

Chapter 3

PLAIN CEMENT CONCRETE WORK

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CHAPTER 3: PLAIN CEMENT CONCRETE WORK**CONCRETE WORK
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| 1 | IS 383 | Specification for coarse and fine aggregate from Natural Source for Concrete |
| 2 | IS 456 | Code of practice for plain and reinforced concrete |
| 3 | IS 516 | Method of test for strength of concrete |
| 4 | IS 1199 | Method of sampling and analysis of concrete |
| 5 | IS 1200 (Part II) | Method of measurement of building and civil engineering work (Concrete work) |
| 6 | IS 1322 | Specification for bitumen fleet for water proofing and damp Proofing |
| 7 | IS 1791 | Specification for batch type concrete mixers |
| 8 | IS 2386 | Method of test for aggregate for concrete work |
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| 13 | IS 9103 | For admixtures for concrete |
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3.1 MATERIAL

Concrete shall consist of a mixture of cement, water and aggregates. Admixtures shall be used only with prior approval of the Engineer. In such cases admixtures shall be used strictly in accordance with the manufacturer's instructions, when approved by the Engineer. Concrete may be plain or be reinforced with steel.

3.1.1 Water, Cement and Fine aggregate

Water, cement and fine aggregate or sand shall be as specified in Chapter 11 – Building works.

3.1.2 Coarse Aggregate

3.1.2.1 General: Aggregate most of which is retained on 4.75mm IS Sieve and contains only as much fine material as is permitted in IS 383 for various sizes and grading is known as coarse aggregate. Coarse Aggregate shall be crushed stone or gravel and it shall be obtained from approved/authorized sources.

It shall consist of naturally occurring (uncrushed, crushed or broken) stones. It shall conform to IS: 383 unless otherwise specified. It shall be free from elongated, flaky or laminated pieces, adhering coatings, clay lumps, coal residue, clinkers, slag, mica or other deleterious matter.

3.1.2.2 Size and Grading

- (i) **Stone aggregate and gravel:** It shall be either graded or single sized as specified. Normal size and grading shall be as under:-

- (a) Nominal sizes of graded stone aggregate or gravel shall be 40, 20, 16, or 12.5mm as specified. For any one of the nominal sizes, the proportion of other sizes shall be in accordance with Table 3.1.

TABLE 3.1
Graded Stone Aggregate or Gravel

| IS Sieve Designation | Percentage passing (by weight) for nominal size of | | | |
|----------------------|--|-----------|-----------|-----------|
| | 40mm | 20mm | 16mm | 12.5mm |
| 75mm | 100 | - | - | - |
| 37.5mm | 95 to 100 | 100 | - | - |
| 19mm | 30 to 70 | 95 to 100 | 100 | - |
| 16mm | - | - | 95 to 100 | 100 |
| 11.2mm | - | - | - | 90 to 100 |
| 9.5mm | 10 to 35 | 25 to 55 | 30 to 70 | 40 to 85 |
| 4.75mm | 0 to 5 | 0 to 10 | 0 to 10 | 0 to 10 |

The maximum size of coarse aggregate shall be as large as possible but not greater than 1/4 of the minimum thickness of concrete member provided that in case of R.C.C. the size presents no difficulty to surround the reinforcement thoroughly and fill up the corners properly.

In plain cement concrete, the maximum size may be 80mm subject to above limitations in absence of any special provisions.

For heavily reinforced beams the maximum size shall be restricted to 5 mm less than minimum lateral distance between the bars. Generally for R.C.C. works 20 mm nominal size of aggregate shall be satisfactory.

Aggregates will be tested before and after concrete mix is established and whenever character or source of material is changed. Tests will include a sieve analysis to determine conformity with limits of gradation.

1. Samples of aggregates 5 Kg in weight will be taken by the Contractor at source of supply and submitted to the Engineer before placing orders. These samples if approved shall remain preserved in the Engineer's care for reference and the type of aggregate used in the works shall not be altered without the Engineer's prior approval.
2. Aggregates shall be obtained from an approved source and shall conform to the requirements of IS: 383.

For fine aggregate grading in table of IS: 383: shall be applicable. Aggregates shall not be flaky or elongated particles, defined as particles having a maximum dimension greater than five times the minimum dimension. Aggregate shall have a water absorption not exceeding two percent when tested in accordance with IS.
3. The Contractor shall sample and carryout analysis in the presence of the Engineer's representative, of the fine aggregate and each nominal size of coarse aggregate in use employing the methods described in IS: 383 and 2386 at least once in each week when concreting is in progress and at such more frequent intervals as the Engineer may require. The grading of all aggregates shall be within the respective limits specified in the codes and if, aggregates vary more than the stipulations in the IS on Fineness Modulus, the Engineer may instruct the Contractor to alter the relative proportions of the aggregates in the mix to allow for such difference, or may require further trial mixes.
4. Storage of aggregates shall be provided at each point where concrete is made such that each nominal size of coarse aggregate and the fine aggregate shall be

kept separated at all times. Contamination of the aggregates by the ground or other foreign matter shall be effectively prevented at all times, and each heap of aggregate shall be capable of draining freely. The Contractor shall ensure that graded coarse aggregates are dumped, stockpiled and removed from stockpiles in a manner that does not cause segregation.

5. Wet fine aggregate shall not be used until, in the opinion of the Engineer, it has drained to a constant and uniform moisture content, unless the Contractor with the knowledge of the Engineer measures the moisture content of fine aggregate and adds water in each batch of concrete mixed to allow for the water contained in the fine aggregate.

3.1.2.3 **Stacking:** Aggregate shall be stacked on a hard, dry and level patch of ground. When stockpiling, the aggregate shall not form pyramids resulting in segregation of different sized materials. It shall be stacked separately according to nominal size of coarse aggregates. Stacking shall be done in regular stacks, of height not exceeding 100cm.

3.1.2.4 **Testing:** Coarse aggregate shall be tested as per IS: 2386

3.1.2.5 **Measurements:** For measurement in terms of stacks, aggregates shall be measured in stacks and paid for after making a deduction of 7.5% of the gross measurements of stacks in respect of aggregates of nominal size 40mm and above. No deduction from the gross measurements of the stacks is to be made in respect of aggregates of nominal size below 40mm.

3.1.2.6 **Chemical Admixtures:** When required, admixtures of approved quality shall be mixed with concrete, as specified. The admixtures shall conform to IS: 9103. Manufacturer's instructions should be scrupulously followed for adding chemical admixture.

3.1.2.7 Water stop

Water stop shall be PVC 200 mm wide conforming to CWPD and BARC specifications to make construction joints and expansion joint watertight.

Water stop installation along the joints shall be done by embedding one half of the water stop in each side of the joint between the adjacent sections of the concrete as per manufacturer's specifications and direction of the Engineer. Water stops shall be properly aligned and placed in position during embedding. To achieve continuity of water stop along the joint, at crossing and at change of alignment the water stops shall be welded as per manufacturer's specification and direction of Engineer.

3.2 CEMENT CONCRETE

3.2.1 Grades of Cement Concrete

The concrete shall be in grade designated as under:

Table 3.2: Grades of Concrete

| Group | Grade Designation | Specified Characteristic Compressive Strength of 150 mm Cube at 28 Days in N/mm ² |
|-------------------|-------------------|--|
| Ordinary Concrete | M10 | 10 |
| | M15 | 15 |
| | M20 | 20 |
| Standard Concrete | M25 | 25 |
| | M30 | 30 |
| | M35 | 35 |
| | M40 | 40 |
| | M45 | 45 |
| | M50 | 50 |
| | M55 | 55 |

| | | |
|------------------------|-----|----|
| High Strength Concrete | M60 | 60 |
| | M65 | 65 |
| | M70 | 70 |
| | M75 | 75 |
| | M80 | 80 |

NOTES

1. In the designation of concrete mix the letter M refers to the mix and the suffixed number to the specified compressive strength of 150mm size cube at 28 days, expressed in N/mm².
2. For concrete of compressive strength greater than M55, design parameters given in the standard may not be applicable and the values may be obtained from specialized literatures and experimental results.

3.2.1.1 The characteristic strength is defined as the strength of material below which not more than 5 percent of the test results are expected to fail.

Table 3.3: Minimum Cement Content, Maximum Water-Cement Ratio and Minimum Grade of Concrete for Different Exposures with Normal Weight Aggregates of 20mm Nominal Maximum Size

| Sl. No. | Exposure | Plain Concrete | | | Reinforced Concrete | | |
|---------|-------------|--|---------------------------------|---------------------------|--|---------------------------------|---------------------------|
| | | Minimum Cement Content kg/m ³ | Maximum Free Water-Cement Ratio | Minimum Grade of Concrete | Minimum Cement Content kg/m ³ | Maximum Free Water Cement Ratio | Minimum Grade of Concrete |
| i) | Mild | 220 | 0.60 | - | 300 | 0.55 | M20 |
| ii) | Moderate | 240 | 0.60 | M15 | 300 | 0.50 | M25 |
| iii) | Severe | 250 | 0.50 | M20 | 320 | 0.45 | M30 |
| iv) | Very Severe | 260 | 0.45 | M20 | 340 | 0.45 | M35 |
| v) | Extreme | 280 | 0.40 | M25 | 360 | 0.40 | M40 |

NOTES

1. Cement content prescribed in this table is irrespective of the grades of cement. The additions such as fly ash or ground granulated blast furnace slag may be taken into account in the concrete composition with respect to the cement content and water-cement ratio if the suitability is established and as long as the maximum amounts taken into account do not exceed the limit of pozzolona and slag specified in IS 1489 (Part 1) and IS 455 respectively.
2. Minimum grade for plain concrete under mild exposure condition is not specified.
3. The above minimum cement content and maximum water cement ratio apply only to 20mm nominal maximum size aggregate. For other sizes of aggregates, these should be changed as per Table 6 of IS 456:2000.
The minimum grade of concrete for plain and reinforced concrete shall be as per Table 3.2

3.2.1.2 Concrete of grades lower than those given in Table 3.2 may be used for plain concrete constructions.

3.2.2 Workability of Concrete

Concrete shall be of a consistency and workability suitable for the conditions of the job. After the amount of water required is determined, the consistency of the mix shall be

maintained throughout the progress of the corresponding parts of the work and approved tests e.g. slump tests, compacting factory tests, in accordance with IS. 1199, shall be conducted from time to time to ensure the maintenance of such consistency.

- 3.2.2.1** The concrete mix proportion chosen should be such that the concrete is of adequate workability for the placing conditions of the concrete and can properly be compacted with the means available. Suggested ranges of workability of concrete measured in accordance with IS 1199 are given below:

| Placing Conditions | Degree of Workability | Slump (mm) |
|---|-----------------------|--------------|
| Blinking concrete; Shallow sections; Pavement s using pavers | Very low | See 3.2.2.2 |
| Mass concrete; Lightly reinforced sections in slabs, beams, walls, columns; Floors; Hand placed pavements; Canal lining; Strip footings | Low | 25-75 |
| Heavily reinforced sections in slabs; Beams, walls, columns; | Medium | 50-100 |
| Slip form work; Pumped concrete | Medium | 75-100 |
| Trench fill; <i>In-situ</i> piling | High | 100-150 |
| Tremie concrete | Very high | See 3.2.2.3. |

NOTE – For most of the placing conditions, internal vibrators (needle vibrators) are suitable. The diameter of the needle shall be determined based on the density and spacing of reinforcement bars and thickness of sections. For tremie concrete, vibrators are not required to be used (see also 3.2.9)

- 3.2.2.2** In the ‘very low’ category of workability where strict control is necessary, for example, pavement quality concrete, measurement of workability by determination of compacting factor will be more appropriate than slump (see IS 1199) and a value of compacting factor of 0.75 to 0.80 is suggested.

- 3.2.2.3** In the ‘very high’ category of workability, measurement of workability by determination of flow will be appropriate (see IS: 9103)

Table 3.4 gives a range of slumps which shall generally be used for various types of construction unless otherwise instructed by the Engineer:

Table 3.4: Slump of Concrete for Various Types of construction

| SLUMP (in mm) FOR VARIOUS TYPES OF CONSTRUCTION | | |
|---|--------------|--------------|
| | Maximum (mm) | Minimum (mm) |
| Reinforced foundation walls and footings | 75 | 25 |
| Plain footings and substructure walls | 75 | 25 |
| Slabs, Beams, and reinforced walls | 100 | 25 |
| Building columns | 100 | 25 |
| Pavements | 50 | 25 |

| | | |
|-------------------------|----|----|
| Heavy mass construction | 50 | 25 |
|-------------------------|----|----|

Table 3.5: Proportions for Nominal Mix Concrete

| Grade of Concrete | Total Quantity of Dry Aggregates by Mass per 50Kg of Cement. To be taken as the Sum of the Individual Masses of Fine and Coarse Aggregates, Kg, Max | Proportion of Fine Aggregate to Coarse Aggregate (by Mass) | Quantity of Water per 50kg of Cement, Max |
|-------------------|---|---|---|
| M5 | 800 | Generally 1:2 but subject to an upper limit of 1:1.5 and a lower limit of 1:2.5 | 60 |
| M7.5 | 625 | | 45 |
| M10 | 480 | | 34 |
| M15 | 330 | | 32 |
| M20 | 250 | | 30 |

3.2.3 Mix Design

Mix design is normally a prerequisite to any concreting job and will be required on all major works. If required by the Contract Documents, an approved testing laboratory shall, at the contractor's expense, design a mix for each class of concrete and shall submit full details of the mix designs to the Engineer for his approval. The Engineer's representative and the Contractor shall clearly code each approved mix with a number and date, and file all details for identifying and reproducing exactly the same mix.

3.2.3.1 General:

Each mix design shall be such that the aggregate shall comprise fine aggregate and coarse aggregate of the size specified and the combined aggregate grading shall be continuous. Aggregate shall be calculated by weight, and batching procedures shall be established. The cement content by weight shall not be outside the minimum and maximum limits calculated from the minimum and maximum dry aggregate to cement ratios specified. The mixes shall be designed to produce an average concrete strength at twenty-eight days after manufacture not less than trial mix test strength specified. The water/cement ratio shall be in the region of 0.45 to 0.55 and shall not exceed 0.60.

3.2.3.2 Preliminary Mix:

The proportions of cement, aggregate and water determined by the Contractor in his mix design shall be preliminary mix of concrete made and tested for strength and workability under laboratory conditions observing the appropriate requirements. These preliminary mixes shall be repeated for adjusted proportions as necessary until concrete mixes meeting requirements of the preliminary and trial mix tests specified with the workability defined herein have been produced. If at the time of construction of the works, the source of cement and or aggregates is changed, or the grading of the aggregate is altered, further preliminary mixes shall be undertaken.

3.2.3.3 Trial:

After the Engineer's approval the preliminary concrete design for each class of concrete and during or following carrying out of the preliminary tests the Contractor shall prepare a trial mix of each class in the presence of the Engineer. The mixes shall be mixed for the same time and handled by means of same plant that the Contractor proposes to use in the works. Proportion of cement, aggregates and water shall be carefully determined by weight in accordance with the approved mix (or modified mix design after preliminary tests) and sieve analysis shall be made, by approved methods of the fine aggregate and

nominal size of coarse aggregate used.

3.2.3.4 Water:

Water for mixing concrete, mortar or grout shall satisfy the recommendations of IS: 456. If required to do so by Engineer, the Contractor shall take samples of water and test them for quality.

3.2.3.5 Admixtures:

Admixtures shall mean material added to concrete materials during mixing for the purpose of altering properties of normal concrete mixes. If the Contractor wishes to use admixtures, otherwise than as expressly ordered by Engineer, he shall first obtain the Engineer's written permission. The methods of use and the quantities of admixture used shall be subject to the Engineer's approval, which approval shall in no way limit the Contractor's obligations under the contract to produce concrete with the specified strength and workability. Concrete of any class containing an admixture shall be separately designed and have separate preliminary tests and trial mixes and tested for approval by the Engineer as if it were a separate class of concrete.

3.2.3.6 Waiver of Mix Design and Weigh Batching

On certain works the Engineer may waive the requirement of designing mixes and may allow the use of established nominal mix proportion, provided always that preliminary trial are made to establish the volumetric batching procedure and mix strengths. The Contractor will ensure that any established procedure approved by the Engineer is strictly adhered to, so as to achieve consistent strength, durability and economy of the concrete while ensuring approved workability of the mix. Any waiver of mix design or weigh batching will not relieve the Contractor of his obligations to consistently produce concrete of the specified and approved strength and durability as determined by works tests defined hereafter. However in any particular work/part of work, the Engineer may decide to adopt mix design (mix) concrete.

3.2.3.7 Workability

The workability of each class of concrete shall be such that satisfactory compaction can be obtained when the concrete is placed and vibrated in the works. There shall be no tendency to segregate when it is handled, transported and compacted by the methods which the Contractor proposes to use when handling, transporting and compacting that class of concrete in the works.

3.2.3.8 Concrete Mix Design

Procedure for designing concrete mixes shall be as per IS: 10262-Recommended Guidelines for Concrete Mix Design.

3.2.4 Preparation prior to concrete placement, final inspection and approval

3.2.4.1

Before the concrete is actually placed in position, the insides of the formwork shall be inspected to see that they have been cleaned and oiled with form oil. Engine oil, Waste oil etc shall not be used. There shall not be any gaps in the form work. Waste paper, gunny bags, mud, dung etc shall not be used to close the gaps. Cover blocks with adequate strength shall be placed to obtain the required cover. No stone chips shall be permitted to be used for cover blocks. Chairs shall be provided for the top reinforcement rods. Binding wire shall not be facing towards the cover portion. No laps shall be provided at the center of span at bottom. Similarly no laps shall be permitted near supports for top reinforcement. Scaffolding shall be braced and wedges shall be driven in to adjust the height. Laps in scaffolding shall be tied with binding wire or nailed. The scaffolding should not rest on soil. The spacing of scaffolding shall not be more than 60

cm. Temporary openings shall be provided to facilitate inspection, especially of bottoms of columns and wall forms to permit removal of sawdust, wood shavings, binding wire, dirt, etc. Openings shall be placed or holes drilled so that these materials and water can be removed easily. Such openings/holes shall be suitably plugged later.

- 3.2.4.2 Slots, openings, holes, pockets, etc., shall be provided in the concrete work in the positions specified or required or as directed by the Engineer.
- 3.2.4.3 Reinforcement and other items to be cast in concrete shall have clean surfaces that will not impair bond.
- 3.2.4.4 Prior to concrete placement, all work shall be inspected and approved by the Engineer and if found unsatisfactory, concrete shall not be poured until after all defects have been corrected.
- 3.2.4.5 Approval by the Engineer of any and all materials and work as required herein shall not relieve the Contractor from his obligation to produce finished concrete in accordance with the requirements of the Specifications.
- 3.2.4.6 **Rain or Wash Water:** No Concrete shall be placed in wet weather or on a water-covered surface. Any concrete that has been washed by heavy rains shall be entirely removed, if there is any sign of cement and sand having been washed away from the concrete mixture. To guard against damage which may be caused by rains, the works shall be covered with tarpaulins immediately after the concrete has been placed and compacted before leaving the work. Any water accumulating on the surface of the newly placed concrete shall be removed by approved means and no further concrete shall be placed there on until such water is removed. To avoid flow of water over/around freshly placed concrete, suitable drains and sumps shall be provided.
- 3.2.4.7 **Bonding Mortar:** Immediately before concrete placement begins, prepared surfaces except formwork, which will come in contact with the concrete to be placed, shall be covered with a bonding mortar (cement grout) specified.

3.2.5 Formwork (Centering & Shuttering)

3.2.5.1 General

Formwork shall be so constructed that concrete can be properly and thoroughly compacted. Formwork shall be firmly supported and adequately strutted, braced or tied. It shall be amenable to adjustment to the lines and dimensions of the finished concrete. It shall be sufficiently strong to resist without excessive distortion under the influence of weather.

All formwork shall be constructed to be rigid to prevent distortion due to pressure of concrete, incidental loads and vibration during the casting of concrete and sufficiently watertight to prevent loss of liquid from the concrete. It shall be capable of being removed without shock or vibration to the concrete. The inside faces of the formwork shall be treated with a mould oil of type approved by the Engineer taking unmistakable care to prevent mould oil from getting on to the reinforcement. The lining material shall not bulge, warp or blister and /or stain the concrete.

3.2.5.2 Types of form work

Formwork shall be constructed of sawn timber or other materials as approved by the Engineer. The edges of the boards shall be planed or otherwise rendered grout tight. This system shall be adopted when rough formwork is required.

Where wrought formwork is necessary to provide a smooth, fair faced finish, the formwork shall be constructed of purpose made metal, fibre glass, waterproof plywood panel or hardboard lined form work. The use of a particular material for wrought formwork shall be consistently maintained throughout the structure. The surface of the

formwork in contact with the concrete shall be smooth and free from all blemishes. Repeated use of wrought formwork shall depend on surfaces, joints and edges remaining clean and undamaged.

The arrangement of the panels comprising the formwork for each member shall be subject to the approval of the Engineer prior to commencement.

3.2.5.3 Alignment of formwork

All formwork is to be aligned so that the finished concrete complies with the requirements and as approved by the Engineer, in advance.

3.2.5.4 The contractor shall be entirely responsible for the sufficiency and efficiency of the formwork and also for the safe removal of the same after the safe removal period. At least 14 days before starting erection of the formwork, the contractor shall prepare detailed drawings and specifications he proposes to use and get approval of the Engineer. Such an approval shall in no way relieve the contractor of his sole responsibility for the adequacy, strength and retention of all the fines in the concrete.

3.2.5.5 Forms shall be maintained after erection to eliminate bending, warping and/or shrinking. They shall be checked for dimensions and conditions immediately prior to the placement of concrete. The Engineer may at any time refuse permission to place concrete within the formwork until they are constructed or corrected satisfactorily even if he had approved the formwork earlier.

3.2.5.6 Metal forms shall be of such thickness that they remain true to shape. Bolts and rivets shall be counter sunk.

3.2.5.7 If, at any time of the work during or after placing the concrete, the forms show signs of sagging or bulging, the concrete shall be removed as instructed by the Engineer, the forms brought to the proper position and new concrete placed.

3.2.5.8 Forms shall be cleaned with compressed air immediately before placing concrete to remove all rubbish and the contractor should ensure that the form work is scrupulously clean from all debris, dirt, wash water and any other refuse. The reinforcement and formwork will then be inspected by the Engineer and concreting shall not be commenced until his approval is obtained. The surface where concrete is placed shall be well wetted before concreting, but no water shall be accumulated.

3.2.5.9 All out effort shall be taken by the contractor to avoid any deflection. However, the maximum allowable deflection shall be as given below.

| Location | Permissible Deflection |
|--|------------------------|
| Between adjacent framing members | + 2 mm |
| Between adjacent ties on a frame | + 1 mm |
| Over the full depth of a vertical face | ± 3 mm |
| Over a 3 metre length horizontally | ± 3 mm |

3.2.5.10 The formwork shall be made generally with the following upward cambers

| Members | Desirable Camber |
|---|------------------------------------|
| Cantilever slabs | - 3 mm for every 1.5 metre of span |
| Slabs of span not greater than 3 metres | - 3 mm for every 3.0 metre of span |
| Cantilever beams | - 6 mm for every 1.5 metre of span |
| Beams of span not greater than 6 metres | - 6 mm for every 3.0 metre of span |

3.2.5.11 Striking or removal of Formwork

Form for hand rails, ornamental work and other vertical surfaces that require a hand finish

shall be removed as soon as the concrete has hardened sufficiently and approval has been obtained.

Unless specified in the drawing or directed by the Engineer, the following shall be the minimum intervals of time that should be allowed between finishing the concrete work and striking the form.

| | |
|--|---------|
| Vertical sides of concrete beams, walls and unloaded columns | 1 day |
| Soffits of Slabs (props left in) | 7 days |
| Props to slabs | 14 days |
| Soffits of beams (props left in) | 14 days |
| Props to beams | 21 days |

However the contractor shall delay the removal of shuttering as long as necessary in order to avoid damages to the work.

Removal of shuttering of soffits prior to the props is permissible only if the design of the shuttering allows such a sequence of operations without the props being in no way disturbed. If the shuttering and props are not independent, both must be left in place until propping is not required.

3.2.6 **Mixing:**

Concrete shall be mixed in mechanical batch type concrete mixers conforming to IS 1791 having two blades and fitted with power loader (lifting hopper type). Half bag mixers and mixers without lifting hoppers shall not be used for mixing concrete. In exceptional circumstances, such as mechanical break down of mixer, work in remote areas or power break down and when the quantity of concrete work is very small, hand mixing may be done with the specific prior permission of the Engineer in writing subject to adding 10% extra cement. When hand mixing is permitted, it shall be carried out on a water tight platform and care shall be taken to ensure that mixing is continued until the concrete is uniform in colour and consistency. Before mixing the stone aggregate or gravel shall be washed with water to remove, dirt, dust and other foreign materials. For guidance, the mixing time may be 1½ to 2 minutes, for hydrophobic cement it may be taken as 2½ to 3 minutes.

3.2.6.1 Machine Mixing: The mixer drum shall be flushed clean with water. Measured quantity of coarse aggregate shall be placed first in the hopper. This shall be followed with measured quantity of fine aggregate and then cement. In case fine aggregate is damp, half the required quantity of coarse aggregate shall be placed in the hopper, followed by fine aggregate and cement. Finally the balance quantity of coarse aggregate shall be fed in the hopper, & then the dry materials are slipped into the drum by raising the hopper. The dry materials shall be mixed for at least four turns of the drum. While the drum is rotating, water shall be added gradually to achieve the water cement ratio as specified or as required by the Engineer. After adding water, the mixing shall be continued until concrete of uniform colour, uniformly distributed material and consistency is obtained. Mixing shall be done for at least two minutes after adding water. If there is segregation after unloading from the mixer, the concrete should be remixed.

The drum shall be emptied before recharging. When the mixer is closed down for the day or at any time exceeding 20 minutes, the drum shall be flushed and cleaned with water.

3.2.6.2 **Hand Mixing:**

When hand mixing has been specifically permitted in exceptional circumstances by the Engineer in writing, subject to adding 10% extra cement, it shall be carried out on a

smooth, clean and water tight platform of suitable size. Measured quantity of sand shall be spread evenly on the platform and the cement shall be dumped on the sand and distributed evenly. Sand and cement shall be mixed intimately with spade until mixture is of even colour throughout. Measured quantity of coarse aggregate shall be spread on top of cement sand mixture and mixing done by shoveling and turning till the coarse aggregate gets evenly distributed in the cement sand mixture. Three quarters of the totally quantity of water required shall be added in a hollow made in the middle of the mixed pile and the material is turned towards the middle of pile with spade. The whole mixture is turned slowly over and again and the remaining quantity of water is added gradually. The mixing shall be continued until concrete of uniform colour and consistency is obtained. The mixing platform shall be washed and cleaned at the end of the day.

3.2.7 Transportation

3.2.7.1 General: All buckets, and containers used for transporting concrete shall be water-tight. Irrespective of the method of transportation adopted, concrete shall be delivered with the required consistency and plasticity without segregation or loss of slump. However, chutes shall not be used for transport of concrete without the written permission of the Engineer and concrete shall not be re-handled before placing.

3.2.7.2 Re-tempered or Contaminated Concrete: Concrete must be placed in its final position before it becomes too stiff to work. On no account, water shall be added after the initial mixing. Concrete, which has become stiff or has been contaminated with foreign materials shall be rejected and disposed of as directed by the Engineer.

3.2.7.3 Cleaning of Equipment: All equipment used for mixing, transporting and placing of concrete shall be maintained in clean condition. All pans, buckets and other equipment shall be thoroughly cleaned after each period of placement.

3.2.8 Procedure for placing of concrete

3.2.8.1 Engineer's approval of equipment & methods: Before any concrete is placed, the entire placing programme, consisting of equipment, layout, proposed procedures and method of placing shall be submitted to the Engineer for approval and no concrete shall be placed until Engineer's approval has been received. Equipment for conveying concrete shall be of such size and design as to ensure a practically continuous flow of concrete during depositing without segregation of materials, considering the size of the job and placement location.

3.2.8.2 Time interval between mixing and placing: Concrete shall be placed in its final position before the cement reaches its initial set and concrete shall normally be compacted in its final position within thirty minutes of leaving the mixer and once compacted, it shall not be disturbed. Where the thirty minute period cannot be complied with, a suitable retarder shall be used on approval of the retarder, its proportion, method of addition etc. by the Engineer and the time limit fixed thereof shall be strictly adhered to.

3.2.8.3 Avoiding Segregation: Concrete shall, in all cases, be deposited as nearly as practicable directly, in its final position, and shall not be re-handled or caused to flow in a manner which will cause segregation, loss of materials, displacement of reinforcement, shuttering or embedded inserts, or impair its strength. For locations where direct placement is not possible, and in narrow forms, the Contractor shall provide suitable chute to confine the movement of concrete. Special care shall be taken when concrete is dropped from a height, especially if reinforcement is in the way, particularly in columns and thin walls.

3.2.8.4 Placing by manual labour: Except when otherwise approved by the Engineer, concrete shall not be dropped from a height more than 1.0 m or handled in a manner, which will cause segregation and shall not be allowed to be re-handled by trowel or rake (panja).

3.2.8.5 Chuting: Where it is necessary to use transfer chutes, specific approval of Engineer must be obtained to type, length, slopes, baffles, vertical terminals and timing of operations.

These shall be so arranged that an almost continuous flow of concrete is obtained at the discharge and without segregation. To allow for the loss of mortar against the sides of the chutes, the initial mix shall have less coarse aggregate. During cleaning of chutes, the wastewater shall be kept clear of the forms. Concrete shall not be permitted to fall from the end of the chutes by more than 1.5 m. Chutes, when approved for use, shall have slopes not flatter than 1 vert: 3 horiz. and not steeper than 1 vert.: 2 horiz. Chutes shall be of metal or metal lined made of circular cross section. The slopes of all chute sections shall be approximately the same. The discharge end of the chutes shall be maintained above the surface of the concrete in the forms.

3.2.8.6 Concrete in Layers: Concreting, once started, shall be continuous until the pour is completed. Concrete shall be placed in successive, horizontal layers of uniform thickness ranging from 15 cm to 90 cm as directed by Engineer. These shall be placed as rapidly as practicable to prevent the formation of cold joints or planes of weakness between each succeeding layer within the pour. The thickness of each layer shall be such that it can be deposited before the previous layer has stiffened. The bucket loads or other units of deposit shall be spotted progressively along the face of the layer with such overlap as will facilitate spreading the layer to uniform depth and texture with minimum shoveling. Any tendency to segregation shall be corrected by shoveling stones into mortar rather than mortar on to stones.

3.2.8.7 Bedding of Layers: The top surface of each pour and bedding planes shall be approximately horizontal unless otherwise instructed.

3.2.9 Compaction: Concrete shall be compacted during placing, with approved vibrating equipment until the concrete has been consolidated to the maximum practicable density, free of pockets of coarse aggregate and fits tightly against all form surfaces, reinforcement and embedded fixtures. Particular care shall be taken to ensure that all concrete placed against the form faces and into corners of forms, against hardened concrete at joints is free from voids or cavities. The use of vibrators shall be consistent with the concrete mix and caution exercised not to over vibrate the concrete to the point that results segregation.

Type of vibrators: Vibrator shall conform to IS. 2505, IS.2506, IS.2514 or IS.4656 specifications as is appropriate. Type of vibration to be used shall depend on the structures where concrete is to be placed. External (Shutter) vibrators to be effective, shall be firmly secured to the form work which must be sufficiently rigid to transmit the vibration and strong enough not to be damaged by it. Immersion vibrators in sufficient numbers and each of adequate size shall be used to properly consolidate all concrete. Tapping or external vibrating of forms by hand tools will not be permitted.

Use of vibrators: The exact manner of application and the most suitable machines for the purpose must be carefully considered and operated by experienced men. Immersion vibrators shall be inserted vertically at points not more than 450 mm apart and the spacing be uniform and withdrawn vertically when air bubbles cease to come to the surface. Immersion vibrators shall be withdrawn very slowly (20-30mm / second). Time required for vibration is about 90 seconds (less time if workability is more). No hole shall be formed after withdrawing the needle. In no case shall immersion vibrators be used to transport concrete inside the forms. Particular attention be paid to vibration at the top of a lift. The total depth of immersion shall be not more than 2/3 rd of the length of the needle. There shall not be any bends in the cable. Higher aggregate sizes require lower frequencies of vibration (100f, 150f, 200f for 40mm, 20mm and 10mm size aggregates). The vibrator shall not be nearer than 1m from free end. Distance between form work and vibrator shall be 100-200mm.

Blending successive layers: When placing concrete in layers, which are advancing horizontally as the work progresses, great care shall be exercised to ensure adequate vibration, blending and melding of the concrete between the succeeding layers.

Penetration of vibrators: The immersion vibrator shall penetrate the layer being placed and also penetrate the layer below for a depth of 100-200 mm while the under layer is still plastic to ensure good bond and homogeneity between the two layers and prevent the formation of cold joints.

Vibrating against Reinforcement (rebar): Care shall be taken to prevent contact of immersion vibrator against reinforcement steel (rebar). Immersion vibrator shall not be allowed to come in contact with reinforcement steel after start of initial set. They shall also not be allowed to come in contact with forms or finished surfaces.

Use of Surface Vibrators: The use of surface vibrators will not be permitted under normal conditions. However, for thin slabs, surface vibrating by specially designed vibrators may be permitted, upon approval of Engineer.

Stone pockets and mortar sandages: The formation of stone pockets and mortar sandages, in corners and against faces of forms shall not be permitted. Should these occur, they shall be removed, reformed and refilled to sufficient depth and shape for thorough bonding, as directed by the Engineer.

Special Provision in placing: When placing concrete in walls with openings, in floors of integral slabs and beam construction and other similar conditions, the placing shall stop when the concrete reaches the top of the opening in walls or bottom horizontal surface of the slab, as the case may be.

Placing shall be resumed before the concrete in place takes initial set, but not until it has had time to settle as determined by the Engineer.

Placing concrete through reinforcing steel: When placing concrete through reinforcing steel, care shall be taken to prevent segregation of the coarse aggregate. Where the congestion of steel makes placing difficult, it may be necessary to temporarily move the top steel aside to get proper placement and restore reinforcing steel to design position and the Engineer's approval shall be obtained prior to adopting this method.

Bleeding: Bleeding or free water on top of concrete being deposited into the forms, shall cause to stop the concrete pour and the conditions causing this defect corrected before any further concreting is resumed.

- 3.2.9.1** 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 coarse aggregate. The surface shall be thoroughly wetted and all free water removed. The surface shall then be coated with neat cement slurry @ 2 kgs of cement per sq.m. On this surface, a layer of concrete not exceeding 150mm in thickness shall first be placed and shall be well rammed against corners and close spots; work, thereafter, shall proceed in the normal way.

3.2.10 Curing and Finishing

3.2.10.1 Curing –General

Curing is the process of preventing loss of moisture from the concrete. The following methods shall be employed for effecting curing.

Moist Curing: Exposed surfaces of concrete shall be kept continuously in a damp or wet condition by ponding or by covering with a layer of sacking, canvas hessian or similar materials and kept constantly wet for at least 7 days from the date of placing concrete in case of ordinary Portland cement and atleast 10 days where mineral admixtures or blended cements are used. The period of curing shall not be less than 10 days for concrete exposed to dry and hot weather conditions. In the case of concrete where mineral admixtures or blended cements are used, it is recommended that above minimum periods may be extended to 14 days.

Membrane Curing: Approved curing compounds may be used in lieu of moist curing with the permission of the Engineer. Such compound shall be applied to all exposed surfaces of the concrete as soon as possible after the concrete has set. Impermeable membrane such as polythene sheet covering the concrete surface may also be used to provide effective barrier against evaporation.

Freshly laid concrete shall be protected from rain by suitable covering.

Over the foundation concrete, the masonry work may be started after 48 hours of its compaction but the curing of exposed surfaces of cement concrete shall be continued along with the masonry work for atleast 7 days. And where cement concrete is used as base concrete for flooring, the flooring may be commenced before the curing period of base concrete is over but the curing of base concrete shall be continued along with top layer of flooring for a minimum period of 7 days.

After the concrete has begun to harden i.e. about 1 to 2 hours after laying, it shall be protected from quick drying by covering with moist gunny bags, sand, canvass hessian or any other material approved by the Engineer. After 24 hours of laying of concrete, the surface shall be cured by ponding with water for a minimum period of 7 days from the date of placing of concrete in case of OPC and at least 10 days where mineral admixtures or blended cements are used. The period of curing shall not be less than 10 days for concrete exposed to dry and hot weather condition.

All concrete shall be cured by keeping it continuously damp for the period of time required for complete hydration and hardening to take place. Preference shall be given to the use of continuous sprays or water ponding, continuously saturated coverings of sacking, canvas, hessian or other absorbent materials, or approved effective curing compounds applied with spraying equipment capable for producing a smooth, even – texture coating providing that the curing compound shall not lead to stubborn staining of exposed concrete surfaces. Extra precautions shall be exercised in curing concrete during cold and hot weather as outlined hereinafter. The quality of curing water shall be the same as that used for mixing concrete. This is very important. Water from sullage drains shall not be used for curing.

3.2.10.2 Curing with Water

Fresh concrete shall be kept continuously wet for a minimum period of 21 days from the date of placing of concrete, following a lapse of 12 to 14 hours after laying concrete. This curing of horizontal surface exposed to the drying winds shall however begin as soon as the concrete has hardened. Water shall be applied to formed surfaces immediately upon removal of forms. Quantity of water applied shall be controlled also to prevent erosion of freshly placed concrete.

3.2.10.3 Alternate curing methods

Whenever, in the judgment of the Engineer, it is necessary to omit the continuous spray method, a covering of clean sand or other approved means such as wet gunny bags, which will prevent loss of moisture from the concrete, may be used. No type of covering will be approved which would stain or damage the concrete during or after the curing period. Covering shall be kept continuously wet during the curing period. For curing of concrete in floors, flat roofs or other level surfaces, the ponding method of curing is preferred. The method of containing the ponding water shall be approved by the Engineer. Special attention shall be given to edges and corners of the slabs to ensure proper protection to these areas. The ponding areas shall be kept continuously filled with water during the curing period.

3.2.10.4 Curing equipment

All equipment and materials required for curing shall be on hand and ready for use before concrete is placed.

3.2.10.5 Protecting fresh concrete

Fresh concrete shall be protected from defacements and damage due to construction operations by leading forms in place for an ample period as specified later in this specification. Newly placed concrete shall be protected by approved means such as tarpaulins from rain, sun and winds. Steps as approved by the Engineer shall also be taken to protect immature concrete from damage by debris, excessive loading, vibration, abrasion or contact with other materials, etc. that may impair the strength and/or durability of the concrete. Workmen shall be warned against and prevented from disturbing green concrete during its setting period. If it is necessary that the workmen enter the area of freshly placed concrete, the Engineer may require that bridges be placed over the area.

3.2.10.6 Repair and replacement of unsatisfactory concrete

Immediately after the shuttering is removed, the surface of concrete shall be inspected and all defective areas called to the attention of the Engineer who may permit rectifying of the defective areas or reject the concrete unit either partially or in its entirety. Rejected concrete shall be removed and replaced by the contractor to Engineer's approval. Holes shall be filled with approved non-shrink spoxy mortar as per manufacturer's specifications and to Engineer's approval. Concrete surfaces shall be finished as described in specifications or as directed by the Engineer. Honeycombed surfaces and rough patches shall be similarly made good (with cutting back of concrete to the rear side of reinforcement as required by the Engineer), in the presence of the Engineer water and air holes shall be filled in. The mortar shall be well worked into the surface with a wooden float. Excess water shall be avoided. Unless instructed otherwise by the Engineer, the surface of the exposed concrete placed against shuttering shall be rubbed down immediately on removal of shuttering lines to remove any irregularities, care being taken to avoid damaging the surface. If reinforcement is exposed or honey-combining occurs at any vulnerable position it may be necessary to cut out the member completely or in part and reconstruct. The decision of the Engineer shall be final in this regard. If only rectification is necessary, the edges should be cut perpendicular to the affected surface with a small under cut as is possible. Anchors, tees or dovetail slots shall be provided whenever necessary to attach the new concrete securely in place. The area extending several centimeters beyond the edges and the surface of the prepared rectification areas shall be saturated with water for 24 hours or prepared as per manufacturer's specifications of the approved repair material immediately before the rectifying material is placed.

3.2.10.7 Finishing- General

The type of finish for formed concrete surfaces shall be as follows, unless varied by the Engineer.

It includes removal of fins and abrupt irregularities, filling defective concrete, filling of holes left by form ties and rods and clean up of loose or adhering debris. Surfaces which will be exposed to the weather and which would normally be level, shall be sloped for drainage. Unless a horizontal surface or the slope required is specified, the tops of narrow surfaces such as stair treads, walls, curbs and parapets shall be sloped across the width approximately 1 in 30. Broader surfaces such as walkways, and platform shall be sloped about 1 in 50. Joints and edges shall be tooled as specified or as directed by the Engineer.

Standard finish for exposed concrete

Exposed concrete shall mean any concrete, other than floors or slabs, exposed to view upon completion of the works. Unless otherwise specified, the standard finish for exposed concrete shall be smooth finish. A smooth finish shall be obtained with the use of lined or plywood forms having smooth and even surfaces and edges. Panels of forms shall be of uniform size and be as large as practicable and install with closed joints. Upon removal of forms, the joints marks shall be smoothened off and all blemishes, projections

etc., removed leaving the surfaces smooth.

Protection

All concrete shall be protected against damage until final acceptance by the Engineer.

3.2.10.8 Testing of concrete will be done as specified in IS 516.

3.2.11 Preparation of ground for receiving foundations

3.2.11.1 General

All earth surfaces upon which or against which concrete is to be placed, shall be well compacted and free from standing water, mud or debris. Soft, yielding soil shall be removed and replaced with suitable earth well compacted or lean concrete as directed by the Engineer. Where specified, lean concrete shall be provided on the earth stratum for receiving concrete. The surface of soils against which concrete is to be placed shall be moistened thoroughly so that no moisture will be drawn from the freshly placed concrete and later shall help to cure the concrete.

3.2.11.2 The preparation of concrete surfaces upon which additional concrete is to be placed later, shall preferably be done by scarifying and cleaning while the concrete is between its initial and final set. This method shall be used wherever practicable; it shall consist of cutting the surface with picks and stiff brooms as directed by the Engineer. Great care shall be taken in performing this work to avoid removal of too much mortar and the weakening of the surface by loosening of aggregate. The final required result shall be a pitted surface from which all dirt, unsound concrete, laitance have been removed.

3.2.11.3 Bonding treatment (Cement grout)

- i) After rock and concrete surfaces upon which new concrete is to be placed have been scarified, cleaned and wetted as specified herein, they shall receive a bonding treatment, immediately before placement of the concrete.
- ii) The bonding medium shall be a coat of cement mortar (Cement grout). The mortar shall have the same cement- sand proportions as the concrete which shall be placed on it.
- iii) Bonding mortar shall be placed in sufficient quantity to completely cover the surface, about 10mm thick for rock surface and about 5mm thick for concrete surface. It shall be brushed or boomed over the surface and worked thoroughly into all cracks, crevices and depressions. Accumulations or puddles of mortar shall not be allowed to settle in depressions and shall be brushed out to a satisfactory degree, as determined by Engineer.
- iv) Mortar shall be placed at such a rate that it can be brushed over the surface just in advance of the placement of concrete. The amount of mortar that will be permitted to be placed at any one time, or the area which it is to cover, shall be in accordance with the Engineer's directions.

3.2.11.4 Cleaning and Bonding formed construction joints

Vertical construction joints shall be cleaned as specified above or by other methods approved by the Engineer. In placing concrete against formed construction joints, the surface of the joints, where accessible, shall be coated thoroughly with the specified bed-joints, bonding mortar immediately before they are covered with concrete or by scrubbing with wire brushes dipped into the fresh concrete.

3.2.12 Inspection

- i) All materials, workmanship and finished construction shall be subject to continuous inspection and approval of the Engineer.
- ii) All materials supplied by the Contractor and all work or construction performed by the Contractor which are rejected as not being in conformity with the

- specification and requirements, shall be immediately replaced.
- iii) All concrete shall be protected against damage until final acceptance by the Engineer.

3.2.13 Clean-up

- i) Upon completion of the concrete work, all forms, equipment, construction tools, protective coverings and any debris resulting from the work shall be removed from the premises.
- ii) All debris, i.e. empty containers, scrap wood, etc., shall be removed as directed by the Engineer.
- iii) The finished concrete surfaces shall be left in a clean condition satisfactory to the Engineer.

3.2.14 Underwater concreting

No concrete shall be placed in water without the Engineer's written permission, which may only be granted if in his opinion it is not practicable to place the concrete in the dry. Concrete shall not be placed in running water nor shall concrete be allowed to fall through water. Any water entering the area where concrete is being placed shall, at the Contractor's expenses, be kept clear of the concreting works. If under water concreting is permitted, the specified mix of concrete shall be strengthened by increasing the cement content by at least 10.0% and reducing the water/cement ratio to no more than 0.45, and the placing shall be only through a tremie approved by the Engineer. The volume or mass of the coarse aggregate shall not be more than twice that of the fine aggregate. The materials shall be so proportioned as to produce a concrete having a slump of not less than 100 mm and not more than 180 mm.

3.2.15 Measurements

3.2.15.1 Dimensions of length, breadth and thickness shall be measured correct to nearest cm. except for the thickness of slab and partition which shall be measured to nearest 5 mm. Areas shall be worked out to nearest 0.01sq.m. Any work done in excess over the specified dimensions or sections shown in drawing shall be ignored

3.2.15.2 Cast-in-situ concrete and or precast concrete work shall be measured in stages described in the item of work, such as:

- a. At or near the ground level
- b. Up to specified height floor level
- c. Between two specified floor levels
- d. Up to specified height above or depth below plinth level/ defined datum level
- e. Between two specified heights or depths with reference to plinth/defined datum level.

3.2.15.3 No deduction shall be made for the following:

- a. Ends of dissimilar materials for example beams, posts, girders, rafters, purlins, trusses, corbels and steps up to 500sq cm in cross sections
- b. Opening up to 0.1 sq metre (1000 sq.cm)
- c. Volume occupied by pipes, conduits, sheathing, etc, not exceeding 100 sq. cm each in cross sectional areas.

3.2.15.4 Cast-in-situ and precast concrete work shall be measured separately.

List of Mandatory Tests

| Material | Clause | Test | Field/Laboratory | Test Procedure | Min. Qty of Material for Carrying out test | Frequency of Testing |
|-----------------|---------------|---|--|-----------------------|---|---|
| Stone aggregate | 3.1.2.1 | a) Percentage of soft or deleterious material | General visual Inspection / Laboratory Test where required by the Engineer | I.S 2386 Part II. | One test for each source or as directed by the Engineer | One Test for each source or as directed by the Engineer |
| | 3.1.2.2 | Particle size distribution | Field /Lab | IS. 383 | 10cum | Every 40cum or part thereof |
| | 3.1.2.4 | a) Estimation of organic impurities | Field /Lab | I.S 2386 Part II | 10cum | - do- |
| | | b) Surface moisture | Field /Lab | I.S 2386 | 10cum | - do- |
| | | c) Determination of 10% fine value | Field /Lab | I.S 2386 | 10cum | -do - |
| | | d) Specified gravity | Field /Lab | I.S 2386 | 10cum | - do- |
| | | e) Bulk density | Field /Lab | I.S 2386 | 10cum | - do- |
| | | f) Aggregate crushing strength | Field /Lab | I.S 2386 | 10cum | - do- |
| | | g) Aggregate impact value | Field /Lab | I.S 2386 | 10cum | - do- |
| Concrete | 3.2.2 | Slump test | Field | I.S 1199 and I.S 9103 | 10cum | 15 cum or part thereof |
| | 3.2.9 | Compaction | Field I.S. 1199 | | 20cum | Every 20cum or part thereof |