum size of the coarse aggregate becomes larger, the ratio should be adjusted from the upper limit to the lower limit.



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## 6.3 Design Mix Concrete

Concrete shall be as designated on drawings such as grade M15, M20, M25 etc. the number representing the specified characteristic compressive strength of 150 mm cube at 28 days, expressed in  $\text{N/mm}^2$  as per Table 2 of IS 456.

The CONTRACTOR shall be entirely responsible for the design of the concrete mix. The design mix shall be approved by the Engineer-in-Charge before commencing any concreting in the works. The concrete mix shall be designed so as to provide dense concrete of requisite workability having a characteristic strength not less than that specified in Table 2 of IS 456. Unless otherwise mentioned the minimum cement content for design mix concrete shall be as per appendix A of IS 456. However a cement content below  $320 \text{ kg/m}^3$  shall not be permitted for structural grade concrete M20 and above.

The procedure given in Indian Standard Recommended Guidelines for concrete mix design IS 10262 shall be followed.

It shall be CONTRACTOR's sole responsibility to carry out preliminary tests of specimens at his own cost as per IS 456 and IS 516. He shall furnish to Engineer-in-Charge a statement of proportions, proposed to be used for various concrete mixes. The minimum strength requirements shall be as follows :

**TABLE II**

Grade of Concrete	Preliminary Test $\text{N/mm}^2$		Works Test $\text{N/mm}^2$	
	at 7 days	at 28 days	At 7 Days	at 28 days
M 15	13.5	20.0	10.0	15.0
M 20	17.5	26.0	13.5	20.0
M 25	22.0	32.0	32.0	25.0
M 30	25.0	38.0	20.0	30.0
M 35	30.0	44.0	23.0	35.0
M 40	33.5	50.0	27.0	40.0

## 7.0 PROPORTIONING

### 7.1 General

Proportioning is the process whereby appropriate proportion of the various constituents of concrete are determined so as to produce concrete of the required strength, denseness, workability, durability and other properties.

Preliminary mix design shall be established well ahead of start of work. The CONTRACTOR shall make trial mixes using samples of coarse aggregates, sand, water and cement, typical of those to be used in the works and which have been tested in an approved laboratory. The Engineer-in-Charge shall permit the use of the concrete mix, based on verification of the strength of concrete as also the workability for the particular placement condition. Such a permit, shall in no way absolve the contractor of his responsibility of providing concrete of the prescribed strength. If subsequent cube tests during execution, show strengths lower than permitted, the Engineer-in-Charge shall order fresh trial mixes to be made by the CONTRACTOR. Such changes in mix design shall be at the CONTRACTOR's expense. Any

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variation in cement consumption shall be used in the process of material reconciliation, in case the cement is supplied by OWNER/BHEL.

## 7.2 Water Cement Ratio

Water cement ratio shall be such as to produce dense concrete of required consistency, specified strength, satisfactory workability and shall be so adjusted to account for moisture content in the aggregates. After the design mix has been approved by the Engineer-in-Charge, the prescribed water cement ratio shall be maintained. The CONTRACTOR shall at frequent intervals determine the water content of the aggregates and thus adjust the amount of mixing water so as to maintain the specified water cement ratio.

## 7.3 Consistency

The concrete shall have such a consistency, that it is workable and upon proper vibration / tamping, flows around the reinforcement, embedded items etc. without any separation of the coarse aggregate.

## 7.4 Workability

The design mix concrete proportions shall be determined such that adequate workability is available for the placing condition and the compaction means available.

Workability of concrete shall be measured in accordance with IS 1199. The suggested ranges of values are given in Table III. However, the value at site shall be determined based on actual placement conditions.

**TABLE III**

Type of Work	Degree of Workability	Values of Workability
Shallow sections with vibrations	Very low	Vee-bee time 10-20 seconds or compacting factor 0.75-0.8
Lightly reinforced sections with vibrations	Low	Vee-bee time 5-10 seconds, or compacting factor 0.8 - 0.85
Lightly reinforced sections without vibrations or heavily reinforced sections with vibrations	Medium	Vee-bee time 2-5 seconds or compacting factor 0.85 - 0.92, or slump 25 - 75 mm.
Heavily reinforced section without vibration	High	Compacting factor above 0.92, or slump 75 - 125 mm.

**Note :** Slumps indicated are for 20 mm aggregate. For smaller aggregates, the values will be lower.

## 7.5 Batching

- 7.5.1 Proportions of aggregates and cement, as decided by preliminary tests, shall be by mass. These proportions shall be maintained during subsequent concrete batching only by means of weigh batchers, capable of controlling the weights within one per cent of the desired value.

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- 7.5.2 Solid admixtures, if used, shall be measured by weight and liquid or paste admixtures shall be measured by volume or weight. Water may be measured by weight or by volume in calibrated tanks. Batching plant if used shall conform to IS 4925. All measuring devices shall be maintained in a clean service cable condition and their calibration checked periodically.
- 7.5.3 The grading of coarse and fine aggregates shall be checked at frequent intervals to ensure that the grading meets the requirements of the mix design. The grading of aggregates shall be obtained by blending aggregates of different sizes in the right proportions.
- 7.5.4 The amount of water to be added shall be adjusted on account of variations in the moisture content in both fine and coarse aggregates as given in IS 2386 Part 3. Similarly the weights of aggregates shall also be adjusted due to variation in moisture contents.
- 7.5.5 No substitution of materials of change in the established mix proportions (excepting those made to account for the variation in moisture content) shall be permitted without additional tests to prove to the satisfaction of the Engineer-in-Charge, the adequacy of concrete strength and quality.
- 7.5.6 In case uniformity in materials used, has been established over a period of time, only the quantities of fine and coarse aggregates may be converted into equivalent volumes for the purpose of volume batching if specifically permitted by Engineer-in-Charge. However, cement shall be weighed. For moist aggregates, allowance shall be made for bulking in accordance with IS 2386 (Part 3). Sizes of boxes shall be such, as to measure the correct quantity of aggregates to be used with one 50 kg bag of cement. While filling boxes, material should be thrown loosely into boxes and struck off without any compaction

## **8.0 MIXING OF CONCRETE**

### **8.1 General**

Concrete shall be mixed in an approved type of mechanical concrete mixer till such time that there is a uniform distribution of the materials and the mass is homogenous and uniform in colour and consistency. In case of segregation after unloading from the mixer, the concrete shall be remixed. Each time the work stops, the mix shall be cleaned out, and while recommencing, the first batch shall have 10% additional cement to allow for sticking in the drum.

Mixing by hand shall not be permitted.

### **8.2 Mixers**

The mixers shall comply with IS 1791 and shall be maintained in satisfactory operating condition. All care shall be taken to keep the mixer drum free of hardened concrete. The blades shall be replaced, when they are worn down by more than 10% of their depth. Should any mixers performance be unsatisfactory on account of wastage of material, leakage of mortar or inadequate mixing in specified time, the mixer shall be removed from operation until it is repaired to the satisfaction of the Engineer-in-Charge.

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## 8.3 Mixing Time

The minimum Mixing time shall be as indicated below.

<u>Mixer Capacity</u>	<u>Minimum Mixing Time</u>
2 cum & less	1.5 mins
3 cum	2.5 mins
5 cum	3 mins

Mixing time shall be computed from the time when all solid materials have been poured into the revolving drum with the further provision that the entire mixing water shall be added prior to the elapse of one-fourth the mixing time. Excessive mixing shall not be permitted.

## 8.4 Records

A set of records and charts for the batching and mixing operations shall be prepared as per the directions of the Engineer-in-Charge.

## 9.0 **ADMIXTURES**

Admixtures may be used in concrete as per manufacturer's instructions, with the approval of Engineer-in-Charge based upon evidence that, with the passage of time, neither the compressive strength nor its durability is reduced. Calcium chloride shall not be used for accelerating set of the cement for any concrete containing reinforcement or embedded steel parts. When calcium chloride is permitted such as in mass concrete works, it shall be dissolved in water and added by an amount not exceeding 1 1/2 percent of the weight of the cement, in each batch of concrete. The designed concrete mix shall be corrected accordingly.

## 10.0 **TESTS**

### 10.1 General

If Engineer-in-Charge feels that the materials i.e. sand, coarse aggregates, etc. are not in accordance with the specifications or if specified concrete strength is not obtained, he may order tests to be carried out on these materials in an approved laboratory as per relevant IS Codes, at CONTRACTOR's own expense.

### 10.2 Testing during Concreting

10.2.1 Grading tests shall be carried out on aggregates as per IS 2386 at intervals, as per instructions by Engineer-in-Charge.

10.2.2 At least one Vee-bee test or slump test shall be carried out for every compressive strength test.

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## 10.2.3 Cube Testing for Strength of Concrete

- (a) Arrangement should be made by CONTRACTOR to have the cubes tested in an approved laboratory or in field at his own expense, with prior consent of Engineer-in-Charge. Samples shall be drawn as per IS 1199 and cubes made as per IS 516. Testing for strength of concrete shall be as per IS 456. The drawing of samples should be spread over the entire period of concreting as also over the various mixing units. The minimum frequency of sampling shall be as follows, but at least one sample shall be drawn per shift.

<u>Volume of concrete in the work (cum)</u>	<u>Minimum number of samples</u>
1 – 5	1
6 – 15	2
16 – 30	3
31 – 50	4
50 and over	4 plus one per additional unit of 50 cum.

A minimum of six cubes shall be prepared from each sample, three for testing after 7 days and three for testing after 28 days. Additional cubes shall be taken if so advised by the Engineer-in-Charge for carrying out compressive strength check on concrete, cured by accelerated methods as laid down in IS 9013.

The specimens shall be tested as per IS 516. The 28 days compressive strength specified in IS 456 shall be the criteria for acceptance or rejection of concrete. In case the concrete is rejected, the CONTRACTOR shall be required to dismantle all such defective portion of work, along with the other work structurally connected with the same. The Engineer-in-Charge shall solely decide the quantity of work or the part of structure to be dismantled.

- (b) The test strength of the sample shall be the average of the strength of three specimens. The individual strengths of specimens shall not vary by more than  $\pm 15$  percent of the average.
- (c) Standard deviation shall be calculated as per Clause 14.5 of IS 456.

## 10.2.4 Acceptance Criteria

- (a) The acceptance criteria based on cube strengths of concrete shall be as specified in Clause 15 of IS 456.
- (b) Concrete not satisfying the criteria shall be rejected at the Engineer-in-Charge's sole discretion or be subjected to testing specified in Cl. 10.3 of this specification.
- (c) Concrete may also be rejected on account of honey combing, porosity, displacement of reinforcement or construction being out of the specified tolerances.

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## 10.3 Testing of Structures

### 10.3.1 General

Should the 28 days cube strengths results be such that the concrete does not conform to the limits set by the acceptance criteria, or should the Engineer-in-Charge have other doubts about the adequacy of the strength of the structure due to poor workmanship, honeycombing, inadequate cover, premature removal of forms, improper curing, etc., the Engineer-in-Charge may ask the CONTRACTOR to perform either in-situ testing of concrete or a load test on the structure. In-situ tests may comprise all or one of the following : Rebound hammer test, ultrasonic test, removal of cores or any other test specified by Engineer-in-Charge. The necessity for the tests and their number be at the sole discretion of Engineer-in-Charge at no extra cost to the OWNER/BHEL.

### 10.3.2 Load Test

The load test shall be carried out to confirm the provisions of Clause 16.5 of IS 456. Engineer-in-Charge shall be the sole and final authority to decide on acceptability of the structure based on the interpretation of the results. Should the structure be deemed unacceptable, Engineer-in-Charge may require the structure or part structure to be dismantled and reconstructed at no extra cost to the OWNER / BHEL.

## 11.0 **PREPARATION PRIOR TO CONCRETE PLACEMENT**

Before concrete is actually placed in position, the inside of the formwork shall be cleaned and oiled. Reinforcement and inserts shall be correctly positioned and securely held.

Necessary openings, cutouts shall be provided.

## 12.0 **PROCEDURE FOR TRANSPORTATION AND PLACING OF CONCRETE**

### 12.1 Approval for Pouring

Prior to pouring concrete, all arrangements, formwork, procedure for placing, with a detailed stepwise scheme of transporting and placing the concrete, mentioning equipment being deployed, location and methods shall be submitted to the Engineer-in-Charge for approval, at least 48 hours prior to concreting. CONTRACTOR shall maintain Pour Card for each pour as per BHEL format.

### 12.2 Transportation

Concrete shall be transported from the mixer to the place of final deposit as rapidly as practicable. Care shall be taken to avoid segregation, loss of constituents and maintaining the required workability before initial setting time of cement. Buckets, containers or conveyors which are leakproof shall be used for this purpose. All such equipments shall be maintained in a good and clean condition by thoroughly cleaning them after each placement. During hot or cold weather, care shall be taken to avoid evaporation loss of water or loss of heat by suitable means.

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## 12.3 Placing

### 12.3.1 Chutes

Open troughs and chutes shall be equipped with baffles and be of short lengths to prevent segregation. The slope of the chute shall not be less than 1 vertical to 3 horizontal nor more than 1 vertical to 2 horizontal. Chutes shall be designed such that the concrete at the lower end passes through a funnel shaped pipe or drop chute, thus causing a certain degree of remixing. Alternately they should discharge into a hopper from which concrete is further conveyed in wheel barrows. In case drop chutes are used the maximum lateral flow of the discharged concrete shall be limited to one meter. When drop chutes are swung from the vertical, the bottom two segments must be vertical in order to prevent segregation. No water shall be added at any point of the chute system to facilitate movement of concrete. Concrete shall not be permitted to fall freely for a height of more than 1.0m nor to strike the forms at an angle. All chutes, troughs and pipes shall be flushed with water at the end of each run, to keep them clean and free from coatings of hardened concrete.

The use of long troughs, chutes and pipes shall be permitted only with the approval of Engineer-in-Charge. In case the conveying arrangement produces unsatisfactory results, the Engineer-in-Charge may withdraw the permission for their use.

### 12.3.2 Placement

- (a) Prior to placing concrete in foundation, all the soil surfaces upon which or against which the concrete is to be placed, shall be thoroughly compacted. The excavation shall be free from all water and debris. Soft or yielding soils shall be removed and replaced with appropriate selected soils or lean concrete compacted to the desired density. When concrete comes in direct contact with absorptive soil, the surface of the soil shall be thoroughly moistened prior to placing concrete.

Concrete shall not be deposited on large sloping rock surfaces. The rock shall be cut, to form rough steps or benches by picking, barring or wedging. The rock surface shall be kept wet for 2 to 4 hours before concreting.

- (b) No concrete shall be placed prior to the approval by Engineer-In-Charge of the formwork, scaffolding, placement of reinforcement and embedded items etc. Any water collected over formwork, bedding surfaces shall be removed.
- (c) Concrete shall be discharged by means of vertical drop only. The drop height shall not exceed 1.0m in any stage of delivery.
- (d) To avoid rehandling of concrete, it should be deposited as near as possible to its final position. Concrete shall be placed in horizontal layers of thickness not exceeding 300mm. In case of any segregation, it shall be corrected by shoveling aggregate into mortar and not mortar over aggregate. All care shall be taken to prevent the formation of pockets or mortar accumulation in the corners of formwork. In case they are formed they shall be removed and refilled ensuring bondage with the earlier concrete.
- (e) Concrete shall be deposited in such manner so as to cause no disturbance to reinforcement or formwork. All temporary bracings for the formwork within the area to be concreted shall be removed once the level of concrete within the form ensures stability of the form. Under no circumstances shall the temporary bracing be left within the concrete.

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- (f) Once concreting has begun, it shall be carried out in a single continuous operation until the completion of all the work for that particular section or between construction joints has been completed. The location of construction joints, other than those shown on drawing shall be previously approved by the Engineer-in-Charge.
- (g) When concrete is to be placed in roof slabs, the entire slab and beams (or portion between expansion joints for large roofs) shall be covered in one single operation without joints or breaks.
- (h) Concreting in extreme temperatures, more than 40°C or less than 5°C, shall be carried out as per procedure given in IS 7861.
- (i) CONTRACTOR shall fix the inserts in the concrete, at the exact level, face and location as shown in the drawing.
- (j) Each placement of concrete in multiple lift work, shall be allowed to set for at least 24 hours after the final set of concrete, before the start of subsequent placement.

## 12.3.3 Concreting Under Water

- (a) Prior to start of work, the contractor shall submit to the Engineer-in-Charge for his approval, the proposed method, equipment, materials and proportions of mix.
- (b) The concrete mix shall have a ratio of fine to coarse aggregate varying between 1:1.5 and 1:2. The additional cement content over that required for dry placement shall be a minimum of 10 percent. The concrete shall have a slump of not less than 100mm and not more than 180mm.
- (c) Concrete shall be deposited continuously until it reaches the required height. Concrete shall deposited either by tremie, drop bottom bucket or by grouting as indicated in Clause 13.2.4 (a), (b), (d) of IS 456.

## 13.0 **COMPACTION**

### 13.1 General

Concrete shall normally be compacted in its final position within thirty minutes of leaving the mixer

### 13.2 Vibrators

No concrete work shall commence prior to ensuring that, adequate number of vibrators are available. Each layer of concrete shall be compacted with immersion type mechanical vibrating equipment with an operational frequency between 8000 to 12000 rpm.

The use of form vibrators shall be permitted at the sole discretion of Engineer-in-Charge. The use of surface vibrators such as pan type or screed board type may be permitted by Engineer-in-Charge for slabs and sections of thickness less than 200mm. Vibrators shall in no case be used for the transport of concrete within forms.



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## 13.3 Method of Compaction

Each layer of concrete shall be compacted using the mechanical vibrators in conjunction with hand spading and tamping. Immersion type vibrators shall be inserted vertically at intervals not more than 450mm, the spacing adjusted to provide overlap with the area vibrated through insertions. The exact spacing shall depend upon the mix proportions and performance of equipment. The duration of vibration shall be limited to the time necessary to produce satisfactory consolidation without causing segregation. Minimum vibration time shall be 20 seconds per 0.1sq.m. of exposed surface. Immersion vibrators shall be withdrawn slowly when air bubbles cease to come to the surface leaving no voids. The concrete shall be worked around reinforcement, embedded items and into corners of form work.

The vibrator shall penetrate the layer being placed and also the layer below while it is still plastic, so as to avoid a cold joint between layers and ensure homogeneity and good bond. Care shall also be taken while the layer is advancing horizontally to ensure bond and homogeneity between successive batches by means of vibrators. The vibrators shall not come in contact with either the form work or the reinforcing steel. Vibrators shall not be allowed to come in contact with finished surfaces after start of initial set.

## 14.0 **EXPANSION, CONSTRUCTION AND SEPERATION JOINTS**

### 14.1 Expansion Joint

Expansion joints shall be provided at the locations and to the details shown on drawings, with the joints filled with approved joint sealing compound

### 14.2 Construction Joints

14.2.1 Construction joints shall be provided at locations as shown on drawings. Concrete shall be placed without interruption until completion of work between construction joints. Any additional construction joint needed to facilitate construction, due to constraints of equipment, time etc. shall be provided only after obtaining the prior approval of Engineer-In-Charge. The joints where provided, should be at right angles to the direction of main reinforcement and shall be kept to the minimum.

14.2.2 The preferred location for joints in columns shall be at an elevation of 100mm to 150mm below the soffit of the deepest beam framing there. Joints shall preferably be avoided for slabs and beams. If found unavoidable the joint shall be vertical and be located between 0.25 of span. Inclined joints shall not be permitted.

14.2.3 Vertical joints shall be obtained through the use of a stop board having slots for the longitudinal reinforcement. A trapezoidal or triangular fillet shall be nailed to the board to form a key. Any concrete which has flowed through the stop board shall be cleaned immediately after the initial set.

14.2.4 When concreting is taken up at a surface which has not fully hardened, the wet surface shall be scrubbed with wire brushes to remove all laitance, care being taken to avoid disturbance of aggregates. The surface shall then be thoroughly wetted, with all free water on the forms being completely removed. The surface shall then be coated with neat cement slurry and a layer of concrete of 150 mm thickness shall then be placed and well rammed against the old concrete, care being taken to fill corners and other areas having small clearances. This shall be followed by concrete placement and compaction in the usual practice.

14.2.5 When concreting is taken up against a surface which has hardened, the surface shall be roughened using wire brushes and compressed air so as to expose the coarse aggregate.

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The surface shall then be cleaned, wetted, and the excess water removed from the forms. Vertical joints shall receive a coat of neat cement slurry, whereas horizontal joints shall be covered with a 10mm to 15 mm cement sand mortar having the same proportion, as the cement and sand in the concrete mix. Concreting in the usual practice shall immediately follow.

- 14.2.6 Reinforcing bars shall be extended a minimum of 50 diameters beyond the construction joint. In the case of columns, the portion of columns between the stopping off level and the top of slab shall be concreted with the beam. A minimum period of two hours must elapse after depositing concrete in columns before placing of concrete in beams, girders or slabs thereon. Beams, girders, brackets, column capitals shall be considered as part of the floor system and shall be monolithically placed.

- 14.2.7 Dowels for concrete work, not likely to be taken up in the near future, shall be wrapped in tar paper and burlap.

## 14.3 Separation Joints

Separation joints shall be provided at locations shown on drawings. It shall be formed by the use of sheet of approved material and make, being stuck on the surface against which concrete is placed. All care shall be taken to prevent tearing of the sheet.

## 15.0 CURING

- 15.1 All concrete shall be cured by use of continuous sprays, ponded water or continuously saturated coverings of sacking, canvas, hessian or other absorbent material which will hold moisture for long periods. The covering should not stain or disfigure the concrete. The covering layer shall be kept continuously wet, starting 8 hours after placement (4 hours in hot weather) for the period of complete hydration with a minimum period of 14 days. The quality of curing water shall be the same as that used for mixing.
- 15.2 For the curing of flat surfaces, the curing for the first 24 hours shall be with a covering as mentioned above followed by ponding for the balance period. A minimum water depth of 25mm shall be maintained continuously.
- 15.3 Membrane curing by use of approved curing compounds may be used in lieu of moist curing with the approval of Engineer-in-Charge. Such compounds shall be applied to all exposed surfaces of the concrete as soon as possible after the concrete has set.
- 15.4 Curing of concrete made of low heat cement, high alumina cement or supersulphated cement shall be carried out as directed by Engineer-in-Charge and as per manufacturers specifications.

## 16.0 REPAIR AND REPLACEMENT OF UNSATISFACTORY CONCRETE

- 16.1 After the striking of the formwork, all concrete work shall be inspected for defects such as honey-combed surfaces, rough patches, holes left by form bolts etc. and shall be brought to the notice of Engineer-in-Charge. Engineer-in-Charge shall at his discretion, permit repair of such defective work or reject it. No extra payment shall be made for the rectification, dismantling and reconstruction of structures or part thereof.

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- 16.2 Rectification of burrs and uneven faces shall be achieved by rubbing them smooth with a carborundum stone. This and other repair work shall be performed as soon as possible after the striking of forms so that the concrete has not hardened completely. Areas of segregation, stone pockets and other damaged areas shall be chipped and all loose material removed with compressed air or by washing, taking care to remove all water from the concrete. For larger repairs concrete shall be chipped out to a depth of 100-150mm. Loose mortar shall be scrubbed out by using wire brushes. Based on the assessment of Engineer-in-Charge, additional reinforcement shall be spliced with existing reinforcement.
- 16.3 Bonding of old concrete with the repair material shall be achieved by wetting the chipped out surface and either sprinkling dry cement on the wet surface or by brushing a coat of rich cement grout (1 cement : 1 sand) followed by the patch mortar for surface repairs, or patch concrete for larger repairs. Epoxy bondage of such repairs may also be permitted by Engineer-in-Charge. In such cases the epoxy shall be applied strictly in accordance with the manufacturers instructions.
- 16.4 The cement mortar / concrete shall have the same proportions as those of the parent concrete. The source of cement shall be the same as that used in the parent concrete. The appropriate shade of concrete / mortar shall be obtained by blending with white Portland cement. The water cement ratio shall be as low as practicable and the cavity shall be filled and well compacted.
- 16.5 The repaired area shall be cured by covering with a wet saturated material, for a period of 24 hours. The subsequent curing of the repair by sprinkling water shall continue for at least 14 days.

## **17.0 CEMENT WASH**

Surfaces which are not to be plastered nor receive any other treatment may be provided one coat of cement wash if so directed by Engineer-in-Charge.

## **18.0 FINISHING**

For surfaces against which backfill or concrete is to be placed, no treatment is required except repair of defective areas. For surfaces below grade, which will receive waterproofing treatment, the concrete shall be free of irregularities. For exposed concrete (exposed to view upon completion of concreting) the standard smooth finish shall be obtained with the use of lined or plywood forms having smooth and even surfaces. Upon removal of forms, the joint marks and surface defects shall be corrected and smoothened off.

## **19.0 PROTECTION OF IMMATURE CONCRETE**

Approved means shall be adopted to prevent immature concrete from damage due to debris, backfilling, vibrations, floatations, loading abrasion, deleterious matter or any other influence that may impair the strength and durability of concrete. Concrete placed below ground level shall be protected from falling earth. The concrete shall be prevented from coming in contact with the earth or ground water for the first 3 days after placement. The ground water level shall be lowered to an approved level by suitable means to prevent floatation or flooding at no extra cost.

## **20.0 HOT WEATHER REQUIREMENTS**

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In case of freshly placed concrete, adequate provisions shall be made to lower concrete temperatures which shall not exceed 38°C, under all weather conditions.

## **21.0 GROUTING**

Grout shall be provided as specified on the drawings. The proportion of Standard Grout shall be such as to produce a flowable mixture, consistent with minimum water content and shrinkage. Surfaces to be grouted shall be thoroughly roughened and cleaned. All structural steel elements to be grouted, shall be cleaned of oil, grease, dirt etc. Grouting once started shall be done quickly and continuously. For non-shrink cementitious grouts, use of non-shrink compounds viz. ferro grout, Shrinkcomp, or equivalent shall be in proportion of one cement, one sand and one non-shrink compound or as per manufacturer's instruction. For non-shrink free flow Non Metallic fluid grout, cement based or Epoxy based, proprietary ready mix products may be used. Variation in grout mixes and procedures shall be permitted if approved by Engineer-in-Charge.

## **22.0 INSPECTION**

All materials, workmanship and finished construction shall be subject to the continuous inspection and approval of Engineer-in-Charge. CONTRACTOR shall replace materials rejected immediately at no cost to OWNER/BHEL.

## **23.0 CLEAN-UP**

Upon the completion of concrete work, all forms, equipment, construction tools, protective coverings and any debris, scraps of wood etc. resulting from the work shall be removed and the premises left clean.

## **24.0 CONCRETE IN LIQUID RETAINING STRUCTURE**

### **24.1 Materials**

#### **24.1.1 General**

Cement, fine and coarse aggregate, water, etc shall be as described in earlier clauses of this specification.

#### **24.1.2 Water Proofing Compound**

(a) Water Proofing Compounds shall be used as per the requirements given in the drawings and as approved by Engineer-in-Charge. The compounds shall conform to IS 2645 and shall be used as per manufacturers specifications and instructions. Test Certificates, as required by Engineer-in-Charge to prove the effectiveness of the compound as also their non-injurious nature, with respect to concrete, shall be produced by CONTRACTOR. Compounds containing calcium chloride shall not be used.

(b) The CONTRACTOR carry out compressive test on concrete cubes where the compound has been used, as per the instructions of Engineer-in-Charge.

#### **24.1.3 PVC Water Stops**

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- (a) Water stops shall be of impermeable material, which when properly placed shall form a permanent water tight seal along the entire joint.
- (b) These shall be of ribbed / serrated type with a central bulb and of width shown on drawings. The minimum thickness of water stops, without ribs / serration shall be 6mm. These shall be of approved make. The joining of two water stop lengths, where necessary shall be done strictly as per manufacturers specification.
- (c) Water stops shall be of maximum possible length, so as to keep the number of joints to a minimum.

## 24.1.4 Concrete

- (a) All clauses of this specification shall be applicable along with the following additional clauses.
- (b) Grading of aggregates shall be done, so as to obtain the densest possible concrete. Water cement ratio shall be kept as low as possible, consistent with the requirement of sufficient workability to produce impervious concrete. The maximum size of coarse aggregate shall be limited to 20 mm.
- (c) Minimum cement content in concrete shall be as specified in IS 3370. Maximum water cement ratio shall be 0.45. Mix design shall cater for required workability and strength consistent with this ratio.
- (d) The concrete placed, shall be well compacted and the joints made tight, so as to be free from honey combing and pores.

## 24.2 Joints

- 24.2.1 All vertical and horizontal joints shall be located as shown on the drawings. For construction joints not shown in the drawing, specific approval regarding location shall be obtained in advance from the Engineer-in-Charge. Where days work joints are formed, they shall be rebated as shown on drawings. Prior to resuming work, care shall be taken to clean out all loose stone, aggregate, nails, wooden chips or any other foreign material. All laitance shall be removed and the face of the concrete well hacked to expose the aggregate. The face shall be properly washed and a thin coat of mortar or grout (1 cement : 1 coarse sand) shall be applied just prior to resuming concreting.
- 24.2.2 Water stops shall be installed by embedding one half width of the water stop on either side of the joint by providing suitable supporting arrangement and as per manufacturers specifications. Water stops shall be located accurately and supported against displacements, during concreting. Water stops shall be joined as per IS 3370 and as per manufacturers specifications at crossings and change of alignments. Jigs made from reinforcing bars may be used for supporting the water stop.
- 24.2.3 Joints shall be properly sealed with polysulphide sealing compounds as per manufacturers recommendations.

## 24.3 Items embedded In Concrete

All pipe sleeves, inserts, etc. required to be embedded in the concrete, shall be accurately placed and held in position. In case any protective coatings are specified, the same shall be applied.

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## 24.4 Rendering

Rendering of the concrete surface in contact with liquid shall be done as per instruction of Engineer-in-Charge. Cement mortar having an approved waterproofing compound, as additive shall be applied to the concrete surface while it is still green. The concrete surface shall be made wet and hacked to obtain a good key before application of the mortar. The mortar shall be steel trowelled and finished with a wooden float.

## 24.5 Curing

All concrete work shall be cured for a minimum period of 21 days.

## 24.6 Hydraulic Testing

24.6.1 All liquid retaining structures shall be tested in accordance with IS 3370, to ensure water tightness. For underground, covered tanks, the maximum drop in the level of the water surface, over a period of seven days, shall not exceed 40mm.

24.6.2 Backfilling around underground structures shall be permitted only after satisfactory completion of all tests and as per instructions of Engineer-in-Charge.

24.6.3 The cost of all testing including hydraulic and structural, along with necessary equipment infrastructure and rectification if required, shall be at the CONTRACTOR's expense.

24.6.4 If the hydraulic test fails, the CONTRACTOR shall at his own cost employ suitable methods after obtaining approval by Engineer-in-Charge, to make the structure leakproof.

24.6.5 In case such attempts fail, the CONTRACTOR shall dismantle and rebuild a satisfactory structure at his own cost and within the stipulated time schedule

## 25.0 **DAMP PROOF COURSE**

The Damp Proof Course shall be 50mm thick and shall consist of plain cement concrete of nominal mix 1:1.5:3 with 10mm and down sized aggregate, with water proofing compound of approved make.

Prior to laying, the top surface of the wall shall be well cleaned and watered. The Damp Proof Course shall be laid in 2 layers of 25mm thickness, with the help of edge shuttering, well tamped and trowelled to achieve a smooth finish. Each layer of the concrete shall be cured, by being kept wet for 48 hours. After the concrete has dried, two coats of hot bitumen of grade A90 / S90 conforming to IS 73 shall be applied at a rate of 1.7 Kg / Sq.M. Over this the second layer of concrete, shall be laid. Finally dry sharp sand shall be sprinkled evenly. Damp Proof Course shall be laid at plinth level, but shall not be carried across doorways.