4.0 CONCRETE WORK

4.1. MATERIAL

Water, cement, fine aggregate or sand, surkhi, and fly ash shall be as specified in Chapter 3.0 – Mortar.

4.1.1 Coarse Aggregate

4.1.1.1 ***General:*** Aggregate most of which is retained on 4.75 mm 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 specified as stone aggregate, gravel or brick aggregate and it shall be obtained from approved/ authorized sources.

(a) *Stone Aggregate:* It shall consist of naturally occurring (uncrushed, crushed or broken) stones. It shall be hard, strong, dense, durable and clean. It shall be free from veins, adherent coating, injurious amounts of disintegrated pieces, alkali, vegetable matter and other deleterious substances. It shall be roughly cubical in shape. Flaky and elongated pieces shall be avoided. **Aggregates from other than natural resources shall comply with the requirements of IS 383.**

(b) *Gravel:* It shall consist of naturally occurring (uncrushed, crushed or broken) river bed shingle or pit gravel. It shall be sound, hard and clean. It shall be free from flat particles of shale or similar laminated material, powdered clay, silt, loam, adherent coating, alkali, vegetable matter and other deleterious substances. Pit gravel shall be washed if it contains soil materials adhering to it. These shall conform to IS 383 unless otherwise specified.

(c) *Brick Aggregate:* Brick aggregate shall be obtained by breaking well burnt or overburnt dense brick/ brick bats. They shall be homogeneous in texture, roughly cubical in shape and clean. They shall be free from unburnt clay particles. Soluble salt, silt, adherent coating of soil, vegetable matter and other deleterious substances. Such aggregate should not contain more than one percent of sulphates and should not absorb more than 10% of their own mass of water, when used in cement concrete. It shall conform to IS 306 unless otherwise specified.

(d) Light weight aggregate such as sintered fly ash aggregate may also be used provided the Engineer-in-Charge is satisfied with the data on the proportion of concrete made with them.

4.1.1.2 ***Deleterious Material:*** Coarse aggregate shall not contain any deleterious material, such as pyrites, coal, lignite, mica, shale or similar laminated material, clay, alkali, soft fragments, sea shells and organic impurities in such quantity as to affect the strength or durability of the concrete. Coarse aggregate to be used for reinforced cement concrete. Coarse aggregate to be used for reinforced cement concrete shall not contain any material liable to attack the steel reinforcement. Aggregates which are chemically reactive with alkalies of cement shall not be used. The maximum quantity of deleterious material shall not be more than five percent of the weight of coarse aggregate when determined in accordance with IS 2386.

4.1.1.3 ***Size and Grading***

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

(a) Nominal sizes of graded stone aggregate or gravel shall be 40, 20, 16, or 12.5 mm as specified. For any one of the nominal sizes, the proportion of other sizes as determined by the method prescribed in Appendix 'A' of Chapter 4 shall be in accordance with Table 4.1.

TABLE 4.1
Graded Stone Aggregate or Gravel

IS Sieve Designation	*Percentage passing (by weight) for nominal size of*			
	40 mm	*20 mm*	*16 mm*	*12.5 mm*
80 mm	100	-	-	-
63 mm	-	-	-	-
40 mm	95 to 100	100	-	-
20 mm	30 to 70	95 to 100	100	100
16 mm	-	-	90 to 100	-
12.5 mm	-	-	-	90 to 100
10 mm	10 to 35	25 to 55	30 to 70	40 to 85
4.75 mm	0 to 5	0 to 10	0 to 10	0 to 10

(b) Nominal sizes of single sized stone aggregate or gravel shall be 63, 40, 20, 16, 12.5 or 10 mm as specified. For any one of the nominal size, the proportion of other sizes as determined by the method prescribed in Appendix 'A' of Chapter 4 shall be in accordance with Table 4.2.

TABLE 4.2
Single Sized (Ungraded) Stone Aggregate or Gravel

IS Sieve Designation	*Percentage passing (by weight) for nominal size of*					
	63 mm	*40 mm*	*20 mm*	*16 mm*	*12.5 mm*	*10 mm*
80 mm	100	-	-	-	-	-
63 mm	85-100	100	-	-	-	-
40 mm	0-30	85-100	100	-	-	-
20 mm	0- 5	0-20	85-100	100	-	-
16 mm	-	-	-	85-100	100	-
12.5 mm	-	-	-	-	85-100	100
10 mm	0-5	0-5	0-20	0-30	0-45	85-100
4.75 mm	-	-	0-5	0-5	0-10	0-20
2.36 mm	-	-	-	-	-	0-5

(c) When stone aggregate or gravel brought to site is single sized (ungraded), it shall be mixed with single sized aggregate of different sizes in the proportion to be determined by field tests to obtain graded aggregate of specified nominal size. For the required nominal size, the proportion of other sizes in mixed aggregate as determined by method prescribed in Appendix 'A' of Chapter 4 shall be in accordance with Table 4.1. Recommended proportions by volume for mixing of different sizes of single size (ungraded) aggregate to obtain the required nominal size of graded aggregate are given in Table 4.3.

TABLE 4.3
Single Sized (Ungraded) Stone Aggregate or Gravel

Cement concrete	*Nominal size of graded aggregate required*	*Parts of single size aggregate of size*				
		50 mm	*40 mm*	*20 mm*	*12.5 mm*	*10 mm*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1:6:12	63	9	-	3	-	-
1:6:12	40	-	9	3	-	-
1:5:10	63	7.5	-	2.5	-	-

(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*
1:5:10	40	-	7.5	2.5	-	-
1:4:8	63	6	-	2	-	-
1:4:8	40	-	6	2	-	-
1:3:6	63	4.5	-	1.5	-	-
1:3:6	40	-	4.5	1.5	-	-
1:3:6	20	-	-	4.5	-	1.5
1:2:4	40	-	2.5	1	-	1.5
1:2:4	20	-	-	3	-	1
1:2:4	12.5	-	-	-	3	1
1:1 ½:3	20	0	0	2	-	1

Note:

(i) The proportions indicated in Table 4.3 above are by volume when considered necessary, these proportions may be varied marginally by Engineer-in-Charge after making sieve analysis of aggregate brought to site for obtaining required graded aggregate. No adjustments in rate shall be made for any variation in the proportions so ordered by the Engineer-in-Charge. If single size coarse aggregate are not premixed at site to obtain the graded coarse aggregate required for the mix, the volume of single size aggregates required for the mix shall be suitably increased to account for reduction in total volume at the site of mixing.

(ii) *Brick Aggregate:* Nominal size of brick aggregate shall be 40 mm and its grading shall be as specified in Table 4.4 when tested for sieve analysis for the method prescribed in Appendix 'A' of Chapter 4.0.

TABLE 4.4
Brick Aggregate

IS Sieve Designation	*Percentage passing (by weight)*
75 mm	100
37.5 mm	95-100
20.0 mm	45-100
4.75 mm	0.50

4.1.1.4 ***Stacking:*** Aggregate shall be stacked on a hard, dry and level patch of ground. When stack piling, 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 100 cm.

4.1.1.5 ***Testing:*** Coarse aggregate shall be tested for the followings (as per IS 2386)

(a) Determination of particle size and shape (Appendix 'A' of Chapter 4)
(b) Estimation of organic impurities (as per IS 2386 - Part II)
(c) Surface moisture (Appendix 'B' of Chapter 4)
(d) Determination of 10% fine value (Appendix 'C' of Chapter 4)

4.1.1.6 ***Measurements:*** The 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 40 mm and above. No deduction from the gross measurements of the stacks is to be made in respect of aggregate of nominal size below 40 mm.

4.1.2 Chemical Admixtures

When required, admixtures of approved quality shall be mixed with concrete, as specified. The admixtures shall conform to IS 9103 and as specified in Chapter 5 - R.C.C.

4.1.2.1 Admixtures may be any one of the following classes for use in concrete:-

(a) Water Reducing Admixtures
(b) Retarding Admixtures
(c) Accelerating Admixtures.
(d) Water Reducing and Retarding Admixtures.
(e) Water Reducing and Accelerating Admixtures.
(f) Permeability Reducing (water proofing) Admixtures.

4.1.2.2 ***Liquid Admixtures:*** Admixtures introduced into the concrete as liquids generally fall into the following categories.

(a) Air Entraining.
(b) Water Reducing.
(c) Water Reducing Retarders.
(d) Retarders.
(e) Water Reducing Accelerators.
(f) Accelerators.

4.1.2.3 Dosage of these admixtures may vary according to manufacturers specification.

4.1.2.4 Two or more admixtures may not be compatible in the same solution. It is therefore mandatory that when two admixtures manufactured by the same manufacturers is being used simultaneously, the manufacturer shall certify their compatibility. In case the two or more admixtures are produces by different manufacturers, then, before their use in concrete, test shall be performed by the manufacturer to establish their compatibility, all such test reports shall be furnished to the Engineer-in-Charge for his approval before their use in concrete.

4.1.2.5 Some admixture may be in the form of powder, particle or high concentration liquids which may require mixing with water prior to dosing. Under these conditions water in solution shall be considered as part of total water content in the batch in order to maintain the water-cement ratio.

4.1.2.6 Admixture manufacturer's recommendation shall be carefully followed so as to ensure complete solution of the product or to prepare a standard solution of uniform strength for easier use.

4.1.2.7 Certain admixtures may contain significant amounts of finely divided insoluble materials or active ingredients which may or may not be readily soluble. It is essential for such admixtures that precautions be taken to ensure that these constituents be kept in a state of uniform suspension before actual batching. When relatively small amounts of powered admixtures are to be used directly, these shall be pre-blended with cement.

4.1.2.8 Admixtures are sold under various trade names and may be in the form of liquids or powders. The proprietary name and the net quantity of content shall be clearly indicated in each package or container of admixtures. The admixtures shall be uniform within each batch and uniform between all batches.

4.1.2.9 No admixtures shall be accepted for use in concrete unless these are tested in accordance with IS 9103 and the test results are approved by the Engineer-in-Charge.

4.2. CEMENT CONCRETE

4.2.1 Grades of Cement Concrete

The concrete shall be in grade designated as under:

TABLE 4.5
Grades of Concrete

Group	*Grade Designation*	*Specified characteristic compressive strength of 150 mm Cube at 28 Days in N/mm^2*
(1)	(2)	(3)
Ordinary Concrete	M10	10
	M15	15
	M20	20
Standard Concrete	M25	25
	M30	30
	M35	35
	M40	40
	M45	45
	M50	50
	M55	55
	M60	**60**
High Strength Concrete	**M65**	**65**
	M70	**70**
	M75	**75**
	M80	**80**
	M 85	**85**
	M 90	**90**
	M 95	**95**
	M 100	**100**

Notes :

1. In the designation of concrete mix M refers to the mix and the number to the specified compressive strength of 150 mm size cube at 28 days, expressed in N/mm^2.
2. For concrete of compressive strength greater than **M60,** design parameters given in the standard may not be applicable and the values may be obtained from specialized literatures and experimental results.

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

TABLE 4.6
Minimum Cement Content, Maximum Water-Cement Ratio and Minimum Grade of Concrete for Different Exposures with Normal Weight Aggregates of 20 mm Nominal; Maximum Size
(Clause 4.2.1.1)

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*
(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
(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 **and types** of cement **and inclusive of mineral admixtures mentioned in 5.9.1.3.** 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. **Beyond which these additions through permitted, shall not be considered for these purpose.**
2. Minimum grade for plain concrete under mild exposure condition is not specified.
3. **The minimum cement content, maximum free water cement ratio and minimum grade of concrete are individually related to exposure.**

The minimum grade of concrete for plain and reinforced concrete shall be as per Table 4.6.

4.2.1.2 Concrete of grades lower than those given in Table 4.6 may be used for lean concrete, foundation for masonry walls or temporary reinforced concrete construction.

4.2.2 Workability of Concrete

4.2.2.1 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)*
(1)	(2)	(3)
Blinding concrete: shallow sections: Pavements using pavers	Very low	See 4.2.2.2
Mass concrete: Lightly reinforced sections in slabs, beams, wall, columns, : floors	Low	25-75
Hand placed pavements: canal lining; Strip footing	Medium	50-100
Heavily reinforced sections in slabs, beams, walls, columns:		
Slip form work: Pumped concrete	Medium	75-100
Trench fill	High	100-150
Tremie concrete	Very High	See 4.2.2.3

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 4.2.7)

4.2.2.2 In the 'very low' category of workability where strict control is necessary, for example, pavement quality concrete, measurement of workability be 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.

4.2.2.3 In the 'very high' category of workability, measurement of workability by determination of flow will be appropriate (see IS 9103).

4.2.3 Concrete Mix Proportioning

4.2.3.1 The determination of the proportion of cement, aggregate and water to attain the required strength shall be made as follows:

(a) *By designing the concrete mix:* such concrete shall be called 'Design mix concrete', for details reference may be made to RCC Chapter.
(b) *By adopting nominal concrete mix:* such concrete shall be called 'Nominal mix concrete'.

Design mix concrete is preferred to nominal mix. If design mix concrete cannot be used for any reason on the work for grades of M20 or lower, nominal mixes may be used with the permission of Engineer-in-Charge, which, however, is likely to involve a higher cement content.

4.2.3.2 ***Nominal Mix Concrete:*** Nominal Mix Concrete may be used for concrete of M20 or lower. The proportions of materials for nominal mix concrete shall be in accordance with Table 4.7.

The cement content of the mix specified in Table 4.7 for any nominal mix shall be proportionately increased if the quantity of water in the mix has to be increased to overcome the difficulty or placement and compaction, so that the water cement ratio as specified is not exceeded.

TABLE 4.7
Proportions for Nominal Mix Concrete
(Clause 4.2.3.2)

Grade of Concrete	*Total Quantity of Dry Aggregates by Mass per 50 kg 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 50 kg of Cement, max Ltr.*
(1)	(2)	(3)	(4)
M5	800	Generally 1:2 but subject to an upper limit of 1: 1 ½ and a lower limit of 1:2 ½	60
M7.5	625		45
M10	480		34
M15	330		32
M20	250		30

Note : - The proportion of the fine to coarse aggregate should be adjusted from upper limit progressively as the grading of fine aggregate becomes finer and the maximum size of coarse aggregate becomes larger. Graded coarse aggregate shall be used.

Note : - Quantity of water required from durability point of view may be less than the value given above.

Example

For an average grading of fine aggregate (that is, Zone II of Table 4 of IS 383), the proportions shall be 1:1 ½ , 1:2 and 1:2 ½ for maximum size of aggregates 10 mm, 20 mm and 40 mm respectively.

4.2.4 Batching

To avoid confusion and error in batching, consideration should be given to using the smallest practical number of different concrete mixed on any site or in any one plant. In batching concrete, the quantity of both cement and aggregate shall be determined by mass; admixture, if solid, by mass: liquid admixture may however be measured in volume or mass: water shall be weighed or measured by volume in a calibrated tank (see also IS 4925). **For projects having sanctioned more than 100 Crores, the concrete shall be sourced from ready mixed concrete plant or from captive on site or off site automatic batching and mixing plants. The concrete produced and supplied by ready mixed concrete plants shall be in accordance with IS 4926. In case of concrete from captive on site or off site automatic batching and mixing plants, similar quality control shall be followed.**

Ready- mixed concrete supplied by ready-mixed concrete plant shall be preferred. For large and medium project sites the concrete shall be sourced from ready-mixed concrete plants or from on site or off site batching and mixing plants (see IS 4926).

4.2.4.1 In case of batch mixing plant at site the grading of aggregate shall be controlled by obtaining the coarse aggregate in different sizes and blending them in right proportions, the different sizes being stocked in separate stock piles. The material should be stock-piled for several hours preferably a day before use. The grading of coarse and fine aggregate should be checked as frequently as possible, the frequency for a given job being determined by the Engineer-in-Charge to ensure that the specified grading is maintained.

4.2.4.2 The accuracy of the measuring equipment shall be within $\pm$ 2 percent of the quantity of cement **and mineral admixtures** being measured and within $\pm$ 3 percent of the quantity of aggregate, **chemical** admixtures and water being measured. **In a batching plant, the concrete production equipment shall be calibrated initially at the time of installation or reconditioning of the equipment and subsequently at the following intervals:**
a) Mechanical/knife edge system: At least once every two months
b) Electrical/load cell system: At least once every three months

4.2.4.3 All ingredients of concrete shall be used by mass except water and chemical admixtures which may be by volume.

4.2.4.4 Volume batching may be allowed only where weigh-batching is not practicable and provided accurate used in concrete have earlier been established. Allowance for bilking shall be made in accordance with IS 2386 (Part 3). The mass volume relationship should be checked as frequently as necessary, the frequency for the given job being determined by Engineer-in-Charge to ensure that the specified grading is maintained.

4.2.4.5 It is important to maintain the water cement ratio constant at its correct value. To this end, determination of moisture contents in both fine and coarse aggregates shall be made as frequently as possible, the frequency for a given job being determined by the Engineer-in-Charge according to weather conditions. The amount of the added water shall be adjusted to compensate for any observed variations in the moisture contents. For the determination of moisture content in the aggregates, IS 2386 (Part 3) may be referred to. To allow for the variation in mass for aggregate due to variations in their moisture content, suitable adjustments in the masses of aggregates shall be made. In the absence of exact data, only in the case of nominal mixes, the amount of surface water may be estimated from the values given in Table 4.8.

TABLE 4.8
Surface Water Carried by Aggregate
(Clause 4.2.4.5)

Sl No	*Aggregate*	*Approximate Percent by mass*	*Quantity of Surface Water l/m3*
(1)	*(2)*	*(3)*	*(4)*
(i)	Very wet sand	7.5	120
(ii)	Moderately wet sand	5.0	80
(iii)	Moist sand	2.5	40
(iv)	[1)] Moist gravel or crushed rock	1.25-2.5	20-40

[1)] Coarser the aggregate, less the water it will carry.

4.2.4.6 No substitutions in materials used on the work or alteration in the established proportions, except as permitted in 4.2.4.4 and 4.2.4.5 shall be made without additional tests to show that the quality and strength of concrete are satisfactory.

4.2.5 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 breakdown and when the quantity of concrete work is very small, hand mixing may be done with the specific prior permission of the Engineer-in-Charge 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 brick aggregate shall be well soaked with water for a minimum period of two hours and stone aggregate or gravel shall be washed with water to remove, dirt, dust and other foreign materials. For guidance, the mixing time may be $1^1/_2$ to 2 minutes, for hydrophobic cement it may be taken as $2^1/_2$ to 3 minutes.

4.2.5.1 ***Power Loader:*** Mixer will be fitted with a power loader complying with the following requirements.

(a) The hopper shall be of adequate capacity to receive and discharge the maximum nominal batch of unmixed materials without spillage under normal operating conditions on a level site.

Note: In such a case the volume of the maximum nominal batch of mixed material is 50% greater than the nominal mixed batch capacity.

(b) The minimum inside width of the feeding edge of the hopper shall be as specified below in Table 4.9.

TABLE 4.9

Nominal size of mixer (T, NT or R).litre	*Minimum inside width of hopper feeding edge*
140	1.0
200	1.1
280	1.2
375	1.4
500	1.5
1000	2.0

T = Tilting; NT = Non-tilting; R = Reverse

(c) The design of the loader shall be such that it allows the loading hopper to be elevated to such a height that the centre line of the chute plate of the hopper when in discharge position, is at an angle of not less than 50º to the horizontal. A mechanical device to aid discharge of the contents as quickly as possible from the hopper to the drum may also be provided. Even when a mechanical device is provided, it is recommended that the angle of centre line of the chute plate of the hopper when in discharge position, should be as larger as practicable, preferably not less than 40º to horizontal.

(d) When the means of raising and lowering the loading hopper includes flexible wire ropes winding on to a drum or drums, the method of fastening the wire to rope to the drums shall be such as to avoid, as far as possible any tendency to cut the strands of the ropes and the fastening should preferably be positioned clear of the barrel of the drum for example, outside the drums flange. When the loading hopper is lowered to its normal loading position, these should be at least one and a half drums of rope on the drum.

(e) Clutch brake and hydraulic control lever shall be designed so as to prevent displacement by liberation or by accidental contact with any person.

(f) The clutch and brake control arrangements shall also be so designed that the operator can control the falling speed of the loader.

(g) Safety device shall be provided to secure the hopper in raised position when not in use.

4.2.5.2 ***Mixing Efficiency:*** The mixer shall be tested under normal working conditions in accordance with the method specified in IS 4643 with a view to check its ability to mix the ingredients to obtain concrete having uniformity within the prescribed limits. The uniformity of mixed concrete shall be evaluated by finding the percentage variation in quantity (mass in water) of cement, fine aggregate and coarse aggregate in a freshly mixed batch of concrete.

The percentage variation between the quantities of cement, fine aggregate and coarse aggregates (as found by weighing in water) in the two halves of a batch and average of the two halve of the batch shall not be more than the following limits:

Cement	8%
Fine aggregate	6%
Coarse aggregate	5%

4.2.5.3 ***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 material shall be mixed for atleast 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- in-Charge. 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 atleast 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 cleaned with water.

4.2.5.4 ***Hand Mixing:*** When hand mixing has been specifically permitted in exceptional circumstances by the Engineer-in-Charge 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 showlling and turning till the coarse aggregate gets evenly distributed the cement sand mixture. Three quarters of the total 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.

4.2.5.5 ***Transportation and Handling :*** Concrete shall be transported from the mixer to the place of laying as rapidly as possible by methods which will prevent the segregation or loss of any of the ingredients and maintaining the required workability.

During hot or cold weather, concrete shall be transported in deep containers, other suitable methods to reduce the loss of water by evaporation in hot weather and heat loss in cold weather may also be adopted.

4.2.6 Placing

The concrete shall be deposited as nearly as practicable in its final position to avoid rehandling. It shall be laid gently (not thrown) and shall be thoroughly vibrated and compacted before setting commences and should not be subsequently disturbed. Method of placing shall be such as to preclude segregation. Care shall be taken to avoid displacement of reinforcement or movement of form work and damage due to rains. As a general guidance, the maximum free fall of concrete may be taken as 1.5 metre.

4.2.7 Compaction

Concrete shall be thoroughly compacted and fully worked around embedded fixtures and into corners of the form work. Compaction shall be done by mechanical vibrator of appropriate type till a dense concrete is obtained. The mechanical vibrators shall conform to IS 2505, IS 2506, IS 2514 and IS 4656. To prevent segregation, over vibration shall be avoided.

Compaction shall be completed before the initial setting starts. For the items where mechanical vibrators are not to be used, the contractor shall take permission of the Engineer-in- Charge in writing before the start of the work. After compaction the top surface shall be finished even and smooth with wooden trowel before the concrete begins to set.

4.2.8 Construction Joints

Concreting shall be carried out continuously upto construction joints. The position and arrangement of construction joints shall be as shown in the structural drawings or as directed by the Engineer-in-Charge. Number of such joints shall be kept minimum. Joints shall be kept as straight as possible. Construction joints should comply with IS 11817.

4.2.8.1 When the work has to be resumed on a surface which has hardened, such surface shall be roughened. It shall then be swept clean and thoroughly wetted. For vertical joints, neat cement slurry, of workable consistency by using 2 kgs of cement per sqm shall be applied on the surface before it is dry. For horizontal joints, the surface shall be covered with a layer of mortar about 10-15 mm thick composed of cement and sand in the same ratio as the cement and sand in concrete mix. This layer of cement slurry of mortar shall be freshly mixed and applied immediately before placing of the concrete.

4.2.8.2 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 sqm. On this surface, a layer of concrete not exceeding 150 mm in thickness shall first be placed and shall be well rammed against old work particular attention being paid to corners and close spots; work, thereafter, shall proceed in the normal way.

4.2.9 Concreting under Special Conditions

4.2.9.1 ***Work in Extreme Weather Conditions:*** During hot and cold weather, the concreting shall be done as per the procedure set out in IS 7861 (Part–I)-1975 and IS 7861 (Part II)-1981 respectively. Concreting shall not be done when the temperature falls below 4.5ºC. In cold weather, the concrete placed shall be protected against frost. During hot weather, it shall be ensured that the temperature of wet concrete does not exceed 38ºC.

4.2.9.2 ***Under Water Concreting:*** Concrete shall not be deposited under water if it is practicable to de-water the area and place concrete in the regular manner. When it is necessary to deposit concrete under water, the methods, equipment, materials and proportions of the mix to be used shall be submitted to and approved by the Engineer-in-Charge before the work is started.

Under-water concrete should have a slump recommended in 4.2.2. The water- cement ratio shall not exceed 0.6 and may need to be smaller, depending on the grade of concrete or the type of chemical attack. For aggregates of 40 mm maximum particle size, the cement content shall be atleast 350 kg/m^3 of concrete.

4. 2.9.3 ***Concrete in Sea Water:*** Concrete in sea-water or exposed directly along the sea-coast shall be at least M20 Grade in the case of plain concrete and M30 in case of reinforced concrete. The use of slag or pozzolana cement is advantageous under such conditions.

(i) Special attention shall be given to the design of the mix to obtain the densest possible concrete: slag, broken brick, soft lime stone, soft sandstone, or other porous or weak aggregates shall not be used.

(ii) As far as possible, preference shall be given to precast members unreinforced, well-cured and hardened, without sharp corners, and having trowel-smooth finished surfaces free from crazing, cracks or other defect; plastering should be avoided.

(iii) No construction joints shall be allowed within 600 mm below low water-level or within 60 mm of the upper and lower planes of wave action. Where unusually severe conditions or abrasion are anticipated, such parts of the work shall be protected by bituminous or silico-fluoride coatings or stone facing bedded with bitumen.

(iv) In reinforced concrete structures, care shall be taken to protect the reinforcement from exposure to saline atmosphere during storage, fabrication and use. It may be achieved by treating the surface of reinforcement with cement wash or by suitable methods.

4.2.10 Curing

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

4.2.10.1 ***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 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 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.

4.2.10.2 ***Membrane Curing*** *:* Approved curing compounds may be used in lieu of moist curing with the permission of the Engineer-in- Charge. 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 the evaporation.

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

4.2.10.4 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 at east 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.

4.2.11 Testing of Concrete

Testing of concrete shall be done as described in chapter of R.C.C.

4.2.12 Form Work

Form work shall be as specified in R.C.C. chapter and shall be paid for separately unless otherwise specified.

4.2.13 Finishes

Plastering and special finishes other than those, obtained through form work shall be specified and paid for separately unless otherwise specified.

4.2.14 Durability of Concrete

A durable concrete is one that performs satisfactorily in the working environment during its anticipated exposure conditions during service **life**. The materials and mix proportions shall be such as to maintain its intergrity and, if applicable, to protect reinforcement from corrosion.

The factors influencing durability include:

(a) The environment;

(b) The cover to embedded steel;

(c) The type and quality of constituent materials;

(d) The cement content and water/ cement ratio of the concrete;

(e) Workmanship, to obtain full compaction and efficient curing; and

(f) The shape and size of the member.

4.2.14.1 *Requirements for Durability*

4.2.14.1.1 *General Evironment :* The general environment to which the concrete will be exposed during its working life is classified into five levels of severity, that is, mild, moderate, severe, very severe and extreme as described in Table 4.10.

TABLE 4.10
Environmental Exposure Conditions

Sl. No	*Environment*	*Exposure Conditions*
(1)	*(2)*	*(3)*
(i)	Mild	Concrete surfaces protected against weather or aggressive conditions,except those situated in coastal area.
(ii)	Moderate	Concrete surfaces sheltered from severe rain or freezing whilst wetConcrete exposed to condensation and rainConcrete continuously under waterConcrete in contact or buried under non-aggressive soil/ ground waterConcrete surfaces sheltered from saturated salt air in coastal area
(iii)	Severe	Concrete surfaces exposed to severe rain, alternate weting and dryingor occasional freezing whilst wet or severe condensation. Concrete completely immersed in sea water.Concrete exposed to coastal environment.
(iv)	Very severe	Concrete surface exposed to sea water spray, corrosive fumes orsevere freezing conditions whilts wet.Concrete in contact with or buried under aggressive sub-soil/ groundwater.
(v)	Extreme	Surface of members in tidal zone.Members in direct contact with liquid/ solid aggressive chemicals.

Note: For the purpose of determining exposure conditions, all places within a distance of 10 kms. of coastal line, sea front would be treated as coastal area.

4.2.14.1.2 *Freezing and Thawing :* Where freezing and thawing actions under wet conditions exist, enhanced durability can be obtained by the use of suitable air entraining admixtures. When concrete lower than grade M50 is used under these conditions, the mean total air content by volume of the fresh concrete at the time of delivery into the construction should be:

Nominal Maximum Size Aggregate (mm)	*Entrained Air Percentage*
20	5 ± 1
40	4 ± 1

4.2.14.1.3 *Exposure to Sulphate Attack :* For the very high sulphate concentration in Class 5 conditions given in Table 4.11, some form of lining such as polyethylene or polychloroprene sheet: or surface coating based on asphalt, chlorinated rubber, epoxy; or polyurethane materials should also be used to prevent access by the sulphate solution.

4.2.14.1.4 *Chlorides in Concrete :* The total amount of chlorides content (as CI) in the concrete at the time of placing shall be as under :

Sl. No.	*Type of Use of Concrete*	*Maximum Total Acid Soluble Chloride Content expressed as kg/ m^3 of Concrete*
(1)	(2)	(3)
(i)	Concrete containing metal and steam cured atelevated temperature and pre-stressed concrete	0.4
(ii)	Reinforced concrete or plain concrete containing embedded metal	0.6
(iii)	Concrete not containing embedded metal or anymaterial requiring protection from chloride	3.0

4.2.14.1.5 *Sulphates in Concrete :* The total water-soluble sulphate content of the concrete mix, expressed as SO_3 should not exceed 4 per cent by mass of the cement in the mix. The sulphate content should be calculated as the total from the various constituents of the mix. The 4 per cent limit does not apply to concrete made with supersulphate cement complying with IS 6909.

TABLE 4.11
Requirements for Concrete Exposed to Sulphate Attack
(Clause 4.2.14.1.3)

Sl No.	*Class*	*Concentration of sulphates, Expresed as SO3 Concrete.*			*Type of Cement*	*Dense, Fully compacted made with 20 mm nominal maximum size Aggregates complying with IS 383*	
		In Soil		*In Ground Water (g/l)*		*Minimum Cement Content kg/m3*	*Maximum Free Water-Cement Ratio*
		Total SO3 (%)	*SO3 in 2:1 (Water: Soil Extract) (g/l)*				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(i)	1	Traces (<0.2)	Less than 1.0	Less than 0.3	Ordinary Portland cement or Portland slag cement or Portland - pozzolana cement	280	0.55
(ii)	2	0.2 to 0.5	1.0 to 1.9	0.3 to 1.2	Ordianry Portland cement or Portland slag cement or Portland pozzolana cement	330	0.50
					Supersulphated cement or sulphate resisting Portland cement	310	0.50
(iii)	3	0.5 to 1.0	1.9 to 3.1	1.2 to 2.5	Supersulphated cement or sulphate resisting Portland cement	330	0.50
					Portland Pozzolana cement or Portland slag cement	350	0.45
(iv)	4	1.0 to 2.0	3.1 to 5.0	2.5 to 5.0	Supersulphated or sulphate resisting Portland cement	370	0.45
(v)	5	More than 2.0	More than 5.0	More than 5.0	Sulphate resisting Portland cement or supersulphated cement with protective coatings	400	0.40

Notes

1. Cement content given in this Table is irrespective of grades of cement.
2. Use of supersulphated cement is generally restricted where the prevailing temperature is above 40°C.
3. Supersulphated cement gives an acceptable life provided that the concrete is dense and prepared with a water-cement ratio of 0.4 or less, in mineral acids, down to pH 3.5.
4. The cement contents given in col. 7 of this Table are the minimum recommended. For SO_3 contents near the upper limit of any class, cement contents above these minimum are advised.

5. For severe conditions, such as thin sections under hydrostatic pressure on one side only and sections partly immersed, considerations should be given to a further reduction of water-cement ratio.

6. Portland slag cement conforming to IS 455 with slag content more than 50 per cent exhibits better sulphate resisting properties.

7. Where chloride is encountered along with sulphates in soil or ground water, ordinary Portland cement with C_3A content from 5 to 8 per cent shall be desirable to be used in concrete, instead of suplhate resisting cement. Alternatively, Portland slag cement conforming to IS 455 having more than 50 per cent slag or a blend of ordinary Portland cement and slag may be used provided sufficient information is available on performance of such blended cements in these conditions.

4.2.15 Measurements

4.2.15.1 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 0.01 sq.m and the cubic contents of consolidated concrete shall be worked out to nearest 0.01 cum. Any work done in excess over the specified dimension or sections shown in the drawing shall be ignored.

4.2.15.2 Concrete work executed in the following conditions shall be measured separately:

(a) Work in or under water
(b) Work in liquid mud
(c) Work in or under foul positions

4.2.15.3 ***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) Upto specified floor level
(c) Between two specified floor levels
(d) Upto specified height above or depth below plinth level/ defined datum level.
(e) Between tow specified heights or depths with reference to plinth/defined datum level.

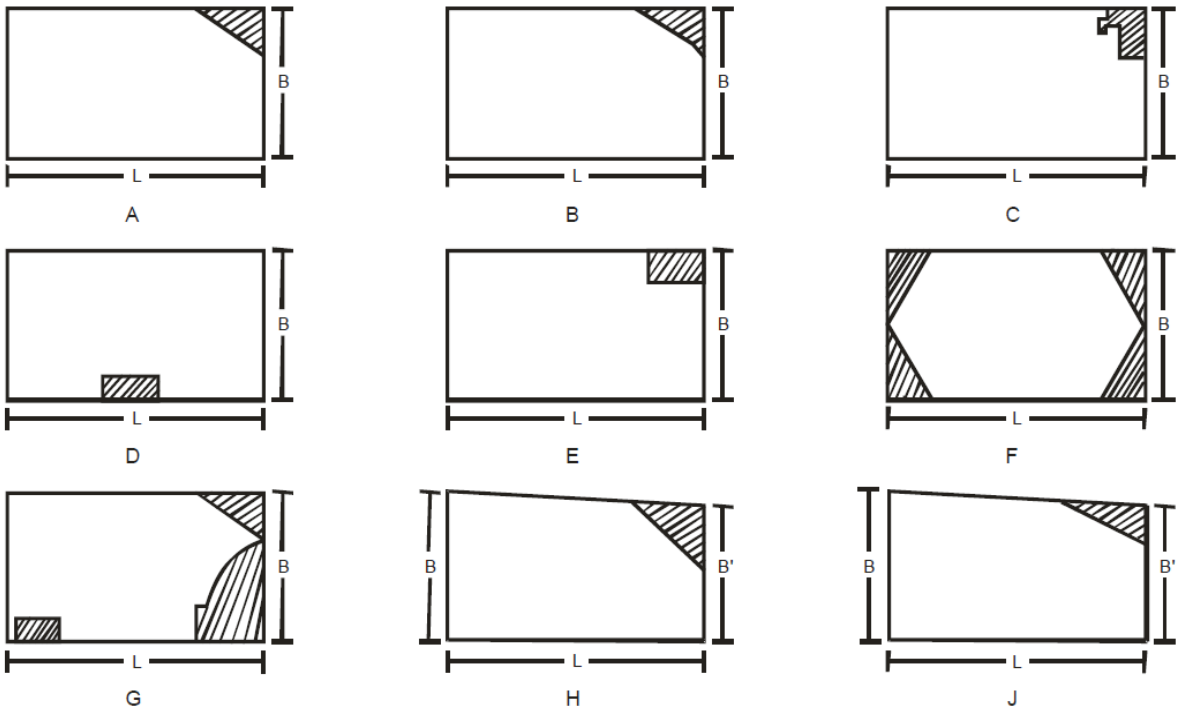
4.2.15.4 No deduction shall be made for the following:

(a) Ends of dissimilar materials for example beams, posts, girders, rafters, purlins, trusses, corbels and steps upto 500 sq cm in cross sections.
(b) Opening upto 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.
(d) Small voids such as shaded portions in Figure A to J below when these do not exceed 40 sq cm each in cross section.

Note: In calculating area of opening, the thickness of any separate lintel or sill shall be included in the height. Nothing extra shall be payable for forming such openings or voids.

Area of Fig. A to G shall be = L x B

Area of Fig. H & J shall be = L x {Average of B and B'}



4.2.15.5 Cast-in-situ and precast concrete work shall be measured sperately.

4.2.15.6 Cast-in-situ concrete shall be classified and measured as follows:

(a) Foundation, footings, bases for columns
(b) Walls (any thickness) including attached pilasters, buttresses, plinth and string courses, fillets etc.
(c) Shelves
(d) Slabs
(e) Chajjas including portions bearing on the wall
(f) Lintels, beams and bressummers
(g) Columns, piers abutments, pillars, post and struts
(h) Stair case including stringer beams but excluding landings.
(i) Balustrades, newels and sailing
(j) Spiral staircase (including landings)
(k) Arches
(l) Domes, vaults
(m) Shell roof, arch ribs and folded piates
(n) Chimneys and shaft.
(o) Breast walls, retaining, walls, return walls
(p) Concrete filling to precast components
(q) Kerbs, steps and the like
(r) String or lacing courses, parapets, copings, bed block, anchor blocks, plain window sills and the like
(s) Cornices and moulded windows sills.
(t) Louvers, fins, facia.

4.2.15.7 Precast cement concrete solid article shall be measured separately and shall include use of moulds, finishing the top surfaces even and smooth with wooden trowel, before setting in position in cement mortar 1:2 (1 cement : 2 coarse sand). Plain and moulded work shall be measured separately and the work shall be classified and measured as under:

Sl.No.	*Classifications*	*Method of measurement*
(i)	String or lacing courses, coping, bed plates, plain windows sills, shelves, louvers, steps etc.	In square meters stating the thickness.
(ii)	Kerbs, edgings etc.	In cubic meters.
(iii)	Solid block work	In cubic metres.
(iv)	Hollow block work	In square metres stating the thickness or in cubic meters.
(v)	Light weight partitions	In square metres stating the thickness or in cubic metres.
(vi)	Light weight partitions	In square metres stating the partition's thickness.

4.2.16 Rate

The rate is inclusive of the cost of labour and materials involved in all the operations described above.

4.3 CEMENT- FLY ASH CONCRETE

4.3.0 Fly ash concrete shall be prepared by mixing graded coarse aggregate of nominal size as specified with fine aggregate, ordinary Portland cement and fly ash in specified proportions with required quantity of water. The recommended composition of cement fly ash concrete are as under:

TABLE 4.12
Fly Ash Concrete Mixes

Composition (Dry Volume)	*Proportion (Dry Volume)*	*Compressive Strength at seven days*
Lean Concrete (1:5:10)		28 kg/cm^2
Cement (Ordinary Portland)	1.0	
Fly ash	2.5	
Sand	4.0	
Stone aggregate	11.0	
Lean Concrete (1:4:8)		37 kg/cm^2
Cement (Ordinary Portland)	1.0	
Fly ash	2.0	
Sand	3.5	
Stone aggregate	9.0	

Note: No fly ash is to be added to Portland Puzzolona cement in any case which itself contains fly ash.

4.3.1 Proportioning

Proportioning shall be done by volume. Boxes of suitable size shall be used for measuring fly ash, sand and aggregate. The internal dimensions of the boxes shall be generally 35x25x40 cm. deep or as otherwise approved by the Engineer -in-charge. The unit of measurement of cement shall be a bag of 50 kg. and this shall be taken as 0.035 cum. While measuring the aggregate, shaking, ramming or heaping shall not be done. The proportioning of sand shall be on the basis of its dry volume and in case of damp sand, allowances for bulkage shall be made as given in the chapter for mortar.

4.3.2 Mixing shall be as specified in 4.2.5 except that the fly ash shall be placed in the hopper before cement in case of machine mixing.

4.3.3 Placing and compaction shall be as specified in 4.2.6 and 4.2.7.

4.3.4 Curing shall be as specified in 4.2.10.

4.3.5 Form work shall be as specified in 4.2.12.

4.3.6 Measurements shall be as specified in 4.2.15.

4.3.7 Rate

Rate shall include the cost of materials and labour involved in all the operations described above.

4.4 DAMP PROOF COURSE

4.4.1 Cement Concrete Layer

This shall consist of cement concrete of specified proportions and thickness. The surface of brick or stone masonry work shall be levelled and prepared before laying the cement concrete. Edge of damp proof course shall be straight, even and vertical. Side shuttering shall consist of steel forms and shall be strong and properly fixed so that it does not get disturbed during compaction and the mortar does not leak through. The concrete mix shall be of workable consistency and shall be tamped thoroughly to make a dense mass. When the sides are removed, the surface should come out smooth without honey-coming. Continuity shall be maintained while laying the cement concrete layer and laying shall be terminated only at the predetermined location where damp proof course is to be discontinued. There shall be no construction joints in the Damp Proof Course.

4.4.2 Curing

Damp proof course shall be cured for at least seven days, after which it shall be allowed to dry.

4.4.3 Application of Hot Bitumen

Where so directed, hot bitumen in specified quantity shall be applied over the dried up surface of cement concrete, properly cleaned with brushes and finally with a piece of cloth soaked in kerosene oil. Bitumen of penetration A 90 or equivalent where used shall be heated to a temperature of 160º ± 5ºC. The hot bitumen shall be applied uniformly all over, so that no blank spaces are left anywhere. It will be paid for separately.

4.4.4 Water Proofing Materials

Where so specified, water proofing material of approved quality shall be added to the concrete mixture in accordance with the manufacturer's specification stating the quantity of water proofing material in litres or kg per 50 kg or cement and will be paid for separately.

4.4.5 Measurements

The length and breadth shall be measured correct to a cm and its area shall be calculated in square metres correct to two places of decimal. The depth shall not be less than the specified thickness at any section.

4.4.6 Rate

The rate is inclusive of the cost of materials and labour involved in all the operations described above except for the applications of a coat of hot bitumen and addition of water proofing materials which shall be paid for separately, unless otherwise specified.

APPENDIX A

DETERMINATION OF PARTICLE SIZE

(Clause 4.1.2.3 & 4.1.2.5)

The apparatus, sample size and test procedure shall be same as specified in sub-head 'MORTARS'.

In order that the sieves shall not be overloaded, care must be taken to ensure that the maximum sieve loads shown in Table A-4.1 (below) are not exceeded at the completion of sieving.

TABLE A-4.1

I.S. Sieve Designation	*Maximum weight for*	
	45 cm dia sieve kg	*30 cm dia sieve kg*
45 mm	10	4.5
40 mm	8	3.5
31.5 mm or 22.1 mm	6	2.5
20 mm	4	2.0
16 mm or 12.5 mm	3	1.5
10 mm	2	1.0
5.6 mm	1.5	0.75
4.75 mm	1.0	0.50
3.35 mm	-	0.30

The sample weight taken will thus normally require several operations on each sieve. Each sieve should be taken separately over a clean tray or receiver until no more than a trace passes, but in any case for not less than two minutes. Materials should not be forced through the apertures but hand placing is permitted. A light brush should be used with fine sieves. The cumulative weight passing each sieve should be calculated as percentage of the total sample weight to the nearest whole number.

APPENDIX B

TEST FOR SURFACE MOISTURE

(Clause 4.1.1.5)

Take a sample of wet aggregate and weigh it (A). Then place it in a frying pan and gently apply heat, meanwhile stirring with a glass rod until the surface moisture disappears. This is apparent when the aggregate loses its shining wet appearance and becomes dull, or when it just attains a free funning condition. The saturated surface dry material is then weighed (B). Continue the heating thereafter until the moisture is evaporated and weigh the dry sample (C). The surface moisture is then calculated as follows:

$$\text{Surface moisture} = 100 \times \frac{A-B}{C}$$

It is expressed as a percentage of dry aggregate.

APPENDIX C

DETERMINATION OF TEN PER CENT FINE VALUE

(Clause 4.1.1.5)

Apparatus: The apparatus for the standard test shall consist of the following:

(a) A 15 cm diameter open-ended steel cylinder, with plunger and base-plate, as shown in Fig. in the end of this appendix. The surfaces in contact with the aggregate shall be machined and case hardened or otherwise treated so as to have a diamond (VH) pyramid hardness number of not less than 650 VH.

(b) A straight metal tamping rod of circular cross-section 16 mm in diameter and 45 to 60 cm long, rounded at one end.

(c) A balance of capacity 3 Kg, readable and accurate to one gram.

(d) I.S. Sieve of sizes 12.5, 10 and 2.36 mm.

(e) A compression testing machine capable of applying a load of 50 tonnes and which can be operated to give a uniform rate of loading so that the maximum load in any test is reached in 10 minutes. This load may vary from 0.5 to 50 tonnes.

(f) For measuring the sample, a cylindrical metal measure of sufficient rigidity to retain its form under rough usage and of the following internal dimensions:

Diameter	11.5 cm
Height	18.0 cm

(g) Means of measuring the reduction in the distance between the plates of the testing machine to the nearest one millimetre during the test (for example, dial gauge).

Test Sample: Material for the test shall consist of aggregate passing a 12.5 mm I.S. Sieve and retained on a 10 mm I.S. Sieve. The aggregate shall be tested in a surface dry condition. If dries by heating the period of drying shall not exceed four hours, the temperature shall be 100ºC to 110ºC and the aggregate shall be cooled to room temperature before testing.

The quantity of aggregate shall be such that the depth of material in the cylinder, after tamping as described below, shall be 10 cm.

The weight of material comprising the test sample shall be determined (weight A) and the same weight of sample shall be taken for the repeat test.

Note: About 6.5 kg of natural aggregate is required to provide the two test samoles. Less of light weight aggregate is required.

The measuring cylinder is filled in three layers of approximately equal depth with aggregate passing a 12.5 mm I.S. Sieve and retained on 10 mm I.S. Sieve. Each layer is subjected to 25 strokes from the tamping rod (16 mm dia and 45 to 60 cm long) rounded to one end, care being taken in case of weak materials not to break the particles. The surface of the aggregate shall be carefully levelled and the plunger inserted so that it rests horizontally on this surface.

Test Procedure: The apparatus, with the test sample and plunger in position, shall then be placed in the compression testing machine. The load shall be applied at a uniform rate so as to cause a total penetration of a plunger in 10 minutes of about: 15.0 mm for rounded or partially rounded aggregates (for example uncrushed gravel) 20 mm for nominal crushed aggregate & 24 mm for honey combed aggregate (for example expanded shales and slags). These figures may be varied according to the extent of the rounding or honey combing.

After reaching the required maximum penetration, the load shall be released and the whole of the material removed from the cylinder and sieved on a 2.36 mm I.S. Sieve. The fines passing the sieve shall be weighed, and this weight expressed as a percentage of the weight of the test sample. Normally, this percentage will fall within the range 7.5 to 12.5, but if it does not, a further test shall be made at a load adjusted appropriately, to bring the percentage fines within the range of 7.5 to 12.5.

A repeat test shall be made at the load that gives as percentage fines within the range 7.5 to 12.5.

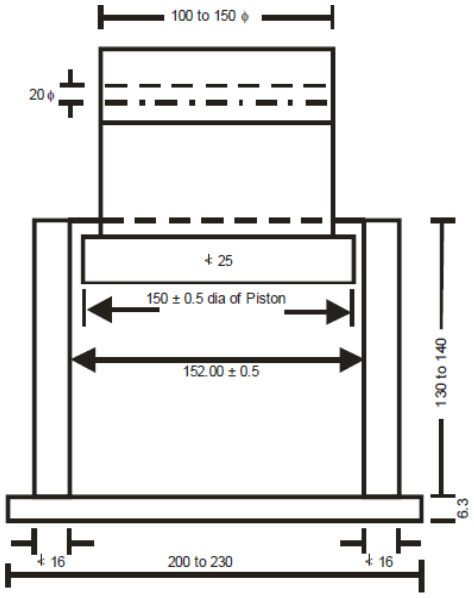
Calculations: The mean percentage fines from the two tests at this load shall be used in the following formula to calculate the load required to give 10 percentage fines.

Load required for 10 percent fines = $\frac{14+X}{Y+4}$

Where X = Load in tonnes and
Y= mean percentage fines from two test at X tonnes load.

Reporting of Results: The load required to produce 10 percent fines shall be reported to the nearest whole number for loads of 10 tonnes or more, the nearest 0.5 tonne for loads of less than 10 tonnes.

The value expressed to the nearest 0.5 tonne should be as follows:
(a) For normal concrete, not less than 5 tonnes.
(b) For wearing surfaces, not less than 10 tonnes.
(c) For granolithic concrete, not less than 15 tonnes.



Drawing not to Scale
All dimensions in millimetres

Internal Diameter of Cylinder = 152.0± 0.5

Fig. C-4.1 : Apparatus for Determination of Ten per cent Fine Value

APPENDIX D

SLUMP TEST

(Clause 4.2.2)

Apparatus: Mould shall consist of a metal frustum of cone having the following internal dimensions:

Bottom diameter……..20 cm

Top diameter……10 cm

Height……30 cm

The mould shall be of a metal other than brass and aluminium of at least 1.6 mm (or 16 BG) thickness. The top and bottom shall be open and at right angles to the axis of the cone. The mould shall have a smooth internal surface. It shall be provided with suitable foot pieces and handles to facilitate lifting it from the moulded concrete test specimen in a vertical direction as required by the test. A mould provided with a suitable guide attachment may be used.

Tamping rod shall be of steel or other suitable material 16 mm in diameter 60 mm long and rounded at one end.

Procedure: The internal surface of the mould shall be thoroughly cleaned and free form superfluous moisture and any set concrete before commencing the test. The mould shall be placed on a smooth horizontal, rigid and non- absorbent surface viz. levelled metal plate. The operator shall hold the mould firmly in place while it is being filled with test specimen of concrete. The mould shall be filled in four layers, each approximately one quarter of height of mould. Each layer shall be tamped with twenty five strikes of the rounded end of the tamping rod. The strokes shall be distributed in a uniform manner over the cross section of the mould and for the second and subsequent layers shall penetrate into the under-lying layer. The bottom layer shall be tamped through out its depth. After the top layer has been rodded, the concrete shall be struck off level with trowel or the tamping rod, so that the mould is exactly filled. Any mortar which shall leak out between the mould and the base plate shall be cleaned away. The mould shall be removed from the concrete immediately after filling by raising it slowly and carefully in a vertical direction. The moulded concrete shall then be allowed to subside and the slump shall be measured immediately by determining the difference between the height of the mould and that of the highest point of specimen.

The above operations shall be carried out at a place free from vibration or shock, and within a period of two minutes after sampling.

Result: The slump shall be recorded in terms of millimeters of subsidence of the specimen during the test. Any slump specimen which collapses or shears off laterally give incorrect result. If this occurs, the test shall be repeated with another sample.

The slump test shall not be used for very dry mixes as the results obtained are not accurate.

SUB HEAD : 5.0

REINFORCED CEMENT CONCRETE WORK

CONTENTS

LIST OF MANDATORY TESTS

Material	*Clause*	*Test*	*Field/ laboratory test*	*Test procedure*	*Min, quantity of material for carrying out the test*	*Frequency of testing*
1	2	3	4	5	6	7
Reinforced cement concrete (Nominal Mix)	5.4.1	(a) Slump test	Field/Lab	Appendix 'D' of Chapter 4	(i) 5 cum in case of column (ii) 20 cum for slabs, beams and connected columns (iii) 20 cum for other R.C.C. work for all other small items and where R.C.C. done in a day is less than 5 cum test may be carried out as required by Engineerin - Charge	(ii) Every 20 cum or part thereof (i) Every 5 cum of part thereof (iii) -Do-
	5.4.9.1	(b) Cube Test	Lab	Appendix 'A'	(i) 5 cum in case of column (ii) 20 cum for slabs, beams and connected Columns (iii) 20 cum for other R.C.C.work for all other small items and where R.C.C. done in a day is less than 5 cum test may be carried out as required by Engineerin-Charge	(i) Every 5 cum or part thereof (ii) Every 20cum or part thereof (iii) -Do

1	2	3	4	5	6	7
Reinforced Cement Concrete (Design Mix)	Coarse Aggregates				50 cum or part thereof & also on each change of source	
	Fine Aggregates				50 cum or part thereof & also on each change of source	
	Cement				50 MT or on each change of source	
	Fresh Concrete	(a) Slump test	Field	Appendix 'D' of Chapter 4	10 cum	50 cum for R.C.C. work including in all other small location. R.C.C.done in a day is less than 50 cum test may be carried out as required by Engineer-in-Charge
	Fresh Concrete	(b) Cube Test	Lab	Appendix 'A'	10 cum or part thereof	50 cum or 10 batches of 5-7 cum each for R.C.C. work in all location taken together. R.C.C. done in a day is less than 50 cum test may be carried out as required by Engineer-in-Charge
Reinforced Cement Concrete (Ready Mix)	Coarse Aggregates				50 cum or part thereof & also on each change of source	
	Fine Aggregates				50 cum or part thereof & also on each change of source	
	Cement				50 MT or on each change of source	
	Fresh Concrete	(a) Slump test	Field/Lab	Appendix 'D' of Chapter 4	10 cum	50 cum for R.C.C. work including in all other small location. R.C.C. done in a day is less than 50 cum test may be carried out as required by Engineer-in-Charge

1	2	3	4	5	6	7	
	Fresh Concrete	(b) Cube Test	Lab	Appendix 'A'	10 cum or part thereof	50 cum or 10 batches of 5-7 cum each for R.C.C. work in all location – taken together. R.C.C. done in a day is less than 50 cum test may be carried out as required by Engineerin-Charge	
Steel for Reinforced cement concrete	5.1.3	(A) Physical Test and chemical tests				(a) For consignment below 100 tonnes (i) under 10 mm dia, one Sample for each 25 tonnes or part thereof (ii) 10 mm to 16 mm dia one sample for each 35 tonnes or part thereof (iii) over 16 mm dia one sample for each 45 tonnes or part thereof	(b) For consignment over 100 tonnes (i) Under 10 mm dia, one sample For each 40 tonnes or part thereof (ii) 10 mm to 16 mm, one sample for each 45 (iii) over 16 mm dia, one sample for each 50 tonnes or part thereof

LIST OF BUREAU OF INDIAN STANDARDS CODES

Sl. No.	*I.S. No.*	*Subject*
1.	IS 226	Structural Steel
2.	IS 2285	Methods for chemical analysis of steel (Issues in various parts)
3.	IS 432 (Part I)	Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement part-I mild steel and medium tensile steel bars.
4.	IS 432 (Part II)	Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement – Part-II hard drawn steel wire.
5.	IS 456	Code of Practices for plain and Reinforced concrete.
6.	IS 516	Method of test for strength of concrete.
7.	IS 716	Specification for pentachlorophenol
8.	IS 1199	Method of sampling and analysis of concrete.
9.	IS 1200 (Part II)	Method of measurement of building and civil engineering work – concrete work
10.	IS 1200 (Part V)	Method of measurement of building and civil engineering work – concrete work (Part 5- Form work)
11.	IS 1566	Specification for hard drawn steel wire fabric for concrete requirement.
12.	IS 1599	Method for bend test
13.	IS 1343	Code of Practice for Prestressed Concrete
14.	IS 1387:1993	General requirements for the supply of metallurgical materials
15.	IS 14687	Guidelines for falsework for concrete structures
16.	IS 1608	Method for tensile testing of steel products
17.	IS 1786	Specification for high strength deformed steel and wires for concrete reinforcement.
18.	IS 1791	Specification for batch type concrete mixes
19.	IS 2502	Code of practice for bending and fixing of bars for concrete reinforcement.
20.	IS 2751	Recommended practice for welding of mild steel plain and deformed bars for reinforced construction.
21.	IS 4925	Batch plants specification for concrete batching and mixing plant
22.	IS 4926	Ready – Mixed Concrete
23.	IS 5522:2014	Specification for Indian Standard Stainless Steel sheet and strips for utensils
24.	IS 6523	Specification for precast reinforced concrete door, window frames
25.	IS 10262	Recommended guidelines for concrete mix design
26.	IS 13311 (Part I)	Indian standard for non-destructive testing of concrete. Method of test for ultrasonic pulse velocity
27.	IS 13311 (Part II)	Indian standard for non-destructive testing of concrete. Method of testing by rebound hammer.
28.	IS 14276:1995	Indian standard for Cement bonded particle boards
29.	IS 16172:2014	Specification for Reinforcement couplers for mechanical splices of bars in concrete

5.0 REINFORCED CEMENT CONCRETE WORK

5.0 GENERAL

Reinforced cement concrete work may be cast-in-situ or Precast as may be directed by Engineer-in-Charge according to the nature of work. Reinforced cement concrete work shall comprise of the following which may be paid separately or collectively as per the description of the item of work.

(a) Form work (Centering and Shuttering)

(b) Reinforcement

(c) Concreting: (1– Cast-in-situ), (2 – Precast)

5.1 MATERIALS

5.1.1 Water, cement, fine and coarse aggregate shall be as specified under respective clauses of chapter 03 mortars and chapter 04 concrete work as applicable.

5.1.2 Fly Ash admixed cement concrete (FACC) and fly ash Blended cements in Cement Concrete (PPCC) in RCC structures.

5.1.2.0 Fly ash Blended Cements conforming to IS 1489 (Part I) may be used in RCC structures as per guidelines given below :

5.1.2.1 ***General***

(i) IS 456- 2000 Code of Practice for Plain and Reinforced Concrete (as amended up to date) shall be followed in regard to Concrete Mix Proportion and its production as under :
   (a) The concrete mix design shall be done as “Design Mix Concrete” as prescribed in clause-9 of IS 456 mentioned above.
   (b) Concrete shall be manufactured in accordance with clause 10 of above mentioned IS 456 covering quality assurance measures both technical and organizational, which shall also necessarily require a qualified Concrete Technologist to be available during manufacture of concrete for certification of quality of concrete.

(ii) Minimum M -25 grade of concrete shall be used in all structural elements made with RCC both in load bearing and framed structure.

(iii) The mechanical properties such as modulus of elasticity, tensile strength, creep and shrinkage of fly ash mixed concrete or concrete using fly ash blended cements (PPCs) are not likely to be significantly different and their values are to be taken same as those used for concrete made with OPC.

(iv) To control higher rate of carbonation in early ages of concrete both in fly ash admixed as well as PPC based concrete, water/binder ratio shall be kept as low as possible, which shall be closely monitored during concrete manufacture.
   If necessitated due to low water/binder ratio, required workability shall be achieved by use of chloride free chemical admixtures conforming to IS 9103. The compatibility of chemical admixtures and super plasticizers with each set OPC, fly ash and /or PPC received from different sources shall be ensured by trials.

(v) In environment subjected to aggressive chloride or sulphate attach in particular, use of fly ash admixed or PPC based concrete is recommended. In cases, where structural concrete is exposed to excessive magnesium sulphate, fly ash substitution/content shall be limited to 18% by weight. Special type of cement with low C3A content may also be alternatively used. Durability criteria like minimum binder content and maximum water /binder ratio also need to be given due consideration in such environment.

(vi) Wet curing period shall be enhanced to a minimum of 10 days or its equivalent. In hot & arid regions, the minimum curing period shall be 14 days or its equivalent.

5.1.2.2 ***Use of Fly ash Admixed Cement Concrete (FACC) in RCC structures***

There shall be no bar on use of FACC in RCC structures subject to following additional conditions.

(i) Fly ash shall have its chemical characteristics and physical requirements etc. conforming to IS 3812 (part I & II) and shall be duly certified.

(ii) To ensure uniform blending of fly ash with cement in conformity with IS 456, a specific facility needs to be created at site with complete computerized automated process control to achieve design quality or with similar facility from Ready Mix Concrete (RMC) plants.

(iii) As per IS 1489 (Part-I) maximum 35% of OPC by mass is permitted to be substituted with fly ash conforming to IS 3812 (Part –I) and same is reiterated.

(iv) Separate storage for dry fly ash shall be provided. Storage bins or silos shall be weather proof and permit a free flow and efficient discharge of fly ash. The filter or dust control system provided in the bins or silos shall be of sufficient size to allow delivery of fly ash maintained at specified pressure to prevent undue emission of fly ash dust, which may interfere weighing accuracy.

5.1.2.3 ***Use of Fly Ash Blended Cements in Cement Concrete (PPCC) in RCC Structures***

(i) Subject to General Guidelines detailed out as above, PPC manufactured conforming to IS 1489 (Part-I) shall be treated at par with OPC for manufacture of Design Mix concrete for structural use in RCC.

(ii) Till the time, BIS makes it mandatory to print the %age of fly ash on each bag of cement, the certificate from the PPC manufacture indicating the same shall be insisted upon before allowing use of such cements in works.

(iii) While using PPC for structural concrete work, no further admixing of fly ash shall be permitted.

5.1.3 Steel for Reinforcement

5.1.3.1 The steel used for reinforcement shall be any of the following types:

(a) Mild steel and medium tensile bars conforming to IS 432 (Part I)

(b) High strength deformed steel bars conforming to IS 1786

(c) Hard drawn steel wire fabric conforming to IS 1566

(d) Structural steel conforming to Grade A of IS 2062

(e) Thermo-mechanically treated (TMT) Bars.

5.1.3.2 Elongation percent on gauge length is $5.65\sqrt{A}$ where A is the cross sectional areas of the test piece.

5.1.3.3 Mild steel is not recommended for the use in structures located in earthquake zone subjected to severe damage and for structures subjected to dynamic loading (other than wind loading) such as railway and highway bridges.

5.1.3.4 Welding of reinforcement bars covered in this specification shall be done in accordance with the requirements of IS 2751.

Nominal mass/weight : The tolerance on mass/ weight for round and square bars shall be the percentage given in Table 5.1 of the mass/ weight calculated on the basis that the masses of the bar/ wire of nominal diameter and of density 7.85 kg/ cm^3 or 0.00785 kg/mm^3.

TABLE 5.1
Tolerance on Nominal Mass

Nominal size in mm	*Tolerance on the Nominal Mass per cent*		
	Batch	*Individual sample +*	*Individual sample for coil (x)*
(a) Upto and including 10	±7	-8	±8
(b) Over 10, upto and including 16	±5	-6	±6
Over 16	±3	-4	±4

\+ for individual sample plus tolerance is not specified
(x) for coil batch tolerance is not applicable
Tolerance shall be determined in accordance with method given in IS 1786.

5.1.3.5 High strength deformed bars & wires shall conform to IS 1786. The physical properties for all sizes of steel bars are mentioned below in Table 5.2.

TABLE 5.2

Sl. No	*Property*	*Fe 415*	*Fe 415 D*	*Fe 500 D*	*Fe 550 D*
(i)	0.2 Per cent Proof stress/ yield stress, Min, N/mm^2	415.0	415.0	500.0	550.0
(ii)	Elongation, per cent, Min. on gauge length 5.65 √A, where A is the corss-sectional area of the test piece.	14.5	18.0	16.0	14.5
(iii)	Tensile strength, Min	10 Per cent more than the actual 0.2 per cent proof stress/ yield stress but not less than 485.0 N/mm^2	12 Per cent more than the actual 0.2 percent proof stress/yield stress but not less than 500.0 N/mm^2	10 Per cent more than the actual 0.2 per cent proof stress/ yield stress but not less than 565.0 N/mm^2	8 Per cent more than the actual 0.2 per cent proof stress/yield stress but not less than 600.0 N/mm^2
(iv)	Total elongation at maximum force, percent, Min on gauge length 5.65 √A, where A is the cross-sectional area of the test piece.	-	5	5	5

Tests: Selection and preparation of Test sample. All the tests pieces shall be selected by the Engineer-in-Charge or his authorized representative either-

(a) From cutting of bars
Or

(b) If he so desires, from any bar after it has been cut to the required or specified size and the test piece taken from and any part of it.

In neither case, the test pieces shall be detached from the bar or coil except in the presence of the Engineer-in-Charge or his authorized representative.

The test pieces obtained in accordance with as above shall be full sections of the bars as rolled and subsequently cold worked and shall be subjected to physical tests without any further modifications. No deduction in size by machining or otherwise shall be permissible. No test piece shall be enacted or otherwise subject to heat treatment. Any straightening which a test piece may require shall be done cold.

Tensile Test: 0.2% proof stress and percentage elongation –
This shall be done as per IS 1608, read in conjunction with IS 226.

RE- test: This shall be done as per IS 1786.

Rebend test: This shall be done as per IS 1786.

5.1.3.6 Chemical composition of reinforcement bars shall be as per Table 5.3 as follows:-

TABLE 5.3

Constituent	*Maximum Per cent*			
	Fe 415	*Fe 415 D*	*Fe 500 D*	*Fe 550 D*
Carbon	0.30	0.25	0.25	0.25
Sulphur	0.060	0.045	0.040	0.040
Phosphorus	0.060	0.045	0.040	0.040
Sulphur and Phosphorus	0.110	0.085	0.075	0.075

5.1.3.7 Thermo Mechanically treated reinforcement bars:

(a) There is no BIS code for TMT bars. The available code BIS 1786 pertains to HSD Bars. Therefore there should be no stipulation that TMT bars should conform to relevant BIS code.

(b) The TMT bars are being produced under valid licence from either of the firms namely Tempcore, Thermex Evcon Turbo & Turbo Quench. These firms have acquired patents and are giving licences to various producers to produce TMT Bars.

(c) The TMT bars shall conform to IS 1786 pertaining to Fe 415 D or Fe 500 D or Fe grade of steel as specified.

(d) In design and construction of reinforced concrete building in seismic zone III and above, steel reinforcement of Grade Fe 415 D shall be used. However, high strength deformed steel bars, produced by thermo mechanical treatment process of grade Fe 415, Fe 500 and Fe 550 having elongation more than 14.5. % and conform to other requirements of Fe 415 D, Fe 500 D and Fe 550 D respectively of IS 1786 may also be used for reinforcement. In future, latest provision of IS 456 and IS 13920 or any other relevant code as modified from time to time shall be applicable.

5.1.4 Stacking and Storage

Steel for reinforcement shall be stored in such a way as to prevent distorting and corrosion. Care shall be taken to protect the reinforcement from exposure to saline atmosphere during storage, fabrication and use. It may be achieved by treating the surface of reinforcement with cement wash or by suitable methods. Bars of different classifications, sizes and lengths shall be stored separately to facilitate issue in such sizes and lengths to cause minimum wastage in cutting from standard length.

5.1.5 Identification

Care shall also be taken to properly identify these bars at site. The staff shall be specially trained for looking for identification marks on these bars given by the manufacturers which are generally given colour code. It will be advisable to see that only one type/grade of bars are brought to site and used in the project after conducting tests for each lot.

5.2 FORM WORK (CENTRING & SHUTTERING)

5.2.1 Form Work

Form work shall include all temporary or permanent forms or moulds required for forming the concrete which is cast-in-situ, together with all temporary construction required for their support.

5.2.2 Design & Tolerance in Construction

Form work shall be designed and constructed to the shapes, lines and dimensions shown on the drawings with the tolerance given below.

(a)	Deviation from specified dimension of cross section of columns and beams	**+10 mm** **-5 mm**
(b)	Deviation from dimensions of footings	
	(i) Dimension in Plan	(+ 50 mm (**-10 mm**
	(ii) Eccentricity in plan	0.02 times the width of the footing in the direction of deviation but not more than 50 mm.
	(iii) Thickness	**+50mm** **Or** **± 0.05 times the specified thickness** **Whichever is less**

(**Note**- These tolerance apply to concrete dimensions only, and not to positioning of vertical steel or dowels).

5.2.3 General Requirement

It shall be strong enough to withstand the dead and live loads and forces caused by ramming and vibrations of concrete and other incidental loads, imposed upon it during and after casting of concrete. It shall be made sufficiently rigid by using adequate number of ties and braces, screw jacks or hard board wedges where required shall be provided to make up any settlement in the form work either before or during the placing of concrete.

Form shall be so constructed as to be removable in sections in the desired sequence, without damaging the surface of concrete or disturbing other sections, care shall be taken to see that no piece is keyed into the concrete.

5.2.3.1 ***Material for Form Work***

(a) *Propping and Centering* : All propping and centering should be either of steel tubes with extension pieces or built up sections of rolled steel.

5.2.3.2 (a) ***Centering/Staging :*** Staging should be as designed with required extension pieces as approved by Engineer-in-Charge to ensure proper slopes, as per design for slabs/ beams etc. and as per levels as shown in drawing. All the staging to be either of Tubular steel structure with adequate bracings as approved or made of built up structural sections made form rolled structural steel sections.

(b) In case of structures with two or more floors, the weight of concrete, centering and shuttering of any upper floor being cast shall be suitably supported on one floor below the top most floor already cast.

(c) Form work and concreting of upper floor shall not be done until concrete of lower floor has set at least for 14 days.

5.2.3.3 ***Shuttering:*** Shuttering used shall be of sufficient stiffness to avoid excessive deflection and joints shall be tightly butted to avoid leakage of slurry. If required, rubberized lining of material as approved by the Engineer-in-Charge shall be provided in the joints. Steel shuttering used or concreting should be sufficiently stiffened. The steel shuttering should also be properly repaired before use and properly cleaned to avoid stains, honey combing, seepage of slurry through joints etc.

(a) *Runner Joists:* RSJ, MS Channel or any other suitable section of the required size shall be used as runners.

(b) Assembly of beam head over props. Beam head is an adopter that fits snugly on the head plates of props to provide wider support under beam bottoms.

(c) Only steel shuttering shall be used, except for unavoidable portions and very small works for which 12 mm thick water proofing ply of approved quality may be used.

5.2.3.4 Form work shall be properly designed for self weight, weight of reinforcement, weight of fresh concrete, and in addition, the various live loads likely to be imposed during the construction process (such as workmen, materials and equipment). In case the height of centering exceeds 3.50 metres, the prop may be provided in multi-stages. A typical detail of multistage shuttering is given in Fig. 5.9.

5.2.3.5 ***Camber:*** Suitable camber shall be provided in horizontal members of structure, especially in cantilever spans to counteract the effect of deflection. The form work shall be so assembled as to provide for camber. The camber for beams and slabs shall be 4 mm per metre (1 to 250) or as directed by the Engineer-in- Charge, so as to offset the subsequent deflection, For cantilevers the camber at free end shall be 1/50th of the projected length or as directed by the Engineer-in-Charge.

5.2.3.5.1 Typical arrangement of form work for 'beams, columns and walls' are shown in Figures 5.1 to 5.8 and form secured by wall ties is shown in Fig. 5.3.

5.2.3.6 ***Walls :*** The form faces have to be kept at fixed distance apart and an arrangement of wall ties with spacer tubes or bolts is considered best. A typical wall form with the components identified is given in Fig. 5.1, 5.2 & 5.3. The two shutters of the wall are to be kept in place by appropriate ties, braces and studs, some of the accessories used for wall form are shown in Fig. 5.3.

5.2.3.7 ***Removal of Form work (Stripping Time) :*** In normal circumstance and where various types of cements are used, forms, may generally be removed after the expiry of the following periods:

Type of Form work	*Minimum period Before Striking Form work for OPC 33 grade*	*Minimum period Before Striking Form work for OPC 43 grade*	*Minimum period Before Striking Form work for PPC*
(a) Vertical form work to columns, walls, beams	16-24 h	16-24 h	24-36 h

Type of Form work	*Minimum period Before Striking Form work for OPC 33 grade*	*Minimum period Before Striking Form work for OPC 43 grade*	*Minimum period Before Striking Form work for PPC*
(b) Soffit form work to slabs (Props to be refixed immediately after removal of formwork)	3 days	3 days	4 days
(c) Soffit form work to beams (Props to be refixed immediately after removal of formwork	7 days	7 days	10 days
(d) Props to slabs: (1) Spanning upto 4.5m (2) Spanning over 4.5m	 7 days 14 days	 7 days 14 days	 10 days 20 days
(e) Props to beams and arches: (1) Spanning upto 6m (2) Spanning over 6m	 14 days 21 days	 14 days 21 days	 20 days 30 days

Note 1: For other types of cement, the stripping time recommended for ordinary Portland cement may be suitably modified. Generally If Portland Pozzolana or low heat cement or OPC with direct addition of fly ash has been used for concrete, the stripping time will be 10/7 of the period stated for OPC with 43 grade cement above.

Note 2: The number of props left under, their sizes and disposition shall be such as to be able to safely carry the full dead load of the slabs, beam or arch as the case may be together with any live load likely to occur during curing or further construction.

Note 3: For rapid hardening cement, 3/7 of above periods for OPC 33 grade will be sufficient in all cases except for vertical side of slabs, beams and columns which should be retained for at least 24 hours.

Note 4: In case of cantilever slabs and beams, the centering shall remain till structures for counter acting or bearing down have been erected and have attained sufficient strength.

Note 5: Proper precautions should be taken to allow for the decrease in the rate of hardening that occurs with all types of cement in cold weather and accordingly stripping time shall be increased.

Note 6: Work damaged through premature or careless removal of forms shall be reconstructed within 24 hrs.

5.2.4 Surface Treatment

5.2.4.1 ***Oiling the Surface*** **:** Shuttering gives much longer service life if the surfaces are coated with suitable mould oil which acts both as a parting agent and also gives surface protections.

A typical mould oil is heavy mineral oil or purified cylinder oil containing not less than 5% pentachlorophenol conforming to IS 716 well mixed to a viscosity of 70-80 centipoises.

After 3-4 uses and also in cases when shuttering has been stored for a long time, it should be recoated with mould oil before the next use.

The second categories of shuttering oils / leavening agents are Polymer based water soluble Compounds. They are available as concentrates and when used diluted with water in the ratio of 1:20 or as per manufacturer specifications. The diluted solution is applied by brush applications on the shuttering both of steel as well as ply wood. The solution is applied after every use.

5.2.4.2 The design of form work shall conform to sound Engineering practices and relevant IS codes.

5.2.5 Inspection of Form Work

The completed form work shall be inspected and approved by the Engineer-in-Charge before the reinforcement bars are placed in position.

Proper form work should be adopted for concreting so as to avoid honey combing, blow holes, grout loss, stains or discoloration of concrete etc. Proper and accurate alignment and profile of finished concrete surface will be ensured by proper designing and erection of form work which will be approved by Engineer-in-Charge.

Shuttering surface before concreting should be free from any defect/ deposits and full cleaned so as to give perfectly straight smooth concrete surface. Shuttering surface should be therefore checked for any damage to its surface and excessive roughness before use.

5.2.5.1 ***Erection of Form Work (Centering and shuttering):*** Following points shall be borne in mind while checking during erection.

(a) Any member which is to remain in position after the general dismantling is done, should be clearly marked.

(b) Material used should be checked to ensure that, wrong items/ rejects are not used.

(c) If there are any excavations nearby which may influence the safety of form works, corrective and strengthening action must be taken.

(d) (i) The bearing soil must be sound and well prepared and the sole plates shall bear well on the ground.
(ii) Sole plates shall be properly seated on their bearing pads or sleepers.
(iii) The bearing plates of steel props shall not be distorted.
(iv) The steel parts on the bearing members shall have adequate bearing areas.

(e) Safety measures to prevent impact of traffic, scour due to water etc. should be taken. Adequate precautionary measures shall be taken to prevent accidental impacts etc.

(f) Bracing, struts and ties shall be installed along with the progress of form work to ensure strength and stability of form work at intermediate stage. Steel sections (especially deep sections) shall be adequately restrained against tilting, over turning and form work should be restrained against horizontal loads. All the securing devices and bracing shall be tightened.

(g) The stacked materials shall be placed as catered for, in the design.

(h) When adjustable steel props are used. They should:
1. be undamaged and not visibly bent.
2. have the steel pins provided by the manufacturers for use.
3. be restrained laterally near each end.
4. have means for centralizing beams placed in the forkheads.

(i) Screw adjustment of adjustable props shall not be over extended.

(j) Double wedges shall be provided for adjustment of the form to the required position wherever any settlement/ elastic shorting of props occurs. Wedges should be used only at the bottom end of single prop. Wedges should not be too steep and one of the pair should be tightened/ clamped down after adjustment to prevent shifting.

(k) No member shall be eccentric upon vertical member.

(l) The number of nuts and bolts shall be adequate.

(m) All provisions of the design and/or drawings shall be complied with.

(n) Cantilever supports shall be adequate.

(o) Props shall be directly under one another in multistage constructions as far as possible.

(p) Guy ropes or stays shall be tensioned properly.

(q) There shall be adequate provision for the movements and operation of vibrators and other construction plant and equipment.

(r) Required camber shall be provided over long spans.

(s) Supports shall be adequate, and in plumb within the specified tolerances.

5.2.5.2 Guidelines for Multistage Certering: The proper handling the situation of multistage centering in buildings or where height of casting of concrete is higher than normal height of 3.5 M or where higher loadings are coming during casting of concrete or large span structures and in situations of casting of some special structures like Domes, Vaults etc.

In all situations, centering/scaffolding/staging for casting of these structures should be properly designed by a qualified and experienced person/agency having past experience in design of false work (centering) for concrete structures and should be proof checked by similar experienced person/ agency and it should be properly approved and issued to contractor by Engineer-In-Charge. The provisions of clause 7 of IS:14687 may be referred for design of false work (centering).

A method statement for erection and dismantling of the centering/scaffolding/staging and process of concreting shall be prepared by contractor and submitted to Engineer-in-Charge for approval and the work shall be commenced only after approval of method statement by Engineer-in-Charge. The provisions of clause 9 of IS:14687 may be referred for erection of false work (centering), safety precautions and other site operations, pertaining to false work (centering).

Experienced form watcher shall be engaged during erection, concreting and dismantling for early detection of any movement or instability in the system. The field engineers shall ensure that CPWD specifications and provisions of BIS codes are strictly followed.

A detailed programme of field safety inspection of centering/scaffolding/form work of such structures during different stages should be chalked out and strictly followed.
Provision of safety net, fall arresting system including other safety gears, for workers, working over these structures shall be made in contract and should be followed strictly.

5.2.6 MEASUREMENTS

5.2.6.1 ***General*** **:** The form work shall include the following:

(a) Splayed edges, notching, allowance for overlaps and passing at angles, sheathing battens, strutting, bolting, nailing, wedging, easing, striking and removal.

(b) All supports, struts, braces, wedges as well as mud sills, piles or other suitable arrangements to support the form work.

(c) Bolts, wire, ties, clamps, spreaders, nails or any other items to hold the sheathing together.

(d) Working scaffolds, ladders, gangways, and similar items.

(e) Filleting to form stop chamfered edges of splayed external angles not exceeding 20mm wide to beams, columns and the like.

(f) Where required, the temporary openings provided in the forms for pouring concrete, inserting vibrators, and cleaning holes for removing rubbish from the interior of the sheathing before pouring concrete.

(g) Dressing with oil to prevent adhesion and

(h) Raking or circular cutting

5.2.6.2 ***Classification of Measurements:*** Where it is stipulated that the form work shall be paid for separately, measurements shall be taken of the area of shuttering in contact with the concrete surface. Dimensions of the form work shall be measured correct to a cm. The measurements shall be taken separately for the following.

(a) Foundations, footings, bases of columns etc. and for mass concrete

(b) Walls (any thickness) including attached pilasters, buttresses, plinth and string courses etc.

(c) Suspended floors, roofs, landings, shelves and their supports and balconies.

(d) Lintels, beams, plinth beams, girders, bressummers and cantilevers.

(e) Columns, pillars, piers, abutments posts and struts.

(f) Stairs (excluding landings) except spiral staircase.

(g) Spiral staircases (including landings).

(h) Arches, Domes, vaults, shells roofs, arch ribs, curvilinear shaped folded plates

(i) Extra for arches, domes, vaults exceeding 6 m span other than curvilinear shaped

(j) Chimneys and shafts.

(k) Well steining.

(l) Vertical and horizontal fins individually or forming box, louvers and bands.facias and eaves board

(m) Waffle or ribbed slabs.

(n) Edges of slabs and breaks in floors and walls (to be measured in running metres where below 200 mm in width or thickness).

(o) Cornices and mouldings.

(p) Small surfaces, such as cantilevers ends, brackets and ends of steps, caps and boxes to pilasters and columns and the like.

(q) Chullah hoods, weather shades, chajjas, corbels etc. including edges and

(r) Elevated water reservoirs.

5.2.6.3 Centering, and shuttering where exceeding 3.5 metre height in one floor shall be measured and paid for separately.

5.2.6.4 Where it is not specifically stated in the description of the item that form work shall be paid for separately, the rate of the RCC item shall be deemed to include the cost of form work.

5.2.6.5 No deductions from the shuttering due to the openings/ obstructions shall be made if the area of each openings/ obstructions does not exceed 0.4 square metre. Nothing extra shall be paid for forming such openings.

5.2.6.6 Form work of elements measured under categories of arches, arch ribs, domes, spiral staircases, well steining, shell roofs, curvilinear folded plates & curvilinear eaves board, circular shafts & chimneys shall not qualify for extra rate for circular work.

5.2.6.7 Extra for circular work shall be admissible for surfaces circular or curvilinear in plan or in elevation beyond the straight edge of supporting beam in respective mode of measurement. However, there may be many different types of such structures. In such cases, extra payment shall be made judiciously after deducting areas where shuttering for circular form work is not involved.

5.2.7 Rate

The rate of the form work includes the cost of labour and materials required for all the operations described above.

5.3 REINFORCEMENTS

5.3.1 General Requirements

Steel conforming to para 5.1.3 for reinforcement shall be clear and free from loose mill scales, dust, loose rust, coats of paints, oil or other coating which may destroy or reduce bond. It shall be stored in such a way as to avoid distortion and to prevent deterioration and corrosion. Prior to assembly of reinforcement on no account any oily substance shall be used for removing the rust.

5.3.1.1 ***Assembly of Reinforcement :*** Bars shall be bent correctly and accurately to the size and shape as shown in the detailed drawing or as directed by Engineer- in-Charge. Preferably bars of full length shall be used. Necessary cutting and straightening is also included. Overlapping of bars, where necessary shall be done as directed by the Engineer-in-Charge. The overlapping bars shall not touch each other and these shall be kept apart with concrete between them by 25mm or $1^{1}/_{4}$ times the maximum size of the coarse aggregate whichever is greater. But where this is not possible, the overlapping bars shall be bound together at intervals not exceeding twice the dia. of such bars with two strands annealed steel wire of 0.90 mm to 1.6 mm twisted tight. The overlaps/ splices shall be staggered as per directions of the Engineer-in-Charge. But in no case the overlapping shall be provided in more than 50% of cross sectional area at one section.

5.3.1.2 ***Bonds and Hooks Forming End Anchorages:*** Reinforcement shall be bent and fixed in accordance with procedure specified in IS 2502, code of practice of bending and fixing of bars for concrete reinforcement. The details of bends and hooks are shown below for guidance.

(a) U-Type Hook

In case of mild steel plain bars standard U type hook shall be provided by bending ends of rod into semicircular hooks having clear diameter equal to four times the diameter of the bar.

Note: In case of work in seismic zone, the size of hooks at the end of the rod shall be eight times the diameter of bar or as given in the structural drawings.

(b) Bends

Bend forming anchorage to a M.S. plain bar shall be bent with and internal radius equal to two times the diameter of the bar with a minimum length beyond the bend equal to four times the diameter of the bar.

5.3.1.3 ***Anchoring Bars in Tension :*** Deformed bars may be used without end anchorages provided, development length equipment is satisfied. Hooks should normally be provided for plain bars in tension. Development length of bars will be determined as per IS: 456.

5.3.1.4 ***Anchoring Bars in Compression :*** The anchorage length of straight bar in compression shall be equal to the 'Development length' of bars in compression as specified in IS: 456. The projected length of hooks, bend and straight lengths beyond bend, if provided for a bar in compression, shall be considered for development length.

5.3.1.5 ***Binders, stirrups, links etc. :*** In case of binders, stirrups, links etc. the straight portion beyond the curve at the end shall be not less than eight times **the** nominal size of bar.

5.3.2 Welding of Bars

Wherever facility for electric **arc** welding **or gas pressure welding** is available, welding of bars shall be done in lieu of overlap. The location and type of welding shall be got approved by the Engineer-in-Charge. Welding shall be as per IS 2751 and 9417.

5.3.3 Placing in Position

5.3.3.1 Fabricated reinforcement bars shall be placed in position as shown in the drawings or as directed by the Engineer -in -charge. The bars crossing one another shall be tied together at every intersection with two strands of annealed steel wire 0.9 to 1.6 mm thickness twisted tight to make the skeleton of the steel work rigid so that the reinforcement does not get displaced during deposition of concrete.

Tack welding in crossing bars shall also be permitted in lieu of binding with steel wire if approved by Engineer-in-Charge.

5.3.3.2 The bars shall be kept in correct position by the following methods:

(a) In case of beam and slab construction pre-cast cover blocks in cement mortar 1:2 (1 cement : 2 coarse sand) about 4x4 cm section and of thickness equal to the specified cover shall be placed between the bars and shuttering, so as to secure and maintain the requisite cover of concrete over reinforcements.

(b) In case of cantilevered and doubly reinforced beams of slabs, the vertical distance between the horizontal bars shall be maintained by introducing chairs, spacers or support bars of steel at 1.0 mere or at shorter spacing to avoid sagging.

(c) In case of columns and walls, the vertical bars shall be kept in position by means of timber templates with slots accurately cut in them: or with clock of cement mortar 1:2 (1 cement: 2 coarse sand) of required size suitable tied to the reinforcement to ensure that they are in correct position during concreting.

(d) In case of other R.C.C. structure such as arches, domes, shells, storage tanks etc. a combination of cover blocks, spacers and templates shall be used as directed by Engineer-in-Charge.

5.3.3.3 ***Tolerance on Placing of Reinforcement*****:** Unless otherwise specified by the Engineer-in-Charge, reinforcement shall be placed within the following tolerances:

	Tolerance in spacing
(a) For effective depth, 200 mm or less	+10 mm
(b) For effective depth, more than 200 mm	+ 15 mm

5.3.3.4 ***Bending at Construction Joints*** **:** Where reinforcement bars are bent aside at construction joints and afterwards bent back into their original position care should be taken to ensure that at no time the radius of the bend is less than 4 bar diameters for plain mild steel or 6 bar diameter for deformed bars. Care shall also be taken when bending back bars to ensure that the concrete around the bar is not damaged.

5.3.3.5 ***Cover :*** The minimum nominal cover to meet durability requirements shall be as under:-

Exposure	*Nominal Concrete cover in mm not less than*
Mild	20
Moderate	30
Severe	45
Very severe	50
Extreme	75

Notes :

1. For main reinforcement upto 12 mm diameter bar for mild exposure the nominal cover may be reduced by 5 mm.
2. Unless specified otherwise, actual concrete cover should not deviate from the required nominal cover by + 10 mm.
3. For exposure condition 'severe' and 'very severe' reduction of 5 mm may be made, where concrete grade is M35 and above.
4. Nominal cover to meet specified period of fire resistance shall not be less than as given in Table 16A of IS 456.

5.3.4 Measurement

Reinforcement including authorized spacer bars and lappages shall be measured in length of different diametre, as actually (not more than as specified in the drawings.) used in the work nearest to a centimetre and their weight calculated on the basis of standard weight given in Table 5.4 below. In case actual unit weight of the bars is less than standard unit weight, but within variation, in such cases weight of reinforcement shall be calculated on the basis of actual unit weight. Wastage and unauthorized overlaps shall not be paid for. Annealed steel wire required for binding or tack welding shall not be measured, its cost being included in the rate of reinforcement.

Where tack welding is used in lieu of binding, such welds shall not be measured. Chairs separators etc. shall be provided as directed by the Engineer-in-Charge and measured separately and paid for.

TABLE 5.4
Cross Sections Area and Mass of Steel Bar

Nominal Size mm	*Cross sectional Area Sq.mm*	*Mass per metre Run Kg.*
6	28.3	0.222
8	50.3	0.395
10	78.6	0.617
12	113.1	0.888
16	201.2	1.58
20	314.3	2.47
25	491.1	3.85
28	615.8	4.83
32	804.6	6.31
36	1018.3	7.99
40	1257.2	9.86

Note: These are as per clause 6.2 of IS 1786.

5.3.5 Rate

The rate for reinforcement shall include the cost of labour and materials required for all operations described above such as cleaning of reinforcement bars, straightening, cutting, hooking bending,

binding, placing in position etc. as required or directed including tack welding on crossing of bars in lieu of binding with wires.

5.3A STEEL FOR REINFORCEMENT READY TO USE "CUT & BEND"

5.3A.1 Cut and bend rebars are customised reinforced steel bars required at construction sites. These shall be made from specialized machinery ensuring exact precision, ready to use pre-cut and pre-bent as per approval drawings. The steel used for reinforcement shall be the following types.

(a) Thermo-mechanically treated (TMT) Bars.

5.3A.2 Elongation percent on gauge length is 5.65A, where A is the cross sectional area of the test piece.

5.3A.3 Welding of reinforcement bars covered in this specification shall be done in accordance with the requirement of IS 2751.

Nominal mass/weight:- The tolerance on mass/weight for round and square bars shall be the percentage given in Table 5.4A of the mass/weight calculated on the basis that the masses of the bar/wire of nominal diameter and of density 7.85 Kg/cm^3 or 0.00785 kg/mm^3.

TABLE 5.4A
Tolerance on Nominal Mass

Nominal size in mm	Tolerance on the Nominal Mass per cent		
	Batch	Individual sample+	Individual sample for coil (x)
(a) Upto and including 10	$\pm$7	-8	$\pm$8
(b) Over 10, upto and including 16	$\pm$5	-6	$\pm$6
(c) Over 16	$\pm$3	-4	$\pm$4

\+ for individual sample plus tolerance is not specified
(x) for coil batch tolerance is not applicable
Tolerance shall be determined in accordance with method given in IS 1786.

5.3A.4 High strength deformed bars & wires shall conform to IS 1786. The physical properties for all sizes of steel bars are mentioned below in Table 5.4B.

TABLE 5.4B

Sl. No.	Property	Fe 500 D	Fe 550 D
(i)	0.2 Per cent Proof stress/yield stress, Min, N/mm^2	500.0	550.0
(ii)	Elongation per cent, Min. on gauge length 5.65 $\sqrt{A}$, where A is the cross-sectional area of the test piece.	16.0	14.5
(iii)	Tensile strength, Min	10 Per cent more than the actual 0.2 per cent proof stress/yield stress but not less than 565.0 N/mm^2.	8 Per cent more than the actual 0.2 per cent proof stress/yield stress but not less than 600.0 N/mm^2.
(iv)	Total elongation at maximum force, percent, Min on gauge length 5.65 $\sqrt{A}$, where A is the cross-sectional area of the test piece.	5	5

Tests:-Selection and preparation of Test sample. All the tests piece shall be selected by the Engineer-in-charge or his authorized representative either-

(a) From cutting of bars
Or

(b) If he so desires, from any bar after it has been cut to the required or specified size and the test piece taken from and any part of it.

In neither case, the test pieces shall be detached from the bar or coil except in the presence of the Engineer-in-charge or his authorized representative.

The test piece obtained in accordance with as above shall be full sections of the bars as rolled and subsequently cold worked and shall be subjected to physical tests without any further modifications. No deduction in size by machining or otherwise shall be permissible. No test piece shall be enacted or otherwise subject to heat treatment. Any straightening which a test piece may require shall be done cold.

Tensile Test: 0.2% proof stress and percentage elongation-
This shall be done as per IS 1608, read in conjunction with IS 226.

RE-test:- This shall be done as per IS 1786.

Rebend test:- This shall be done as per IS 1786.

5.3A.5 Chemical composition of reinforcement bars shall be as per Table 5.4C as follows:-

TABLE 5.4C

Constituent	Maximum Per cent	
	Fe 500 D	Fe 550 D
Carbon	0.25	0.25
Sulphur	0.040	0.040
Phosphorus	0.040	0.040
Sulphur and Phosphorus	0.075	0.075

5.3A.6 Thermo Mechanically treated reinforcement bars:

(a) There is no BIS code for TMT bars. The available code BIS 1786 pertains to HSD Bars. Therefore there should be no stipulation that TMT bars should conform to relevant BIS code.

(b) The TMT bars are being produced under valid licence from either of the firms namely Tempcore, Thermex Evcon Turbo & Turbo Quench. These firms have acquired patents and are giving licences to various producers to produce TMT Bars.

(c) The TMT bars shall conform to IS 1786 pertaining to Fe 500 D or Fe grade of steel as specified.

(d) In design and construction of reinforcement concrete building in seismic zone III and above, steel reinforcement of Grade Fe 415 D shall be used. However, high strength deformed steel bars, produced by thermomechanical treatment process of grade Fe 500 and Fe 550 having elongation more than 14.5% and conform to other requirements of Fe 500 D and Fe 550 D respectively of IS 1786 may also be used for reinforcement. In future, latest provision of IS 456 and IS 13920 or any other relevant code as modified from time to time shall be applicable.

5.3A.7 Assembly of Rebars

5.3A.7.1 The rebars shall be bend correctly and precisely to the size and shape as shown in the detailed drawing or as directed by Engineer-in-charge. Overlapping of bars, where necessary shall be done as directed by the Engineer-in-charge. The overlapping bars shall not touch each other and these shall be kept apart with concrete between them by 25 mm or 1¼ times the maximum size of the coarse aggregate whichever is greater. But where this is not possible, the overlapping bars shall be bound together at intervals not exceeding twice the dia. of such bars with two strands annealed steel wire of 0.90 mm to 1.6 mm twisted light. The overlaps/splices shall be staggered as per direction of the Engineer-in-charge. But in no case the overlapping shall be provided in more than 50% of cross sectional area at one section.

5.3A.7.2 Bonds and Hooks Forming End Anchorages:-Reinforcement shall be bent and fixed in accordance with procedure specified in IS 2502, code of practice of bending and fixing of bars for concrete reinforcement.

5.3A.7.3 Anchorages Bars in Tension:-Deformed bars may be used without end anchorages Development length of bars will be determined as per IS: 456.

5.3A.7.4 Anchorages Bars in Compression:-The anchorages length of straight bar in compression shall be equal to the 'Development length' of bars in compression as specified in IS: 456. The projected length of bend and straight length beyond bend, if provided for a bar in compression, shall be considered for development length.

5.3A.7.5 Binders, stirrups, link etc:-In case of binders, stirrups, link etc. the straight portion beyond the curve at the end shall be not less than eight times the nominal size of bar.

5.3A.8 Welding of Bars.

Wherever facility for electric arc welding or gas pressure welding is available, welding of bars shall be done in lieu of overlap. The location and type of welding shall be got approved by the Engineer-in-charge. Welding shall be as per IS 2751 and 9417.

5.3A.9 Placing in Position

5.3A.9.1 Fabricated reinforcement bars shall be placed in position as shown in the drawings or as directed by the Engineer-in-charge. The bars crossing one another shall be tied together at every intersection with two strands of annealed steel wire 0.9 to 1.6 mm thickness twisted tight to make the skeleton of the steel work rigid so that the reinforcement does not get displaced during deposition of concrete.

Tack welding in crossing bars shall also be permitted in lieu of binding with steel wire if approved by Engineer-in-charge.

5.3A.9.2 The bars shall be kept in correct position by the following methods:

(a) In case of beam and slab construction pre-cast cover blocks in cement mortar 1:2 (1cement : 2 coarse sand) about 4 x 4 cm section and of thickness equal to the specified cover shall be placed between the bars and shuttering, so as to secure and maintain the requisite cover of concrete over reinforcements.

(b) In case of cantilevered and doubly reinforced beams of slabs, the vertical distance between the horizontal bars shall be maintained by introducing chairs, spacers or support bars of steel at 1.0 metre or at shorter spacing to avoid sagging.

(c) In case of columns and walls, the vertical bars shall be kept in position by means of timber templates with slots accurately cut in them or with block of cement mortar 1:2 (1 cement : 2 coarse sand) of required size suitable tied to the reinforcement to ensure that they are in correct position during concreting.

(d) In case of other R.C.C. structure such as arches, domes, shells, storage tank etc. a combination of cover blocks, spacers and templates shall be used as directed by Engineer-in-charge.

5.3A.9.3 Tolerance on Placing of Reinforcement:-Unless otherwise specified by the Engineer-in-charge, reinforcement shall be placed within the following tolerances.

	Tolerance in spacing
(a) For effective depth, 200 mm or less	+ 10 mm
(b) For effective depth, more than 200 mm	+ 15 mm

5.3A.9.4 Bending at Construction Joints:-Where reinforcement bars are bent aside at construction joints and afterwards bent back into their original position, care should be taken to ensure that at no time the radius of the bend is less than 6 bars diameter. Care should also be taken when bending back bars to ensure that the concrete around the bar is not damaged.

5.3A.9.5 Cover:-The minimum nominal cover to meet durability requirements shall be as under:-

Exposure	Nominal Concrete cover in mm not less than
Mild	20
Moderate	30
Severe	45
Very severe	50
Extreme	75

Note : 1. For main reinforcement upto 12 mm diameter bar for mild exposure the nominal cover may be reduced by 5 mm.

2. Unless specified otherwise, actual concrete cover should not deviate from the required nominal cover by + 10 mm.

3. For exposure condition ‘severe’ and ‘very severe’ reduction of 5 mm may be made, where concrete grade is M 35 and above.

4. Nominal cover to meet specified period of fire resistance shall not be less than as given in Table 16A of IS 456.

5.3A.10 Measurement

The Measurement shall be as specified under para 5.3.4

5.3A.11 Rate

The Measurement shall be as specified under para 5.3.5

5.3B REINFORCEMENT COUPLERS

5.3B.1 General requirement of material

Reinforcement coupler shall have adequate strength, length and internal threads as per manufacturer's design to be able to meet the performance requirement as per IS Code. All reinforcement coupler shall be finished smooth and shall be free from burrs, cracks and other manufacturing defects. The threads shall be clearly formed and shall be free from imperfections. The nominal sizes of reinforcement couplers based on their internal diameter shall correspond to the size of bars covered under IS Code 1786. Each coupler should be identifiable by marks/ brands which indicate name of manufacture or their brand name, class designation, nominal size and grade of reinforcement for which it is intended and BIS standard mark.

5.3B.2 Performance Requirement: All reinforcement couplers shall meet the performance requirements as per IS Code 16172:2014 clause 9.2, 9.3, 9.4 and 9.5.1. Class H couplers in addition to above shall also meet requirement of clause 9.5.2 of IS Code 16172:2014.
The static tensile test shall constitute acceptance test.

5.3B.3 Sampling and criteria for conformity: Sampling and criteria for conformity shall be as per Annexure 'F' of IS Code 16172:2014

5.3B.4 Installation procedure/ instructions: The manufacturer/ supplier shall provide written installation instructions. The installation instructions shall be clear and understandable. The described installation procedure of reinforcement coupler shall be repeatable and able to achieve its performance under different job site circumstances.

5.3B.5 Measurement : The reinforcement couplers shall be measured in numbers.

5.3B.6 Rate : The rate shall be inclusive of all materials &labour involved in fixing parallel threaded couplers to reinforcement bars.

5.4 CONCRETING

5.4.0 The concrete shall be as specified under chapter 4 concrete work. The proportion by volume or by the weight of ingredients shall be as specified.

5.4.1 Consistency

The concrete which will flow sluggishly into the forms and around the reinforcement without any segregation of coarse aggregate from the mortar shall be used. The consistency shall depend on whether the concrete is vibrated on or hand tamped, it shall be determined by slump test as prescribed in sub-head "concrete" under workability – requirement.

5.4.2 Placing of Concrete

5.4.2.1 Concreting shall be commenced only after Engineer-in-Charge has inspected the centering, shuttering and reinforcement as placed and passed the same. Shuttering shall be clean and free from all shavings, saw dust, pieces of wood, or other foreign material and surfaces shall be treated as prescribed in 5.2.4.

5.4.2.2 In case of concreting of slab and beams, wooden plank or cat walks of chequerred MS plated or bamboo chalies or any other suitable material supported directly on the centering by means of wooden blocks or lugs shall be provided to convey the concrete to the place of deposition without disturbing the reinforcement in any way. Labour shall not be allowed to walk over the reinforcement.

5.4.2.3 In case of columns and wall, it is desirable to place concrete without construction joints. The progress of concreting in the vertical direction, shall be restricted to one metre per hour.

5.4.2.4 The concrete shall be deposited in its final position in a manner to preclude segregation of ingredients. In deep trenches and footings concrete shall be placed through chutes or as directed by the Engineer-in-Charge. In case of columns and walls, the shuttering shall be so adjusted that the vertical drop of concrete is not more than 1.5 metres at a time.

5.4.2.5 During cold weather, concreting shall not be done when the temperature falls below 4.5^{0}C. The concrete placed shall be protected against frost by suitable covering. Concrete damaged by frost shall be removed and work redone.

5.4.2.6 During hot weather precaution shall be taken to see that the temperature of wet concrete does not exceed 38ºC. No concrete shall be laid within half an hour of the closing time of the day, unless permitted by the Engineer-in-Charge.

5.4.2.7 It is necessary that the time between mixing and placing of concrete shall not exceed 30 minutes so that the initial setting process is not interfered with.

5.4.3 Compaction

It shall be as specified in sub-head of Concrete Work of this specification.

5.4.3.1 Concrete shall be compacted into dense mass immediately after placing by means of mechanical vibrators designed for continuous operations complying with IS 2505, IS 2506, IS 2514 and IS 4656. The Engineer- in- Charge may however relax this condition at his discretion for certain items depending on the thickness of the members and feasibility of vibrating the same and permit hand compaction instead. Hand compaction shall be done with the help of tamping rods so that concrete is thoroughly compacted and completely worked around the reinforcement, embedded fixtures, and into corners of the form. The layers of concrete shall be so placed that the bottom layer does not finally set before the top layer is placed. The vibrators shall maintain the whole of concrete under treatment in an adequate state of agitation; such that de-aeration and effective compaction is attained at a rate commensurate with the supply of concrete from the mixers. The vibration shall continue during the whole period occupied by placing of concrete, the vibrators being adjusted so that the centre of vibrations approximates to the centre of the mass being compacted at the time of placing.

5.4.3.2 Concrete shall be judged to be properly compacted, when the mortar fills the spaces between the coarse aggregate and begins to cream up to form an even surface. When this condition has been attained, the vibrator shall be stopped in case of vibrating tables and external vibrators. Needle vibrators shall be withdrawn slowly so as to prevent formation of loose pockets in case of internal vibration. In case both internal and external vibrators are being used, the internal vibrator shall be first withdrawn slowly after which the external vibrators shall be stopped so that no loose pocket is left in the body of the concrete. The specific instructions of the makers of the particular type of vibrator used shall be strictly complied with. Shaking of reinforcement for the purpose of compaction should be avoided. Compaction shall be completed before the initial setting starts, i.e. with 30 minutes of addition of water to the dry mixture.

5.4.3.3 In case of roof slabs the top surface shall be finished even and smooth with wooden trowel, before the concrete begins to set. Sprinkling of dry cement while finishing shall not be resorted to.

5.4.4 Construction joints

5. 4.4.1 Joints are a common source of weakness and, therefore, it is desirable to avoid them. If this is not possible, their number shall be minimized. Concreting shall be carried out continuously up to construction joints, the position and arrangement of which shall be indicated in Fig 5.26 or as directed by Engineer-in-Charge.

5.4.4.2 In case of columns the joints shall be horizontal and 10 to 15 cm below the bottom of the beam running into the column head. The portion of the column between the stepping off level and the top of the slab shall be concreted with the beam.

5.4.4.3 When stopping the concrete on a vertical plane in slabs and beams, and approved stop board (see Fig. 26C) shall be placed with necessary slots for reinforcement bars or any other obstruction to pass the bars freely without bending. The construction joints shall be keyed by providing a triangular or trapezoidal fillet nailed on the stop board. Inclined or feather joints shall not be permitted. Any concrete flowing through the joints of stop board shall be removed soon after the initial set. When concrete is stopped on a horizontal plane, the surface shall be roughened and cleaned after the initial set.

5.4.4.4 When the work has to be resumed, the joint shall be thoroughly cleaned with wire brush and loose particles removed. A coat of neat cement slurry at the rate of 2.75 kg of cement per square metre shall then be applied on the roughened surface before fresh concrete is laid.

5.4.5 Expansion Joints

Expansion joints shall be provided as shown in the structural drawings or as indicated in Fig. 5.10 to 5.25 or as directed by Engineer-in-Charge, for the purpose of general guidance. However it is recommended that structures exceeding 45 m in length shall be divided by one or more expansion joints. The filling of these joints with bitumen filler, bitumen felt or any such material and provision of copper plate, etc. shall be paid for separately in running metre. The measurement shall be taken two places of decimal stating the depth and width of joint.

5.4.6 Curing

After the concrete has begun to harden i.e. about 1 to 2 hours after its 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-in-Charge. 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.

5.4.7 Rectification of Surface defects of Minor nature

Immediately on removal of forms, the R.C.C. work shall be examined by the Engineer-in-Charge, before any defects are made good.

(a) The work that has sagged or contains honey combing to an extent detrimental to structural safety or architectural concept shall be rejected as given in para 5.4.9.4 for visual inspection test.

(b) Surface defects of minor nature may be accepted. On acceptance of such a work by the Engineer-in-Charge, the same shall be rectified as follows:

1. Surface defects which require repair when forms are removed, usually consist of bulged due to movement of forms, ridges at form joints, honey-combed areas, damage resulting from the stripping of forms and bolt holes, bulges and ridges are removed by careful chipping or tooling and the surface is then rubbed with a grinding stone. Honey-combed and other defective areas must be chipped out, the edges being cut as straight as possible and perpendicularly to the surface, or preferably slightly under cut to provide a key at the edge of the patch.

2. Shallow patches are first treated with a coat of thin grout composed of one part of cement and one part of fine sand and then filled with mortar similar to that used in the concrete. The mortar is placed in layers not more than 10mm thick and each layer is given a scratch finish to secure bond with the succeeding layer. The last layer is finished to match the surrounding concrete by floating, rubbing or tooling on formed surfaces by pressing the form material against the patch while the mortar is still plastic.

3. Large and deep patches require filling up with concrete held in place by forms. Such patches are reinforced and carefully dowelled to the hardened concrete.

4. Holes left by bolts are filled with mortar carefully packed into places in small amounts. The mortar is mixed as dry as possible, with just enough water so that it will be tightly compacted when forced into place.

5. Tiered holes extending right through the concrete may be filled with mortar with a pressure gun similar to the gun used for greasing motor cars.

6. Normally, patches appear darker than the surrounding concrete, possibly owing to the presence on their surface of less cement laitance. Where uniform surface colour is important, this defect shall be remedied by adding 10 to 20 percent of white Portland cement to the patching mortar, the exact quantity being determined by trial.

7. The same amount of care to cure the materials in the patches should be taken as with the whole structure. Curing must be started as soon as possible, after the patch is finished to prevent early drying. Damp Hessian may be used but in some locations it may be difficult to hold it in place. A membrane curing compound in these cases will be most convenient.

(c) **Whenever required**, The exposed surface of R.C.C. work shall be plastered with cement mortar 1:3 (1 cement : 3 fine sand) of thickness not exceeding 6 mm to give smooth and even surface true to line and form. Any RCC surface which remains permanently exposed to view in the completed structure, shall be considered exposed surfaced for the purpose of this specification.

(d) The surface which is to receive plaster or where it is to be joined with brick masonry wall, shall be properly roughened immediately after the shuttering is removed, taking care to remove the laitance completely without disturbing the concrete. The roughening shall be done by hacking. Before the surface is plastered, it shall be cleaned and wetted so as to give bond between concrete and plaster.

RCC work shall be done carefully so that the thickness of plaster required for finishing the surface is not more than 6 mm.

(e) The surface of RCC slab on which the cement concrete or mosaic floor is to be laid shall be roughened with brushes while the concrete is green. This shall be done without disturbing the concrete.

5.4.8 Strength of Concrete

The compressive strength on the work tests for different mixed shall be as given in Table 5.5 below:-

TABLE 5.5

Concrete Mix (Nominal Mix on Volume basis)	*Compressive Strength in (Kg/ sq cm)*	
	7 days'	*28 days'*
1:1:2	210	315

1:1.5:3	175	265
1:2:4	140	210

5.4.9 Testing of Concrete

5.4.9.0 Regular mandatory tests on the workability of the fresh concrete shall be done to achieve the specified compressive strength of concrete. These will be of two types

(a) Mandatory Lab, Test
(b) Mandatory Field Test

Results of Mandatory Field Test will prevail over mandatory Lab. Test.

5.4.9.1 ***Cube Test for Compressive Strength of Concrete - Mandatory Lab Test :*** Mandatory tests shall be carried out as prescribed in Appendix A of Chapter 5.

5.4.9.2 ***Additional Test*** *:* Additional test, if required, shall be carried out as prescribed in Appendix B of Chapter 5.

5.4.9.3 ***Slump Test :*** This test shall be carried out as prescribed in sub-head 4 of concrete.

5.4.9.4 ***Visual Inspection Test :*** The concrete will be inspected after removal of the form work as described in para 5.4.7.2 The question of carrying out mandatory test or other tests described in Appendix A and B (para 5.4.9.1 and 5.4.9.2) will arise only after satisfactory report of visual inspection.

The concrete is liable to be rejected if:

(i) It is porous or honeycombed as per para 5.4.7.2 (a).
(ii) Its placing has been interrupted without providing a proper construction joint.
(iii) The reinforcement has been displaced beyond tolerance specified or construction tolerances have not been met.

However, the hardened concrete may be accepted after carrying out suitable remedial measures to the satisfaction of the Engineer-in-Charge at the risk and cost of the contractor.

5.4.10 Standard of Acceptance – for Nominal Mix

5.4.10.1 ***Mandatory Lab. Test :*** For concrete sampled and tested as prescribed in Appendix A of Chapter 5, the following requirement shall apply.

5.4.10.2 Out of six sample cubes, three cubes shall be tested at 7 days and remaining three cubes at 28 days.

5.4.10.3 ***7 days' Tests***

Sampling: The average of the strength of three specimen shall be accepted as the compressive strength of the concrete provided the variation in strength of individual specimen is not more than $\pm$ 15% of the average. Difference between the maximum and minimum strength should not exceed 30% of average strength of three specimens. If the difference between maximum and minimum strength exceeds 30% of the average strength, then 28 days' test shall have to be carried out.

Strength: If the actual average strength of sample accepted in para 'sampling' above is equal to or higher than specified strength upto $\pm$15% then strength of the concrete shall be considered in order.

In case the actual average strength of sample accepted in the above para is lower than the specified or higher by more than 15% then 28 days' test shall have to be carried out to determine the compressive strength of concrete cubes.

5.4.10.4 ***28 days' Test***

(a) The average of the strength of three specimen be accepted as the compressive strength of the concrete provided the strength of any individual cube shall neither be less than 70% nor higher than 130% of the specified strength.

(b) If the actual average strength of accepted sample exceeds specified strength by more than 30% the Engineer-in-Charge, if he so desires, may further investigate the matter. However, if the strength of any individual cube exceeds more than 30% of specified strength, it will be restricted to 130% only for computation of strength.

(c) If the actual average strength of accepted sample is equal to or higher than specified strength upto 30% then strength of the concrete shall be considered in order and the concrete shall be accepted at full rates.

(d) If the actual average strength of accepted sample is less than specified strength but not less than 70% of the specified strength, the concrete may be accepted at reduced rate at the discretion of Engineer-in-Charge (see para 5.4.13.2).

(e) If the actual average strength of accepted sample is less than 70% of specified strength, the Engineer-in-Charge shall reject the defective portion of work represented by sample and nothing shall be paid for the rejected work. Remedial measures necessary to retain the structure shall be taken at the risk and cost of contractor. If, however the Engineer-in-Charge so desires, he may order additional tests (See Appendix B of Chapter 5) to be carried out to ascertain if the structure can be retained. All the charges in connection with these additional tests shall be borne by the contractor.

5.4.10.5 ***Acceptance Criteria of Field Test (Additional Test – Not Mandatory)***

(A) Preparation of Standard Test Cubes for calibration of Rebound Hammer at site

(a) In the beginning the standard test cubes of the specified mix shall be prepared by field units before undertaking any concrete work in each project.

(b) At least 18 standard cubes necessary for formation of one specimen of specified mix, shall be cast by site staff well in advance. From these 18 cubes any 3 cubes may be selected at random to be tested for crushing strength of 7 days. The crushing strength obtained should satisfy the specified strength for the mix as per specification or agreement. If the strength is satisfactory then the remaining cube will form the standard samples for calibration of rebound hammer. In case of failure, the site staff should totally reject the samples and remove them also and then make another set of samples by fresh mixing or alternatively, out of the remaining 15 cubes, 3 cubes will be tested on 28 days. If the 28 days' tests are found satisfactory then remaining 12 cubes will form the standard sample for calibration at 28 days' strength otherwise all samples shall be rejected and whole procedure repeated to form a fresh specimen. All the results shall be recorded in a register.

(c) No concreting will be allowed unless the standard specimen cubes are obtained.

The criteria for acceptance and calibration of hammer will be 28 days' strength. The 7 days' strength is only to facilitate the work to start.

(d) No work (for the concrete cast between 8th and 28th day) shall be allowed to be paid unless 28 days' cube strength is obtained. For the concrete cast between 8th and 28th day, the decision to make the payment may be taken by the Engineer-in-charge on the basis of existing criteria. Concrete work will be rejected if 28 days' strength falls short as per acceptance criteria. No further work will be allowed till the acceptable standard cubes are obtained.

(e) *Frequency*: it will be once in each quarter or as per the direction and discretion of Engineer-in-Charge. Whenever the acceptance criteria is changed or concrete mix or type of cement is changed or Engineer-in-Charge feels it necessary for recorded reasons with the approval of the authority according to technical sanction, fresh specimen shall be prepared.

(B) Calibration of Hammer

(a) Simultaneously, same three cubes to be tested on 28 days as referred in para A (b) above shall be used to correlate the compressive strength of their concrete with rebound number as per procedure described in para 5.2 of the IS 13311 (Part 2) "Indian standard for non-destructive testing of concrete Method of test by rebound hammer which is given below in para B (b). The average of values of the rebound number (minimum readings) obtained in respect of same three cubes passing on 28 days' work test shall form the datum reference for remaining cubes for the strength of cubes.

(b) The concrete cubes specimens are held in a compression testing machine under a fixed load, measurements of rebound hammer taken and then compressive strength determined as per IS 516. The fixed load required is of the order of 7 N/mm^2 when the impact energy of the hammer is about 2.2 NM.

If the specimen are wet cured, they should be removed from wet storage & kept in the laboratory atmosphere for about 24 hours before testing.

Only the vertical faces of the cubes as cast should be tested for rebound number. At least nine readings should be taken on each of the three vertical faces accessible in the compression testing machine when using rebound hammers. The points of impact in the specimen must not be nearer than 20 mm from the edge & should not be less than 20 mm from each other. The same points must not be impacted more than once.

(c) The rebound number of hammer will be determined on each of the remaining (18-3-3=12) cubes. Whenever the rebound number of hammer of any individual cube varies by more than +25% form the datum readings referred to in para B (a) above, that cube will be excluded and will not be considered for standard specimen cubes for calibration. It must be ensured that at least 8 cubes out of 12 that is 66.67% are within the permissible range of variation of rebound number i.e. +25% or otherwise whole procedure shall have to be repeated and fresh specimen prepared.

These 8 cubes will form one standard sample in the beginning before commencement of work and shall be kept carefully for the visiting officers who will calibrate their hammers on these cubes.

(d) This calibration will be done by field staff with their hammer and then chart of calibration giving the details of the average readings, date & month of casting, mix of the concrete etc. shall be prepared and signed by Engineer-in-Charge and will be duly preserved for future reference as and when required.

(C) Preservation of Cubes at site

Standard sample cubes cast shall be carefully preserved at site under the safe custody of AE or his representative for making them available together with the charts, to the officers of QCTA/CTE or any other senior departmental officer, during their inspection of the work. They will calibrate their hammer on these cubes if required.

(D) Testing at Site

(D-1) Testing Equipments

(D-2) Testing will be done generally by non-destructive methods like rebound hammers etc. Each field Division/ Sub Division/ Unit will purchase rebound hammers and keep them in working order at work site. The testing will be done only by hammers which are duly calibrated.

(D-3) The relative strength of actual field work will be tested with reference to strength of these standard cubes and calibration charts of a hammer for determining the rebound number on the field work. The hammer will be used as per manufacturer's guidelines at various locations chosen at random. The number of location/reading on each wall, beam or column etc. shall not be less than 12. All the readings should be within the +25% range of values prescribed in calibration chart normally. However, reading indicating good strength will be when it is at per with calibrated value or between 100% & 125% and very good if more than 125% any value between 100% & 75% of calibrated value shall be considered satisfactory. Values from 75% to 50% shall be considered for payment at rates reduced on prorate basis. The concrete indicating rebound number less than 50% of calibrated value shall be rejected and not paid for.

(E) Acceptance of Field Tests and Strength

If the relative strength of actual field work is found satisfactory considering the calibration charts with reference to the standard cube test kept at site, the representative work will be considered satisfactory. If the work is considered below satisfactory, the same will be dealt as stated in para D-3 above.

(F) 7 days' Strength in Rare Cases only

Normally cube crushing strength on 28 days' test shall form the basis of acceptance. However in rare cases of time bound projects/ urgent repairs 7 days' cube test strength criteria may be adopted on similar lines using 7 days' standard test cubes and calibration graphs/ curves/ charts for 7 days' in lieu of 28 days' and testing work done at 7 days'.

(G) Precautions

(G-1) The testing shall be done generally as per guidelines of manufacture of the apparatus and strictly in accordance with the procedure laid down in clause 6 of IS 13311 (Part 2): Indian Standard for Non-Destructive Testing of Concrete - Method of Test by Rebound Hammer.

(G-2) The rebound hammers are influenced by number of factor like type of cement aggregate, surface conditions, moisture content, age of concrete & extent of calibration of concrete etc. hence care shall be taken to compare the cement, aggregate etc. and tested under the similar surface conditions having more or less same moisture content and age. However effect of age can be ignored for concrete between 3 days & 3 months old.

5.4.11 Measurements

5.4.11.1 Dimensions shall be measured nearest to a cm except for the thickness of slab which shall be measured correct to 0.5 cm. The areas shall be worked out nearest to 0.01 Sq. mt. The cubical contents shall be worked out to nearest 0.01 cubic metre.

5.4.11.2 Reinforced cement concrete whether cast-in-situ or pre cast shall be classified and measured separately as follows.

(a) Raft, footing, bases of columns and mass concrete etc. all work up to plinth level, column up to plinth level, plinth beams.

(b) Wall (any thickness) including attached pilasters, buttresses plinth and string course, fillets, column, pillars, piers, abutments, post and struts etc.

(c) Suspended floors, roofs, landings and balconies.

(d) Shelves

(e) Chajjas

(f) Lintel, beams and bressummers.

(g) Columns, pillars, piers, abutments, posts and struts.

(h) Stair-cases including waist or waist less slab but excluding landing except in (i) below.

(i) Spiral stair-case (including landing).

(j) Arches, arch ribs, domes and vaults.

(k) Chimneys and shafts.

(l) Well steining.

(m) Vertical and horizontal fins individually or forming box, louvers and facias.

(n) Kerbs, steps and the like.

(o) String courses, bands, coping, bed plates, anchor blocks, plain window sills and the like.

(p) Mouldings as in cornices, window sills etc.

(q) Shell, dome and folded plates.

(r) Extra for shuttering in circular work in plan.

5.4.11.3 Work under the following categories shall be measured separately.

(a) Rafts, footings, bases of columns etc. and mass concrete.

(b) All other items upto floor two level.

(c) From floor two level to floor three level and so on.

(d) R.C.C. above roof level shall be measured along with R.C.C. Work in floor just below.

5.4.11.4 No deduction shall be made for the following:

(a) Ends of dis-similar materials (e.g. Joists, beams, post, girders, rafter, purlins, trusses, corbels steps etc.) upto 500 sq cm in cross-section.

(b) Opening upto 0.1. sqm.

Note: In calculating area of openings upto 0.1 sqm the size of opening shall include the thickness of any separate lintels or sills. No extra labour for forming such openings or voids shall be paid for.

(c) The volume occupied by reinforcement.

(d) The volume occupied by water pipes, conduits etc. not exceeding 25 sq cm each in cross sectional area. Nothing extra shall be paid for leaving and finishing such cavities and holes.

5.4.11.5 Measurement shall be taken before any rendering is done in concrete members. Measurement will not include rendering. The measurement of R.C.C. work between various units shall be regulated as below:

(a) Slabs shall be taken as running continuously through except when slab is monolithic with the beam. In that case it will be from the face to face of the beam.

(b) Beams shall be measured from face to face of columns and shall be including haunches, if any, between columns and beam. The depth of the beam shall be from the bottom of slab to the bottom of beam if beam and slab are not monolithic. In case of monolithic construction where slabs are integrally connected with beam, the depth of beam shall be from the top of the slab to the bottom of beam.

(c) The columns measurements shall be taken through.

(d) Chajjas along with its bearing on wall shall be measured in cubic metre nearest to two places of decimal. When chajjas is combined with lintel, slab or beam, the projecting portion shall be measured as chajjas, built in bearing shall be measured as per item of lintel, slab or beam in which chajja bears.

(e) Where the band and lintels are of the same height and the band serves as lintel the portion of the band to be measured as lintel shall be for clear length of opening plus twice the over all depth of band.

5.4.12 Tolerances

Subject to the condition that structural safety is not impaired and architectural concept does not hamper, the tolerances in dimensions of R.C.C. members shall be as specified in the drawings by the designer. Whenever these are not specified, the permissible tolerance shall be decided by the Engineer-in-Charge after consultations with the Designer, if necessary.

When tolerances in dimensions are permitted, following procedure for measurement shall apply.

(a) If the actual dimension of R.C.C. members do not exceed or decrease the design dimensions of the members plus or minus tolerance limit specified above, the design dimensions shall be taken for the purpose of measurement.

(b) If the actual dimensions exceed the design dimensions by more than the tolerance limit, the design dimensions only shall be measured for the purpose of payment.

(c) If the actual dimensions decrease more than the tolerance limit specified, the actual dimensions of the RCC members shall be taken for the purpose of measurement and payment.

(d) For acceptance of RCC members whose dimensions are not exactly as per design dimensions, the decision of Engineer-in-Charge shall be final. For the purpose of payment, however, the clarification as given in para a, b & c above shall apply.

5.4.13 Rate

5.4.13.1 The rate included the cost of materials and labour involved in all the operations described above except for the cost of centering and shuttering, **finishing & reinforcement**.

5.4.13.2 On the basis of mandatory lab tests, in case of actual average compressive strength being less than specified strength but upto 70% of specified strength, the rate payable shall be in the same proportion as actual average compressive strength bears to specified compressive strength.

Example:

1. Average compressive strength in 80% of specified strength. Rate payable shall be 80% of agreement rate.
2. In case average compressive strength is less than 70% of the specified strength, the work represented by the sample shall be rejected.
3. However, on the basis of mandatory field tests, where they prevail, the rates of the work represented by samples showing actual compressive strength less than specified strength shall be worked out as per para 5.4.10.5 (D-3) above. In addition, Engineer-in-charge may order for additional tests (see Appendix 'B' of chapter 5) to be carried out at the cost of contractor to ascertain if the portion of structure where in concrete represented by the samples had been used, can be retained on the basis of these tests. Engineer-in-Charge may take further remedial measured as necessary to retain the structure at the risk and cost of the contractor.

5.4.13.3 Where throating or plaster drip or moulding is not required to be provided in RCC chajjas, deduction for not providing throating or plaster drip or moulding shall be made from the item of R.C.C. in chajjas. The measurement for deduction item shall be made in running metres correct to a cm of the edge of chajja.

5.4.13.4 No extra payment for richer mix which projects into any member from another member during concreting of junctions of beams and columns etc. will be made except to the extent structurally considered necessary and when so indicated in the structural drawings. The payment for work done under items of different mixed shall be limited strictly to what is indicated in the structural drawings.

5.5 ENCASING ROLLED STEEL SECTIONS

5.5.1 General Requirements

Before concrete work is started, the Engineer-in-Charge shall check that all rolled steel sections to be encased, have been erected truly in position. The sections shall be unpainted and shall be wire brushed to remove the loose rust/ scales etc. Where so specified, ungalvanised metal, having mesh or perforations large enough to permit the free passage of 12.5 mm nominal size aggregate through them shall be wrapped round the section to be encased and paid for separately.

5.5.2 Wrapping

5.5.2.1 In case of columns, the wrapping shall be arranged as illustrated in Fig. 5.27 to pass through the centre of the concrete covering. The wrapping of the entire length of the columns be carried out in stages and no stage shall cover more than 1.5 metre of height of columns. Successive wrappings shall be carried out only after the immediate adjacent wrapping has been encased in concrete. The surface and edges of the flanges of the steel columns shall have a concrete cover of not less than 50mm. The wrappings of the successive stages shall be tied together.

5.5.2.2 In the case of beams and grillages, the wire mesh or expanded metal shall be wrapped round the lower flange of the beam as illustrated in Fig. 5.28 and the wrapping shall be suspended by wire hangers 5 mm diameter placed at about 1.2 metres centres. The surfaces and edges of the steel sections shall have a concrete cover of not less than 50mm. The wrapping shall pass through the centre of the concrete covering at the edges and soffits of the flanges.

5.5.3 Form Work shall be as prescribed in 5.2.

5.5.4 Concreting

Concrete shall consist of a mix of 1:2:4 (1 cement : 2 coarse and : 4 graded stone aggregate of 12.5 mm nominal size) unless a richer mix is specified. The mix shall be poured solidly around the steel sections and around the wrapping by vibrating the concrete into position. Consistency of concrete, Placing of concrete and its compaction, curing, finishing and strength of concrete shall be as described in 5.4.

5.5.5 Measurements

The length shall be measured correct to one cm and other dimensions correct of 0.5 cm. The cement concrete shall be measured as per gross dimensions of the encasing exclusive of the thickness of plaster. No deduction shall be made for the volume of steel sections, expanded metal, mesh or any other reinforcement used therein. However, in case of boxed stanchions or girders, the boxed portion only shall be deducted.

Fabric reinforcement such as expanded metal shall be measured separately in square metres stating the mesh and size of strands.

The description shall include the bending of the fabric as necessary, Racking or circular cutting and waste shall be included in the description.

5.5.6 Rate

The rate shall include the cost of materials and labour required for all the operations described above except the cost of fabric reinforcement. The cost of providing and erecting steel section and wire hangers shall be paid for separately.

5.6 PRECAST REINFORCED CONCRETE

5.6.1 General Requirements

Precast reinforced concrete units such as columns, fencing posts, door and window frames, lintels, chajjas, copings, sills , shelves, slabs, louvers etc. shall be of grade of mix as specified and cast in forms or moulds. The forms/ moulds shall be of fiber glass or of steel sections for better finish. Provision shall be made in the forms and moulds to accommodate fixing devices such as nibs, clips, hooks, bolts and forming of notches and holes. The contractor may precast the units on cement or steel platform which shall be adequately oiled provided the surface finish is of the same standard as obtained in form. Each unit shall be cast in one operation.

5.6.2 Concrete used for precasting the units should be well proportioned, mixed, placed and thoroughly compacted by vibrations or tamping to give a dense concrete free from voids and honey combing.

5.6.3 Precast articles shall have a dense surface finish showing no coarse aggregate and shall have not cracks or crevices likely to assist in disintegration of concrete or rusting of steel or other defects that would interfere with the proper placing of the units. All angle of the precast units with the exception of the angles resulting from the splayed or chamfered faces shall be true right angles. The arises shall be clean and sharp except those specified or shown to be rounded. The wearing surface shall be true to the lines. On being fractured, the interior of the units should present a clean homogeneous appearance.

5.6.4 The longitudinal reinforcement shall have a minimum cover of 12 mm or twice the diameter of the main bar, whichever is more, unless otherwise directed in respect of all items except fencing posts or electric posts where the minimum cover shall be 25 mm.

5.6.5 Curing

After having been cast in the mould or form the concrete shall be adequately protected during setting in the first stages of hardening from shocks and from harmful effects of frost, sunshine, drying winds and cold. The concrete shall be cured at least for 7 days from the date of casting.

5.6.6 The precast articles shall be matured for 28 days before erection or being built in so that the concrete shall have sufficient strength to prevent damage to units when first handled.

5.6.7 Marking

Precast units shall be clearly marked to indicate the top of member and its location and orientation in the structure.

5.6.8 Precast units shall be stored, transported and placed in position in such as manner that they will not be overstressed or damaged.

5.6A PRECAST DOOR AND WINDOW FRAMES

5.6A.1 MATERIALS

5.6A.1.1 Factory Made Precast Reinforced Concrete Door and Window Frame- The frame shall be manufactured from M 40 grade reinforced cement concrete of specified thickness confirming to IS:4021. The ingredients of RCC for the manufacture of precast reinforced concrete door and window frames shall comply with the requirements given in Table 1 of IS:6523.

5.6A.1.2 Aggregates - The aggregates shall consist of well-graded mixture of clean coarse and fine aggregates. The nominal maximum size of coarse aggregates shall not exceed 10 mm.

5.6A.1.3 Concrete - The mix proportion of the concrete shall be determined by the manufacturer and shall be such as to produce a dense concrete not weaker than grade M 40.

5.6A.1.4 Reinforcement - Steel reinforcement shall be minimum of 3 nos. 6 mm dia M.S. bars tied with 3 mm dia mild steel wire placed @ 200 mm c/c. The reinforcement bars and wires shall confirm to IS432 (Part-I & II).

Reinforcement shall be clean and free from loose millscale, loose rust, mud, oil, grease or any other coating which may reduce the bond between the concrete and steel.

5.6A.1.5 Cement Concrete Block – Cement Concrete Block of minimum size 15 cm x 10 cm x 10 cm, shall be of nominal mix concrete 1:3:6 and hold fast shall be embedded in the Block.

5.6A.1.6 High Strength Polymer Block–High Strength Polymer Block for securing hinges, tower bolts, sliding bolts shall be confirming to IS3395.

5.6A.1.7 Mild Steel Galvanised Sleeves& Bolts -Mild Steel Galvanised Sleeves& Boltsshall be confirming to IS806, IS 1363 and IS 4736.

5.6A.1.8 Hinges– Bright finished or black enamelled mild Steel butthinges shall be confirming to IS1341.

5.6A.2 MANUFACTURE

5.6A.2.1 Construction and Finish

5.6A.2.1.1 Each frame shall be made of concrete proportioned, mixed, placed and compacted by vibration/pressing to give a dense concrete free from voids and honeycombing.

Compaction by vibration may be done using a vibrating table or a shutter vibrator. A good finish may generally be obtained by using smooth surface moulds and proper vibration of concrete. Any small surface defects shall be rectified by rubbing with Carborundum stone before erection of the frame. Plastering or touching shall not be done under any circumstances.

5.6A.2.1.2 Each member of the frame shall have a dense surface finish showing no coarse aggregate and shall have no crevices likely to assist in the disintegration of concrete or rusting of steel by the action of natural agencies.

5.6A.2.1.3 The specification of M 40 grade concrete shall be according to Sub Head:5.0of CPWD Specification 2019 Vol-I.

5.6A.2.1.4 The RCC door/window frames shall be cast in rubber / PUmoulds / shuttering having proper shape and dimension with smooth finish.

5.6A.2.1.5 Rubber / PU moulds/ shuttering for RCC door/window frames are casted suitably on the vibrating table having good quality vibration facility to achieve adequate compaction and smooth finish without blow holes or crisis.

5.6A.2.1.6 Curing shall be done as per Section 4.2.10 of CPWD Specification 2019 Vol.-1.

5.6A.2.2 Positioning of Reinforcement - The vertical as well as the horizontal members of the frame shall be reinforced with longitudinal bars. The longitudinal reinforcement for each of the vertical or horizontal member shall be in one piece. The longitudinal bar shall be firmly held by means of at least 3 mm dia steel ties spaced at not more than 200 mm centre to centre.

5.6A.2.2.1 Cover - The longitudinal reinforcement shall have a minimum clear cover of 12 mm or twice the diameter of the main bar, whichever is more.

5.6A.2.2.2 Casting-The entire frame may be cast complete in one piece.

5.6A.3 Hinges – Bright finished or black enamelled mild steel butt hinges of minimum size 100 mm shall be used. For door frames 80 cm wide and under, three hinges shall be rigidly fixed to one jamb and for door frames above 80 cm wide, four hinges shall rigidly fixed to one jamb, if it is single shutter, where the height of door shutter exceeds 2.15 metres, one additional hinge shall be provided for every 0.5 m or part thereof the additional height. In all cases the hinges shall be so fixed that the distance from the inside of the head rebate to the top of the upper hinge is 20 cm and the distance from the bottom of the door frame to the bottom of the bottom hinge is also kept about 200 mm. The middle hinges shall be at equal distances from lower and upper hinges or as agreed to between the purchaser and the supplier. Hinges shall be made of steel 2.5mm thick with zinc coated removable pin of 6 mm diameter. The space between the two leaves of the hinge when closed shall be 3 mm and the leaf that is not fixed to the frame shall have four counter sunk holes to take cross recessed head screws.

5.6A.4 Other Hardware fixing- RCC frames shall be provided with high strength polymer blocks at the appropriate locations for fixing hinges of adequate sizeon the vertical members. The Hinge blocks shall be of minimum size 120 mm x 25 mm x 25 mm with the provision to pass one longitudinal reinforcement bar through the Hinge block, to ensure proper anchoring with the concrete. Screw holding capacity of Hinge blocks should not be less than 200 kg per screw. Blocks shall not get cracked on hammering a nail or screw and should be soft enough to drill a hole to drive a screw easily. Such blocks shall also be provided at appropriate locations for fixing latches, tower bolts, mortise locks and cylindrical locks, etc.Specially designed M.S. galvanized sleeves shall also be provided for accommodating 6 mm dia fully threaded bolts for fixing holdfasts on vertical members.

5.6A.5 Finishing- The surface of door frame shall be thoroughly cleaned, free of rust, mill scale, dirt, oil etc. After pre-treatment two coats of paints as directed by the Engineer-in-charge shall be applied to the exposed surface.

5.6A.6 Fixing-Frames shall be fixed up right in plumb and plane. To avoid sag or bow in width during fixing orduring construction phase, temporary struts across the width preventing sides bulging inwards may be provided. Wall shall be built solid on each side and grouted at each course to ensure solid contact with frame leaving no voids behind the frame. Three lugs shall be provided on each jamb with spacing not more than 75 cm. The temporary struts should not be removed till the masonry behind the frame is set.Fixing door, window or clerestory window chowkhats in existing opening shall be done as per section 14.2 of CPWD Specification 2019 Vol-II.

5.6A.7 Measurements -The length shall be measured in running metre correct to a cm along the centre line of the frames.

5.6A.8 Rate -The rate shall include the cost of labour and material involved in all the operation described above.

5.7 PRECAST CEMENT CONCRETE JALI

5.7.0 The jali shall be of cement concrete 1:2:4 (1 cement 2 coarse sand:4 stone aggregate 6 mm nominal size) reinforced with 1.6 mm thick mild steel wire, unless otherwise specified.

5.7.1 Fixing

The jali shall be set in position true to plumb and level before the joints sills and soffits of the openings are plastered. It shall then be properly grouted with cement mortar 1:3 (1 cement :3 coarse sand) and rechecked for levels. Finally the jambs, sills and soffits shall be plastered embedding the jali uniformly on all sides.

5.7.2 Measurements

The jali shall be measured for its gross superficial area. The length and breadth shall be measured correct to a cm. The thickness shall not be less than that specified.

5.7.3 Rate

The rate shall be inclusive of materials and labour involved in all the operations described above except plastering of jambs, sills and soffits, which will be paid for under relevant items of plastering.

5.7A EXPANSION JOINT COVERING WITH CEMENT BONDED PARTICLE BOARD

5.7A.1 Materials :

Species of wood which do not hinder the process of setting of cement shall be used. Suitable additives such as sodium silicate conforming to IS 381:1995 and aluminum sulphate conforming

IS260:2001 shall be used to prevent inhibitive effect of setting & cement when other services are used. Also cement conforming to IS 8112:2013 shall be used.

Tolerance in thickness

(i) Un-sanded boards
6mm to 12mm: $\pm$ 1mm

(ii) Sanded boards
(For all thickness) : $\pm$ 0.3mm

5.7A.2 Physical Requirements :

5.7A.2.1 Workability: The boards shall not crack or split when drilled, sawed or nailed perpendicular to surface. For nailing perpendicular to surface a pre-bore of 0.8 times the diameter of the nail shall be made. Other requirements shall be as stated in Table 1 (i.e. requirement of physical and mechanical properties of cement bonded particle boards) of IS 14276: 1995.

5.7A.2.2 Sampling and Inspection: In any consignment, all the boards of the same dimensions and manufactured under similar condition of product shall be grouped together to constitute a lot. The number of boards to be selected from a lot , method of selection ,test specimen and number of specimen shall be in accordance withIS Code : 14276 : 1995

5.7A.2.3 Criteria for conformity: A lot shall be considered as conforming to the requirement of the specification if the sample and test specimen pass the requirements prescribed in clause 10 of IS Code 14276:1995. In case of failure, double the number of samples shall be taken from the lot for testing. The lot shall be considered to have passed if all these samples conform to the requirement as specified in clause 10 of IS Code:14276: 1995.

5.7A.3 Measurement : The length of sheet shall be measured correct to a cm.

5.7A.4 Rate : The rate shall be inclusive of all materials and labour involved in fixing cement bonded wood particle board over expansion joints.

5.7B EXPANSION JOINT COVERING WITH STAINLESS STEEL GRADE 304

5.7B.1 Material:

General requirement to the supply of material shall conform to IS 1387:1993

Stainless steel sheets and strips shall be free from harmful defects such as scale, rust, blisters, laminations, cracked edges and seams.

5.7B.2 Chemical composition: It shall be as given in table 1 of IS 5522 : 2014 with permissible variations between specified analysis and check analysis as per table 2 of IS 5522 : 2014 when the analysis of steel carried out according to IS :228 and its relevant parts.

5.7B.3 Tolerances: The tolerances for thickness shall be as per clause 10.1 of IS 1387 : 1993

5.7B.4 Mechanical properties: The mechanical properties of the material shall be as per Table-3 of IS 1387 : 1993

5.7B.5 Frequency of sampling: One test shall be made on each coil and for every 100 sheets for each size of the same cast.

5.7B.6 Measurement : The length of sheet shall be measured, correct to a cm.

5.7B.7 Rate : The rate shall be inclusive of all material and labour involved in fixing stainless steel plate over expansion joints.

5.8 DESIGN MIX

5.8.0 Definition

Design mix concrete is that concrete in which the design of mix i.e. the determination of proportions of cement, aggregate & water is arrived as to have target mean strength for specified grade of concrete. The minimum mix of M25 shall be used in all structural elements in both load bearing & RCC framed construction.

5.8.1 Mix Design and Proportioning

5.8.1.1 Mix proportions shall be designed to ensure that the workability of fresh concrete is suitable for conditions of handling and placing, so that after compaction it surrounds all reinforcement and completely fills the formwork. When concrete is hardened, it shall have the stipulated strength, durability and impermeability.

5.8.1.2 Determination of the proportions by weight of cement, aggregates and water shall be based on design of the mix.

5.8.1.3 As a trial the manufacturer of concrete may prepare a preliminary mix according to provisions of SP: 23. Reference may also be made to ACI 211.1-77 for guidance.

5.8.1.4 Mix design shall be tried and the mix proportions checked on the basis of tests conducted at a recognized laboratory approved by the Engineer-in-Charge.

5.8.1.5 All concrete proportions for various grades of concrete shall be designed separately and the mix proportions established keeping in view the workability for various structural elements, methods of placing and compacting.

5.8.1.6 Before using an admixture in concrete, its performance shall be evaluated by comparing the properties of concrete with the admixture and concrete without any admixture. Chloride content of admixture should be declared by the manufacturer of admixture and shall be within limits stipulated by IS:9103.

5.8.2 Standard Deviation

5.8.2.1 Standard deviation calculations of test results based on tests conducted on the same mix design for a particular grade designation shall be done in accordance with IS 456.

5.8.3 Acceptance Criteria for Design Mix

5.8.3.1 ***Compressive Strength :*** The concrete shall be deemed to comply with the strength requirements when both the following condition are met:

(a) The mean strength determined from any group of four consecutive test results complies with the appropriate limits in col 2 of Table 5.6.

(b) Any individual test result complies with the appropriate limits in col. 3 of Table 5.6.

5.8.3.2 ***Flexural Strength :*** When both the following conditions are met, the concrete complies with the specified flexural strength.

(a) The mean strength determined from any group of four consecutive test results exceeds the specified characteristic strength by at least 0.3 N/mm^2.

(b) The strength determined from any test result is not less than the specified characteristic strength/ 0.3 N/mm^2.

5.8.3.3 ***Quantity of Concrete Represented by Strength Test Results :*** The quantity of concrete represented by a group of four consecutive test results shall include the batches from which the first and last samples were taken together with all intervening batches.

For the individual test result requirements given in col 3 of Table 5.6 or in item (b) of 5.8.3.2. Only the particular batch from which the sample was taken shall be at risk.

Where the mean rate of sampling is not specified the maximum quantity of concrete that four consecutive test results represent shall be limited to 60 m^3.

5.8.3.4 If the concrete is deemed not to comply pursuant to 5.8.3 the structural adequacy of the parts affected shall be investigated and any consequential action as needed shall be taken.

5.8.3.5 Concrete of each grade shall be assessed separately.

5.8.3.6 Concrete is liable to be rejected if it is porous or honey-combed, its placing has been interrupted without providing a proper construction joint, the reinforcement has been displaced beyond the tolerances specified, or construction tolerances have not been met. However, the hardened concrete may be accepted after carrying out suitable remedial measured to the satisfaction of the Engineer-in-Charge.

5.8.4 Cement Content of Concrete

5.8.4.1 For all grades of concrete manufactured/produced, minimum cement content in the concrete shall be 330 kg per cubic metre of concrete. Also, irrespective of the grade of concrete the maximum cement content shall not be more than 500 kg per cubic metre of concrete. These limitations shall apply for all types of cements of all strengths.

5.8.4.2 Actual cement content in each grade of concrete for various conditions of variable shall be established by design mixes within the limits specified in para 5.8.4.1 above.

5.8.5 Water Cement Ratio and Slump

5.8.5.1 In proportioning a particular mix, the manufacturer/ producer/ contractor shall give due consideration to the moisture content in the aggregates, and the mix shall be so designed as to restrict the maximum free water cement ratio to less than 0.5.

5.8.5.2 Due consideration shall be given to the workability of the concrete thus produced. Slump shall be controlled on the basis of placement in different situations. For normal methods of placing concrete, maximum slump shall be restricted to 100 mm when measured in accordance with IS 1199.

TABLE 5.6
Characteristic Compressive Strength Compliance Requirement
(Clause 5.8.3.1 and 5.8.3.3)

Specified Grade	*Mean of the Group of 4 Non- Overlapping Consecutive Test Results in N/mm³*	*Individual Test Results in N/mm³*
(1)	*(2)*	*(3)*
M15 and above	$\geq f_{ck}$ + 0.825 x established standard deviation (rounded off to nearest 0.5 N/mm^2) or f_{ck} + 3 N/mm^2 whichever is greater	≥ f_{ck}-3 N/mm^2

NOTE –

1. In the absence of established value of standard deviation, the values given in Table may be assumed, and attempt should be made to obtain results of 30 samples as early as possible to establish the value of standard deviation.

2. **For concrete of quantity up to 30 m^3 (where the number of samples to be taken is less than four as per frequency of sampling given in 5.11.5(d), the mean of test results of all such samples shall be f_{ck} + 4 N/mm^2, minimum**

5.8.6 Approval of Design Mix

5.8.6.1 The producer/ manufacturer/ contractor of concrete shall submit details of each trial mix of each grade of concrete designed for various workability conditions to the Engineer-in-Charge for his comments and approval. Concrete of any particular design mix and grade shall be produced/ manufactured for works only on obtaining written approval of the Engineer-in-Charge.

5.8.6.2 For any change in quality/ quantity in the ingredients of a particular concrete, for which mix has been designed earlier and approved by the Engineer-in-Charge, the mix has to be redesigned and approval obtained again.

5.8A R.C.C FOR PIERS, ABUTMENTS, POTAL FRAMES, PIER CAPS AND BEARING PEDESTALS AND SEISMIC ARRESTERS

5.8A.1 GENERAL

Reinforced cement concrete work shall be cast-in-situ as directed by Engineer-in-Charge according to the nature of work. Reinforced cement concrete work shall comprise of the following which may be paid collectively or separately as per the description of the item of work.

(a) Reinforcement
(b) Self compacting design mix concrete of minimum grade M50/M60by using admixure Retarder / Plasticizer and micro silica as per design mix.

5.8A.2 MATERIALS

5.8A.2.1 Water, cement, fine and coarse aggregate shall be as specified under respective clauses of chapter 03 of mortars, chapter 04 of concrete work and chapter 20 of Pile Work as applicable.

5.8A.2.2 General

(i) IS 456- 2000 Code of Practice for Plain and Reinforced Concrete (as amended up to date) shall be followed in regard to Concrete Mix Proportion and its production as under:
  (a) The concrete mix design shall be done as “Design Mix Concrete” as prescribed in clause-9 of IS 456 mentioned above.
  (b) Concrete shall be manufactured in accordance with clause 10 of above mentioned IS 456 covering quality assurance measures both technical and organizational, which shall also necessarily require a qualified Concrete Technologist to be available during manufacture of concrete for certification of quality of concrete.

(ii) Self-compacting concrete of grade M-50/M-60 shall be used in all structural elements.
If necessitated due to low water/binder ratio, required workability shall be achieved by use of chloride free chemical admixtures conforming to IS 9103. The compatibility of chemical admixtures and super plasticizers with OPC, received from different sources shall be ensured by trials.

(v) In cases, where structural concrete is exposed to excessive magnesium sulphate, flyash substitution/content shall be limited to 18% by weight. Special type of cement with low C3A content may also be alternatively used. Durability criteria like minimum binder content and maximum water /binder ratio also need to be given due consideration in such environment.

(vi) Curing as per provision in IS 456:2000 (with amendment). Wet curing period shall be enhanced to a minimum of 10 days or its equivalent. In hot & arid regions, the minimum curing period shall be 14 days or its equivalent.

5.8A.3 Steel for reinforcement

Steel shall be thermo mechanically treated bar Fe-500D as per IS1786-2008 (with amendments) or more as per as per clause 5.1.3 of CPWD Specification Vol.I, 2019 with upto date correction slips.

5.8A.3.1 Cover

Cover as per IS456:2000 (with amendment) and clause 5.3.3.5 of CPWD Specification Vol.I, 2019.

5.8A.4 Concreting

Self-compacting concrete of grade M-50/M-60 for construction of piers, abutments, portal frames, pier caps and bearing pedestals and seismic arresters over pier/ abutment caps at all locations with specified grade using Ordinary Portland Cement (conforming to strength requirement of IS:8112).

5.8A.4.1 Strength of concrete

As per IS 456:2000 with amendments.

5.8A.5 Self Compacting Concrete

Self-compacting concrete shall be able to flow under its own weight and completely fill the formwork, even in the presence of dense reinforcement, without the need of any vibration, whilst maintaining homogeny.

5.8A.5.1 Guiding Technical specification for Self compacting concrete.

The specification, performance and conformity requirements for structural concrete are given in IS 456-2000 Annex - J. Test methods. The filling ability and stability of self-compacting concrete in the fresh state shall be defined by four key characteristics like flow ability viscosity, passing ability & Segregation resistance. Each characteristic shall be addressed by one or more test methods:

Grade	*M30 & above*
Cementitious content	*400 – 600kg / m3*
Admixtures	*PCE based & Viscosity Modifiers or as per design mix*
Flow	*550 – 850 mm*
T 50 time	*Time of 2-5 seconds*
V-Funnel	*Time Max 25 seconds*
L – Box ratio	*0.8 – 1.0*
Compressive Strength	*As per Specification of IS 456.*

Characteristic	**Preferred test method(s)**
Flow ability	Slump-flow test
Viscosity (assessed by rate of flow)	T500 Slump-flow test or V-funnel test
Passing ability	L-box test

5.8A.5.1.1 Slump - flow

Slump-flow value describes the flow ability of a fresh mix in unconfined conditions. It is a sensitive test that will normally be specified for all SCC, as the primary check that the fresh concrete consistence meets the specification. Visual observations during the test and/or measurement of the T_{500} time can give additional information on the segregation resistance and uniformity of each delivery.

The following are typical slump-flow classes for a range of applications:

SF1 (550 - 650 mm) is appropriate for:

- Unreinforced or slightly reinforced concrete structures that are cast from the top with free displacement from the delivery point (e.g. housing slabs)
- Casting by a pump injection system (e.g. tunnel linings)
- Sections that are small enough to prevent long horizontal flow (e.g. piles and some deep foundations).

SF2 (660 - 750 mm) is suitable for many normal applications (e.g. walls, columns)

SF3 (760 – 850 mm) is typically produced with a small maximum size of aggregates (less than 16 mm) and is used for vertical applications in very congested structures, structures with complex shapes, or for filling under formwork. SF3 will often give better surface finish than SF 2 for normal vertical applications but segregation resistance is more difficult to control.

Target values higher than 850 mm may be specified in some special cases but great care should be taken regarding segregation and the maximum size of aggregate should normally be lower than 12 mm.

Class	Slump – Flow in mm	Conformity criteria
SF 1	550 to 650	>520 & <700
SF 2	660 to 750	>640 & <800
SF 3	760 to 850	>740 & <900

Picture above shows Slump flow test

5.8A.5.1.2 Viscosity

Viscosity can be assessed by the T_{500} time during the slump-flow test or assessed by the V-funnel flow time. The time value obtained does not measure the viscosity of SCC but is related to it by describing the rate of flow. Concrete with a low viscosity will have a very quick initial flow and then stop. Concrete with a high viscosity may continue to creep forward over an extended time.

Viscosity (low or high) should be specified only in special cases such as those given below. It can be useful during mix development and it may be helpful to measure and record the T_{500} time while doing the slump-flow test as a way of confirming uniformity of the SCC from batch to batch.

VS1/VF1 has good filling ability even with congested reinforcement. It is capable of self-levelling and generally has the best surface finish. However, it is more likely to suffer from bleeding and segregation.

VS2/VF2 has no upper class limit but with increasing flow time it is more likely to exhibit thixotropic effects, which may be helpful in limiting the formwork pressure (see Clause 10.5) or improving segregation resistance. Negative effects may be experienced regarding surface finish (blow holes) and sensitivity to stoppages or delays between successive lifts.

Class	V-Funnel Time in Seconds	Conformity criteria
VF 1	≤ 9	± 3
VF 2	10 to 25	± 3

5.8A.5.1.3 Passing ability

Passing ability describes the capacity of the fresh mix to flow through confined spaces and narrow openings such as areas of congested reinforcement without segregation, loss of uniformity or causing blocking. In defining the passing ability, it is necessary to consider the geometry and density of the reinforcement, the flowability/filling ability and the maximum aggregate size.

The defining dimension is the smallest gap (confinement gap) through which SCC has to continuously flow to fill the formwork. This gap is usually but not always related to the reinforcement spacing. Unless the reinforcement is very congested, the space between reinforcement and formwork cover is not normally taken into account as SCC can surround the bars and does not need to continuously flow through these spaces.

Examples of passing ability specifications are given below:

PA 1 structures with a gap of 80 mm to 100 mm, (e.g. housing, vertical structures)
PA 2 structures with a gap of 60 mm to 80 mm, (e.g. civil engineering structures)

For thin slabs where the gap is greater than 80 mm and other structures where the gap is greater than 100 mm no specified passing ability is required.
For complex structures with a gap less than 60 mm, specific mock-up trials may be necessary.

Class	Passing Ability	Conformity criteria
PA 1	≥ 0.8 with 2 bars	≥ 0.75
PA 2	≥ 0.8 with 3 bars	≥ 0.75

5.8A.5.1.4 Segregation resistance

Segregation resistance is fundamental for SCC in-situ homogeneity and quality. SCC can suffer from segregation during placing and also after placing but before stiffening. Segregation which occurs after placing will be most detrimental in tall elements but even in thin slabs, it can lead to surface defects such as cracking or a weak surface.

In the absence of relevant experience, the following general guidance on segregation resistance classes is given:

Segregation resistance becomes an important parameter with higher slump-flow classes and/or the lower viscosity class, or if placing conditions promote segregation. If none of these apply, it is usually not necessary to specify a segregation resistance class.

SR1 is generally applicable for thin slabs and for vertical applications with a flow distance of less than 5 metres and a confinement gap greater than 80 mm.

SR2 is preferred in vertical applications if the flow distance is more than 5 metres with a confinement gap greater than 80 mm in order to take care of segregation during flow.

SR2 may also be used for tall vertical applications with a confinement gap of less than 80 mm if the flow distance is less than 5 metres but if the flow is more than 5 metres a target SR value of less than 10% is recommended.

SR2 or a target value may be specified if the strength and quality of the top surface is particularly critical.

5.8A.6 Laying of RMC concrete

All Ready Mixed Designed concrete from plant shall be laid with the help of concrete pump of adequate capacity for which nothing extra shall be paid over and above the quoted rates in relevant items. However, small quantity can be allowed without pump with prior written approval of Engineer-in-charge as per site requirement.

NOTE :- In case cement content as per the approved design mix is more or less than the cement contents for cubic metre of concrete specified in the nomenclature of the item, financial adjustment by way of extra payment or such recovery for more or less cement content shall be effected at the rate provided in BOQ with applicable quoted percentage.

5.8A.7 Specifications for pier, abutment, pier/abutment cap. (IRC 78-2014)

(i) Thickness of the wall of hollow concrete pier should not be 300mm.

(ii) Pier shall be designed to withstand the load enforced from the superstructure and the load enforces on the pier itself, apart from the effect of itself weight in general, pier may be solid, hollow or framed structure.

(iii) In case of pier consisting of 2 or more columns, the horizontal forces at the bearing be distributed on columns as required by appropriate analysis.

(iv) The lateral reinforcement of the walls of hollow circular RCC pier shall not be less than 0.3% of the sectional area of the walls of pier. This lateral reinforcement shall be distributed 60% on outer face and 40% in inner face.

5.8A.7.1 Abutments

(i) The abutment will carry superstructure from one side, it should be designed/dimensioned to retain earth from the approach embankment.

(ii) The embankment to should be design to be withstand earth pressure in normal condition in addition to load enforces transferred from superstructure. In addition, any load acting on the embankment, including self-weight is to be considered.

(iii) All abutments and abutment columns shall be designed for a live load surcharge equivalent to 1.2m height of earth fill. The effective width of the columns need not be increased as in clause 710.4.3 for surcharge effect when spill through abutment is adopted.

(iv) Abutment should also be designed for water current forces during 'scour all round' condition.

(v) The Weight of earth filling material on heel may be considered. In case of toe, the weight may be considered if the bed is protected.

(vi) In case of abutments having counterfort, the minimum thickness of the front wall should not be less than 200mm and the thickness of the counterfort should not be less than 250mm.

(vii) In case of box type abutments, weep holes shall be provided similar to hollow piers as per clause 710.2.9.

5.8A.7.2 Pier and abutment cap.

The width of the abutment and pier cap shall be sufficient to accommodate:

(i) The bearing living an offset 150mm beyond them.

(ii) The blast wall

(iii) The space for jacks to lift the super structure for repair/replacement of bearing, etc.

(iv) The equipment for pre-restrain operation where necessary, over and above space for end block in cast in situ cases.

(v) The drainage arrangement for water on the cap.

(vi) Seismic arrestor if provided.

(vii) To accommodate inspection ladders.

5.8A.7.2.1 The thickness of cap over the hollow pier or column type of abutment should not be less than 250mm but in case of solid plain or reinforced concrete pier and abutment, the thickness can be reduced to 200mm.

5.8A.7.2.2 Pier/abutment caps should be suitably designed and reinforced to take care of concentrated point loads dispersing in pier/abutment. Caps cantilevering out from the supports or resting on two or more columns shall be designed to cater for the lifting of superstructure on jacks for repair/ replacement of bearings. The locations of jacks shall be predetermined and permanently marked on the caps.

5.8A.7.2.3 In case of bearing are placed centrally over the columns and the width of bearing/pedestal is located within half the depth of cap from any external face of column, the load from bearing will be considered to have been directly transferred to columns and the cap been need not be designed for flexure.

5.8A.7.2.4 Reinforcement in pier and abutment cap where the bearing satisfied the square root formula stated in clause 307.1 of IRC 21, the pier cap shall be reinforced with total minimum of 1% steel assuming a cap thickness of 225mm. the total steel shall be distributed equally and provided both at top and bottom in two directions. The reinforcement in the direction of length of the pier shall extend from and end to end of the pier cap while the reinforcement at right angle shall extend for the full width of the pier cap and be in form of stirrups. In addition, two layers of mass reinforcement one at 20mm from top and the other at 100mm centers in both directions shall be provided directly under the bearing.

5.8A.8 Measurement

Quantity of concrete in cum of pier, abutment, pier caps, bearing pedestal and seismic arrestor over pier/abutment cap shall be measured. “Excess/less cement used for design mix including the extra cement required under water concreting is payable/recoverable separately”.

5.8A.9 Rate

The rate include cost of steel, centering and shuttering etc. complete including testing of material etc. for casting pier and pier cap in one/two stage, necessary tools, plants, machinery and all related operations as required to complete the work as per drawing and specification with all leads, lifts and depth true to level and position but excluding the cost of providing reinforcement. Reinforcement shall be measured and paid separately.

5.8B R.C.C. DIRPHRAGM WALL

5.8B.1 GENERAL

Reinforced cement concrete work shall be cast-in-situ as directed by Engineer-in-Charge according to the nature of work. Reinforced cement concrete work shall comprise of the following which may be paid collectively as per the description of the item of work. Form work shall be paid separately.

(a) Reinforcement
(b) Self compacting design mix concrete of minimum grade M30 with suitable Retarder / Plasticizer: (Cast-in-situ) with tremie controlled pipe
(c) Bentonite slurry
(d) Concrete mix 1:2:4 for guide walls.

5.8B.2 MATERIALS

5.8B.2.1 Water, cement, fine and coarse aggregate shall be as specified under respective clauses of chapter 03 of mortars, chapter 04 of concretework and chapter 20 of Pile Work as applicable.

5.8B.2.2 Fly Ash admixed cement concrete (FACC) and fly ash blended cements in Cement Concrete (PPCC) in RCC structures.

5.8B.2.2.1 Fly ash Blended Cements conforming to IS 1489 (Part I) may be used in RCC structures as per guidelines given below:

5.8B.2.2.2 General

(i) IS 456- 2000 Code of Practice for Plain and Reinforced Concrete (as amended up to date) shall be followed in regard to Concrete Mix Proportion and its production as under:

  (a) The concrete mix design shall be done as “Design Mix Concrete” as prescribed in clause-9of IS 456 mentioned above.

  (b) Concrete shall be manufactured in accordance with clause 10 of above mentioned IS 456covering quality assurance measures both technical and organizational, which shall alsonecessarily require a qualified Concrete Technologist to be available during manufacture ofconcrete for certification of quality of concrete.

(ii) Minimum M-30 grade of concrete shall be used in all structural elements.

(iii) The mechanical properties such as modulus of elasticity, tensile strength, creep and shrinkage offly ash mixed concrete or concrete using fly ash blended cements (PPCs) are not likely to besignificantly different and their values are to be taken same as those used for concrete made with OPC.

(iv) To control higher rate of carbonation in early ages of concrete both in fly ash admixed as well as PPC based concrete, water/binder ratio shall be kept as low as possible, which shall be closelymonitored during concrete manufacture.

  If necessitated due to low water/binder ratio, required workability shall be achieved by use ofchloride free chemical admixtures conforming to IS 9103. The compatibility of

chemicaladmixtures and super plasticizers with each set OPC, fly ash and /or PPC received from differentsources shall be ensured by trials.

(v) In environment subjected to aggressive chloride or sulphate attack in particular, use of fly ashadmixed or PPC based concrete is recommended. In cases, where structural concrete isexposed to excessive magnesium sulphate, flyash substitution/content shall be limited to 18% byweight. Special type of cement with low C3A content may also be alternatively used. Durabilitycriteria like minimum binder content and maximum water /binder ratio also need to be given dueconsideration in such environment.

(vi) Curing as per provision in IS 456:2000 (with amendment). Wet curing period shall be enhanced to a minimum of 10 days or its equivalent. In hot & aridregions, the minimum curing period shall be 14 days or its equivalent.

5.8B.3 Steel for reinforcement

Steel shall be thermo mechanically treated bar Fe-500D as perIS1786-2008 (with amendments) or more as per as per clause 5.1.3 of CPWD Specification Vol.I, 2019 with upto date correction slips.

5.8B.3.1 Cover

Cover as per IS456:2000 (with amendment) and clause 5.3.3.5 of CPWD Specification Vol.I, 2019

5.8B.4 Concreting

Constructing cast-in situ RCC diaphragm wall by providing and laying machine batched, machine mixed, self-compacting, ready mix reinforced cement concrete, tremie controlled.

5.8B.4.1 Strength of concrete

As per IS 456:2000 with amendments.

5.8B.5 SELF COMPACTING CONCRETE

Self-compacting concrete shall be able to flow under its own weight and completely fill the formwork, even in the presence of dense reinforcement, without the need of any vibration, whilst maintaining homogeny.

5.8B.5.1 Guiding Technical specification for Self compacting concrete.

The specification, performance and conformity requirements for structural concrete are given in IS 456-2000 Annex - J. Test methods. The filling ability and stability of self-compacting concrete in the fresh state shall be defined by four key characteristics like flow ability viscosity, passing ability &Segregation resistance. Each characteristic shall be addressed by one or more test methods:

Grade	M30 & above
Cementitious content	400 – 600kg / m^3
Admixtures	PCE based & Viscosity Modifiers or as per design mix
Flow	550 – 850 mm
T 50 time	Time of 2-5 seconds
V-Funnel	Time Max 25 seconds
L – Box ratio	0.8 – 1.0
Compressive Strength	As per Specification of IS 456.

Characteristic	**Preferred test method(s)**
Flow ability	Slump-flow test
Viscosity (assessed by rate of flow)	T500 Slump-flow test or V-funnel test
Passing ability	L-box test

5.8B.5.2 Slump-flow

Slump-flow value describes the flow ability of a fresh mix in unconfined conditions. It is a sensitive test that will normally be specified for all SCC, as the primary check that the fresh concrete consistence meets the specification. Visual observations during the test and/or measurement of the T_{500} time can give additional information on the segregation resistance and uniformity of each delivery.

The following are typical slump-flow classes for a range of applications:

SF1 (550 - 650 mm) is appropriate for:

- Unreinforced or slightly reinforced concrete structures that are cast from the top with free displacement from the delivery point (e.g. housing slabs)
- Casting by a pump injection system (e.g. tunnel linings)
- Sections that are small enough to prevent long horizontal flow (e.g. piles and some deep foundations).

SF2 (660 - 750 mm) is suitable for many normal applications (e.g. walls, columns)

SF3 (760 – 850 mm) is typically produced with a small maximum size of aggregates (less than 16 mm) and is used for vertical applications in very congested structures, structures with complex shapes, or for filling under formwork. SF3 will often give better surface finish than SF 2 for normal vertical applications but segregation resistance is more difficult to control.

Target values higher than 850 mm may be specified in some special cases but great care should be taken regarding segregation and the maximum size of aggregate should normally be lower than 12 mm.

Class	Slump – Flow in mm	Conformity criteria
SF 1	550 to 650	>520 & <700
SF 2	660 to 750	>640 & <800
SF 3	760 to 850	>740 & <900

5.8B.5.3 Viscosity

Viscosity can be assessed by the T_{500} time during the slump-flow test or assessed by the V-funnel flow time. The time value obtained does not measure the viscosity of SCC but is related to it by describing the rate of flow. Concrete with a low viscosity will have a very quick initial flow and then stop. Concrete with a high viscosity may continue to creep forward over an extended time.

Viscosity (low or high) should be specified only in special cases such as those given below. It can be useful during mix development and it may be helpful to measure and record the T_{500} time while doing the slump-flow test as a way of confirming uniformity of the SCC from batch to batch.

VS1/VF1 has good filling ability even with congested reinforcement. It is capable of self-levelling and generally has the best surface finish. However, it is more likely to suffer from bleeding and segregation.

VS2/VF2 has no upper class limit but with increasing flow time it is more likely to exhibit thixotropic effects, which may be helpful in limiting the formwork pressure (see Clause 10.5) or improving segregation resistance. Negative effects may be experienced regarding surface finish (blow holes) and sensitivity to stoppages or delays between successive lifts.

Class	V-Funnel Time in Seconds	Conformity criteria
VF 1	≤ 9	± 3
VF 2	10 to 25	± 3

5.8B.5.4 Passing ability

Passing ability describes the capacity of the fresh mix to flow through confined spaces and narrow openings such as areas of congested reinforcement without segregation, loss of uniformity or causing blocking. In defining the passing ability, it is necessary to consider the geometry and density of the reinforcement, the flowability/filling ability and the maximum aggregate size.

The defining dimension is the smallest gap (confinement gap) through which SCC has to continuously flow to fill the formwork. This gap is usually but not always related to the reinforcement spacing. Unless the reinforcement is very congested, the space between reinforcement and formwork cover is not normally taken into account as SCC can surround the bars and does not need to continuously flow through these spaces.

Examples of passing ability specifications are given below:

PA 1 structures with a gap of 80 mm to 100 mm, (e.g. housing, vertical structures)
PA 2 structures with a gap of 60 mm to 80 mm, (e.g. civil engineering structures)

For thin slabs where the gap is greater than 80 mm and other structures where the gap is greater than 100 mm no specified passing ability is required.

For complex structures with a gap less than 60 mm, specific mock-up trials may be necessary.

Class	Passing Ability	Conformity criteria
PA 1	≥ 0.8 with 2 bars	≥ 0.75
PA 2	≥ 0.8 with 3 bars	≥ 0.75

5.8B.5.5 Segregation resistance

Segregation resistance is fundamental for SCC in-situ homogeneity and quality. SCC can suffer from segregation during placing and also after placing but before stiffening. Segregation which occurs after placing will be most detrimental in tall elements but even in thin slabs, it can lead to surface defects such as cracking or a weak surface.

In the absence of relevant experience, the following general guidance on segregation resistance classes is given:

Segregation resistance becomes an important parameter with higher slump-flow classes and/or the lower viscosity class, or if placing conditions promote segregation. If none of these apply, it is usually not necessary to specify a segregation resistance class.

SR1 is generally applicable for thin slabs and for vertical applications with a flow distance of less than 5 metres and a confinement gap greater than 80 mm.

SR2 is preferred in vertical applications if the flow distance is more than 5 metres with a confinement gap greater than 80 mm in order to take care of segregation during flow.

SR2 may also be used for tall vertical applications with a confinement gap of less than 80 mm if the flow distance is less than 5 metres but if the flow is more than 5 metres a target SR value of less than 10% is recommended.

SR2 or a target value may be specified if the strength and quality of the top surface is particularly critical.

5.8B.5.6 Laying of RMC concrete

All Ready Mixed Designed concrete from plant shall be laid with the help of concrete pump of adequate capacity for which nothing extra shall be paid over and above the quoted rates in relevant items. However, small quantity can be allowed without pump with prior written approval of Engineer-in-charge as per site requirement.

NOTE :- In case cement content as per the approved design mix is more or less than the cement contents for cubic metre of concrete specified in the nomenclature of the item, financial adjustment by way of extra payment or such recovery for more or less cement content shall be effected at the rate provided in BOQ with applicable quoted percentage.

5.8B.6 Specifications for diaphragm wall

(i) Cast-in-situ RCC diaphragm wall shall be as per IS14344:1996.

(ii) Rigid type of diaphragm wall or plastic concrete diaphragm wall shall be constructed by resorting to either successive panel method or alternate panel method. For cement bentonite slurry trench diaphragm wall, alternate panel method of construction is suitable in view of the time that is require to achieve hardness of the mix put in the trench.

5.8B.6.1 Tolerance:

(i) Guide walls:
Finished faces of the guide wall toward the trench shall be vertical. There shall be no rigid or abrupt change of the guide wall and variation from a straight line or a specified profile shall not exceed 25mm in 3 meter.

(ii) Diaphragm wall:
Verticality
Face of the wall and ends of panel shall be vertical within a tolerance of 1:80.
In positioning of reinforcement longitudinal tolerance of cage head at top of the guide wall measured along the trench, shall be 75mm and vertical tolerance at caged head in relation to top of guide wall shall be 50mm.

(iii) Testing
Testing of material to be used for the work shall be done in a laboratory to confirm their usability as per applicable IS Standard.

Mix for rigid concrete, plastic concrete and cement bentonite slurry shall be design in a laboratory and testing shall be done to ascertain various parameters like compressive and tensile strength, permeability, modulus of elasticity, erodibility, PH value, etc. to be confirm that the mix design satisfies the design parameter.

Sample of mix at the time of placing shall be collected and kept in air tight sealed molds of specified size till due dates of various tests. Important test to be perform are as under: -

(a) Compressive strength: Test shall be carried out at 7, 28 and 90 days.

(b) Triaxial compressive strength test shall be carried out on filling material like plastic concrete, cement, bentonite etc. to determine stress strain characteristic, modulus of elasticity and shear parameters, test shall be carried out at 7, 28 and 90 days in consolidated undrained conditions.

(c) Permeability test on sample shall be conducted after 28 days in membrane permeameter.

5.8B.6.2 Instrumentation:

(i) Placement of instruments simultaneously with casting of panel is difficult, as there is a possibility of damaging the instruments, wires etc., or losing their sensitivity due to vibrations generated during placement of concrete. It is, therefore, preferable to install the instrument outside the completed diaphragm wall to measure in-situ performance.

5.8B.6.2.1 Deformation of the structure

For the purpose of measuring deformation behavior of the diaphragm, inclinometers at various location shall be installed close to the diaphragm wall.

5.8B.6.2.2 Settlement gauge

Settlement gauged may be installed at selected locations to measured vertical displacement. Gauges shall not have an error of more than 1mm.

5.8B.6.2.3 Piezometric levels:

To judge the efficiency in water tightness of the diaphragm wall, residual discharge collected downstream of the cut off wall is the essential measurement. This can be determined by a double network of Piezometers placed on either side of the wall and well protected by filters. Chemical and physical analysis water may be useful to pinpointed its source. Observations frequency shall not be more than 15 days.

5.8B.6.2.4 Permeability

100mm diameter tubes extending to random depths, shall be placed at the center of the thickness of the diaphragm panel at randomly chosen locations. After a period of 28 days bore holes may be drilled into the diaphragm below the tubes and permeability test by pumping in method carried out. The in-situ permeability of the diaphragm shall be compared with the specified limit as per requirement.

5.8B.7 Records

Following records shall be maintained in a manner approved by the Engineer-in-charge.

(i) Name of Project/work.

(ii) Panel No. & reference drawing no.

(iii) Date of commencement and completion of excavation

(iv) Date of concreting of panel

(v) Length of panel

(vi) Thickness of panel

(vii) Top of guide wall level

(viii) Depth of guide wall

(ix) Top level of wall as cast, in relation to top of guide wall at the edges and at the center.

(x) Depth of panel from base of top of guide wall

(xi) Strata encountered

(xii) Volume of panel and volume of concrete used, slump, water cement ratio.

(xiii) Cube taken and their result.

(xiv) Details of reinforcement (cage type)

(xv) Detail of any obstructions/ peculiar conditions encountered and time spent and measures taken in overcoming them.

(xvi) Type and proportion of any additives used and reason for use.

5.8B.8 Measurement

Actual area of diaphragm wall correct to two places of decimal, from design bottom level to the design cut off level (including portion incurred in the rock upto the design bottom level) only shall be measured for payment. "Excess/less cement used for design mix including the extra cement required under water concreting is payable/recoverable separately".

5.8B.9 Rate

The rate include cost of all inputs of labour, material and T&P, cost of handling, lifting and placing in position the reinforcement cage in the trench, including cost of reinforcement bar, welding, etc. involved in the work and all other incidental expenditure for completing the work as directed by the Engineer-in-charge shall include the cost of labour and material involved in all the operation describedabove.

5.9 READY MIXED CONCRETE (as per IS 4926)

5.9.1 Materials

5.9.1.1 ***Selection and Approval of Materials*** **:** Materials used should satisfy the requirements for the safety, structural performance durability and appearance of the finished structure, taking full account of the environment to which it will be subjected. The selection and use of materials shall be in accordance with IS 456. Materials used shall conform to the relevant Indian Standards applicable. Where materials are used which are not covered by the provisions of the relevant Indian Standard, there should be satisfactory data on their suitability and assurance of quality control. Records and details of performance of such materials should be maintained. Account should be taken of possible interactions and compatibility between IS 4926 and materials used. Also, prior permission of the purchaser shall be obtained before use of such materials.

5.9.1.2 ***Cement*** : Cement used for concrete shall be in accordance with the requirements of IS 456.

5.9.1.3 ***Mineral Admixtures :*** Use of mineral admixtures shall be permitted in accordance with the provisions of IS 456.

5.9.1.4 ***Aggregates :*** Aggregates used for concrete shall be in accordance with the requirement of IS 456. Unless otherwise agreed testing frequencies for aggregates in plant shall be as given IS 4926.

5.9.1.5 ***Chemical Admixtures***

(i) Use of chemical admixtures shall be permitted in accordance, with the provisions of IS 456 and IS 9103.

(ii) It shall be the responsibility of the producer to establish compatibility and suitability of any admixture with the other ingredients of the mix and the determine the dosage required to give the desired effect.

(iii) Admixtures should be stored in a manner that prevents degradation of the product and consumed within the time period indicated by the admixture supplier. Any vessel containing an admixture in the plant or taken to site by the producer shall be clearly marked as to its content.

(iv) When offering or delivering a mix to a purchaser it should be indicated if such a mix contains an admixture or combination of admixtures or not. The admixtures may be identified generically and should be declared on the delivery ticket.

(v) The amount of admixture added to mix shall be recorded in the production record. In special circumstances, if necessary, additional dose of admixture may be added at project site to regain the workability of concrete with the mutual agreement between the producer and the purchaser.

5.9.1.6 ***Water :*** Water used shall be in accordance with the requirement of IS 456. Unless otherwise agreed, the testing frequencies for water shall be as given in Annex A.

The use of re-cycled water is encouraged as long as concrete of satisfactory performance can be produced and steps are taken to monitor the build up of chlorides in any recirculated water and that any subsequent adjustments to the mix design are made to ensure that any overall limit on chloride contents is satisfied. The addition of any recycled water shall be monitored and controlled to meet these requirements.

The total amount of water added to the mix shall be recorded in the production record. The water content of concrete shall be regulated by controlling its workability or by measuring and adjusting the moisture contents of its constituent materials. The producer's production staff and truck -mixer, drivers shall be made aware of the appropriate responses to variations in concrete consistency of a particular mix caused by normal variations in aggregate moisture content or grading.

5.9.2 General Requirements

5.9.2.1 ***Basis of Supply :*** Ready-mixed concrete shall be supplied having the quality and the quantity in accordance with the requirement agreed with the purchaser or his agent. Notwithstanding this, the concrete supplied shall generally comply with requirements of IS 456.

All concrete will be supplied and invoiced in terms of cubic metres (full or part) of compacted fresh concrete. All proportioning is to be carried out by mass except water and admixture, which may be measured by volume.

5. 9.2.2 ***Transport of Concrete :*** Ready-mixed concrete shall be transported from the mixer to the point of placing as rapidly as practicable by methods that will maintain the required workability and will prevent segregation, loss of any constituents or ingress of foreign matter or water. The concrete shall be placed as soon as possible after delivery, as close as is practicable to its final position to avoid re- handling or moving the concrete horizontally by vibration. If required by the purchaser the producer can utilize admixtures to slow down the rate of workability loss, however this does not remove the need for the purchaser to place the concrete as rapidly as possible. The

purchaser should plan his arrangements so as to enable a full load of concrete to be discharged within 30 minutes of arrival on site.

Concrete shall be transported in a truck-mixer unless the purchaser agrees to the use of non-agitating vehicles. When non-agitating vehicles are used, the mixed concrete shall be protected from gain or loss of water.

5.9.2.3 ***Time in Transport :*** The general requirement is that concrete shall be discharged from the truck-mixer within 2 h of the time of loading. However, a longer period may be permitted if retarding admixtures are used or in cool humid weather or when chilled concrete is produced. The time of loading shall start from adding the mixing water to the dry mix of cement and aggregate or of adding the cement to the wet aggregate whichever is applicable.

Ready-mixed concrete plant shall have test facilities at its premises to carry out routine tests as per the requirement of the standard.

5.9.3 Sampling and Testing of Ready-Mixed Concrete

5.9.3.1 ***Point and Time of Sampling*** **:** For the assessment of compliance of ready-mixed concrete, the point and time of sampling shall be at discharge from the producer's delivery vehicle or from the mixer to the site or when delivered into the purchaser's vehicle. It is critical that the sampling procedure and equipment used enables as representative a sample as possible to be taken of the quantity of concrete delivered (see Annex A).

The sampling may be carried out jointly by the purchaser and the supplier with its frequency mutually agreed upon. However, it will not absolve the supplier of his responsibility from supplying in concrete as per the requirement given in this standard or otherwise agreed to where so permitted in the standard.

5.9.3.2 ***Workability :*** The test for acceptance is to be performed upon the producer's delivery vehicle discharge on site or upon discharge into the purchaser's vehicle. If discharge from the producers' vehicle is delayed on site due to lack of preparedness on behalf of the purchaser then the responsibility passes to the purchaser after a delay of more than 30 min.

The workability shall be within the following limits on the specified value as appropriate:

Slump ± 25 mm or 1/3 of the specified value, whichever is less.

Compacting factor : ± 0.03, where the specified value is 0.90 or greater,
± 0.04, where the specified value is less than 0.90 but more than 0.80,
± 0.05, where the specified value is 0.80 or less.

Flow table test may be specified for concrete, for very high workability (see IS 9103) Acceptance criteria for spread (flow) are to be established between the supplier and the purchaser.

5.9.3.3 ***Specified Strength***

(i) Compliance shall be assessed against the requirements of IS 456 or other agreed Indian Standard. The purchaser may perform his sampling and testing or may enter into an arrangement with the producer to provide his testing requirements.

(ii) Unless otherwise agreed between the parties involved, the minimum testing frequency to be applied by the producer in the absence of a recognized ready- mixed concrete industry method of production control should be one sample for every 50 m^3 of production or every 50 batches, whichever is the greater frequency. Three test specimens shall be made up for each sample for testing at 28 days (see also IS 456).

In order to get a relatively quicker idea of the quality of concrete, optional test on beams for modulus of rupture at 72 ± 2 h or at 7 days or compressive strength test at 7 days may be carried out in addition to 28 days compressive strength test. For this purpose the value should be arrived at based on actual testing. In all cases 28 days compressive strength shall alone be the criteria for acceptance or rejection of the concrete.

(iii) The purchaser shall inform the producer if his requirements for sampling and testing are higher than one sample every 50 m^3 or 50 batches, whichever is the greater frequency.

5.9.3.4 ***Additional Compliance Criteria*** *:* Any additional compliance criteria shall be declared to the producer by the purchaser prior to supply and shall be mutually agreed upon in terms of definition, tolerance frequency of assessment, method of test and significance result.

5.9.3.5 ***Non-Compliance :*** The action to be taken in case of non-compliance shall be declared and mutually agreed upon.

5.9.4 Information to be Supplied by the Purchaser

5.9.4.1 The purchaser shall provide to the producer the details of the concrete mix or mixes required by him and all pertinent information on the use of the concrete and the specified requirements. Prior to supply taking place, it is recommended that a meeting is held between the purchaser and the producer. Its objective to clarify operational matters such as notice to be given prior to delivery, delivery rate, the name of the purchasers authorized representative who will coordinate deliveries, any requirements for additional services such as pumping, on site testing or training, etc.

5.9.4.2 ***Designed Mixes :*** Where the purchaser specifies a designed mix to be supplied it is essential that all relevant information is conveyed to the producer. In order to assist in this, the format given in Annex B may be completed and forwarded to the producer at the time of enquiry.

5.9.4.3 ***Prescribed Mixes :*** The concrete mix shall be specified by its constituent materials and the properties or quantities of those constituents to produce a concrete with the required performance. The assessment of the mix proportions shall form an essential part of the compliance requirements. The purchaser shall provide the producer with all pertinent information on the use of the concrete and the specified requirements. In order to assist in this, the format given in Annex B may be followed with suitable modifications as applicable to prescribed mixes.

5.9.5 Information to be Supplied by the Producer

When requested, the producer shall provide the purchaser with the following information before any concretes is supplied:

(a) Nature and source of each constituent material,

(b) Source of supply of cement,

(c) Proposed proportions or quantity of each constituent/ m^3 of fresh concrete.

(d) Generic type(s) of the main active constituent(s) in the admixture;

(e) Whether or not the admixture contains chlorides and if so, the chloride content of the admixture expressed as a percentage of chloride ion by mass of admixture;

(f) Where more than one admixture is used, confirmation of their compatibility and

(g) Initial and final setting time of concrete when admixture is used at adopted dosage (tested as per IS 8142).

5.9.6 Production and Delivery

5.9.6.1 *Materials Storage and Handling*

(i) *Cement :* Separate storage for Different types and grades of cement shall be provided. Containers may be used to store cement of different types provided these are emptied before loading new cement. Bins or silos shall be weatherproof and permit free flow and efficient discharge of the cement. Each silo or compartment of a silo shall be completely separate and fitted with a filter or alternative method of dust control. Each filter or dust control system shall be of sufficient size to allow delivery of cement to be maintained at a specified pressure, and shall be properly maintained and prevent undue emission of cement dust and prevent interference with weighing accuracy by build up of pressure. Cement shall be stored and stacked in bags and shall be kept free from the possibility of any dampness or moisture coming in contact with them and where cement can be stored and retrieved without undue damage to the bags. The bags are to be protected from becoming damp either from the ground or the weather. The cement is to be used in the order it is delivered (see also IS 4082).
In case, the cement remains in storage for more than 3 months, the cement shall be retested before use and shall be rejected, if it fails to conform to any of the requirements given in the relevant Indian Standard.

(ii) *Dry Pulverized Fuel Ash and Other Mineral Admixtures :* Suitable separate arrangement for storage of pulverized fuel ash, silica fume, metakeolin, rice husk ash, ground granulated blast furnace slag such as for cement, shall be provided, in the plants utilizing these materials.

(iii) *Aggregates (Coarse and Fine) :* Stockpiles shall be free draining and arranged to avoid contamination and to prevent intermingling with adjustment material. Handling procedures for loading and unloading aggregates shall be such as to reduce segregation to a minimum. Provision shall be made for separate storage for each nominal size and type of aggregate and the method of loading of storage bins shall be such as to prevent intermingling of different sizes and types. Fine aggregates shall be stacked in a place where loss due to the effect of wind is minimum (see also IS 4082 and IS 456).

(iv) *Water :* An adequate supply shall be provided and when stored on the plant such storage facilities shall be designed to minimize the risk of contamination.

(v) *Chemical Admixtures :* Tanks or drums containing liquid admixtures shall be clearly labeled for identification purposes and stored in such a way to avoid damage, contamination or the effects of prolonged exposure to sunlight (if applicable). Agitation shall be provided for liquid admixture, which are not stable solutions.

5.9.6.2 *Batching Plants and Batching Equipment :* Hoppers for weighing cement, mineral admixtures, aggregates and water and chemical admixture (if measured by mass) shall consist of suitable container freely suspended from a scale or other suitable load-measuring device and equipped with a suitable discharging mechanism. The method of control of the loading mechanism shall be such that, as the quantity required in the weighing hopper is approached the material may be added at controllable rate and shut off precisely within the weighing tolerances specified in Annex C. The weighing hoppers for cement, mineral admixtures aggregate shall be capable of receiving their rated load, without the weighed material coming into contact with the loading mechanism. Where the rated capacity of a batching plant mixing cycle is less than 2.0 m^3, additional precautions shall be taken to ensure that the correct number of batches are loaded into the truck mixer. The weighing hoppers shall be constructed so as to discharge efficiently and prevent the build up of materials. A tare adjustment, up to 10 percent of the nominal capacity of the weigh scale, shall be provided on the weighing mechanism so that the scale can be adjusted to zero at least once each day. Dust seals shall be provided on cement hoppers between the loading mechanism and the weigh hopper, and shall be fitted so as to prevent the emission of cement dust and not affect weighing accuracy. The hopper shall be vented to permit escape of air without emission of cement dust.

Vibrator or other attachment, where fitted, shall not affect the accuracy of weighing. There shall be sufficient protection to cement and aggregate weigh hoppers and weighing mechanisms to prevent interference with weighing accuracy by weather conditions or external build-up of materials.

Where chemical admixture dispensers are used, they shall be capable of measurement within the tolerance in annex C and calibrated container or weigh scales shall be provided to check the accuracy of measurement at least once a month.

Where a continuous mixer with ribbon loading is used the batching procedure specified by the manufacture of the plant shall be followed.

Each control on the batching console and weigh-dial or display shall be clearly labeled with its function and where concerned with the batching of materials, the materials type.

When more than one type or grade of cement is being used, the weighing device and discharge screw or other parts of the transfer system shall be empty before changing from on type of cement to another.

When more than one type or grade of cement is being used, the weighing devised and discharge screw or other parts of the transfer system shall be empty before changing from on type of cement to another.

When pulverized fuel ash and other mineral admixtures are batched through the cement weigh system, the weighing device and discharge screw or other parts of the transfer system shall be empty when the weighing system has returned to zero reading or completed the batch.

Where a back weigh system is utilized to weigh materials a system shall be in place so as to prevent materials being loaded during the process of weighing.

5.9.6.3 ***Measurement of Materials :*** Cement and mineral admixture materials shall be measured by mass in a hopper or compartment separate from those used for other materials and on a scale of appropriate sensitivity, measurement being taken from a zero reading. Aggregates shall be measured by mass, allowance being made for the free moisture content of the aggregates. The added water shall be measured by volume or by mass. Any liquid chemical admixture (or paste) shall be measured by volume or by mass and any solid admixture by mass. When weighing materials any build up in the hopper during the day must be tared out or allowed for in the batch weights. After measurement all materials shall be discharged into the mixer without loss.

The accuracy of the measuring equipment shall be within $\pm$ 2 percent of the quantity of cement and mineral admixtures being measured and within $\pm$ 3 percent of the quantity of aggregate, chemical admixture and water being measured. The plant operator shall be provided with a clear display of the quantities of materials to be batched for each mix and batch size with information identifying the display to be selected for each designed and prescribed mix to be produced. Analogue scale displays for the weighing of cement, mineral admixtures, aggregates and water shall be readily discernable from the operating position. For digital readouts the numerals shall be readily discernable from the operating position .

Fully automatic production systems shall be fitted with control equipment to allow the correct operation of the plant to be monitored during weighing and batching. Automatic control systems on batching plants shall not commence batching until all hoppers have been emptied and /or tared and the scales zeroed unless such systems are designed to take account of build up in their programming.

All scales shall be tested and calibrated as per Annex C.

5.9.6.4 *Mixing*

(i) *Washing Out Water :* Before loading concrete materials or mixed concrete into either a stationary mixer or truck mixer any water retained in the mixing drum for washing out purposes shall be completely discharged.

(ii) *Stationary or Central Mixers :* Stationary mixers shall not be loaded in excess of the manufacturer's rated capacity. The mixing time shall be measured from the time all the materials required for the batch, including water, are in the drum of the mixer. The mixing time shall not be less than that recommended by the manufacturer. Where a continuous mixing plant is used, the complete mixing time shall be sufficient to ensure that the concrete is of the required uniformity.

(iii) *Truck Mixers :* When a truck mixer is used for the partial or complete mixing of concrete, mixing shall be considered to commence from the moment when all the materials required for the batch, including water, are in the rotating drum of the mixer.

Truck or agitators shall not be loaded in excess of the manufacturer's rated capacity. In order to produce a satisfactory mix, and where there is no data available to establish different period and speed of revolutions, mixing shall continue for not less than 60 revolutions of the truck mixer drum at a rate of not less than 7 revolutions/min. All completely truck mixed concrete shall be visually inspected for uniformity prior to leaving the plant.

When a truck mixer or agitator is used for transporting concrete which has been mixed before leaving the plant, the concrete shall be agitated during transit and remixed at the site for at least 2 min so that the concrete is of the required uniformity.

Where water is added to the concrete in the truck mixer through the truck mixer water meter and when such water is being accounted for in the total water within the mix, it shall be ensured that the truck mixer water meter is in operational condition and properly calibrated. Where a water meter is not available, water must be measured in a suitable container before being added to the truck mixer.

(iv) *Condition of Mixers :* Stationary and truck mixers shall be maintained in an efficient and clean condition with no appreciable build up of hardened concrete or cement in the mixing drum, on the mixing blades, or on the loading hopper or discharge chutes.

5.9.6.5 *Delivery Ticket :* Immediately before discharging the concrete at the point of delivery, the producer or his representative shall provide the purchaser with a preprinted delivery ticket for each delivery of concrete on which is printed, stamped or written the minimum information detailed invoicing as per Annex D.

5.9.7 Quality Control

Quality control of ready-mixed concrete may be divided into three components, forward control, immediate control and retrospective control.

5.9.7.1 *Forward control :* Forward control and consequent corrective action are essential aspects of quality control. Forward control includes the following.

(i) Control of purchased material Quality

(ii) Control of Materials storage

(iii) Mix design and mix design modification

(iv) *Transfer and Weighing Equipment :* The producer shall be able to demonstrate that a documented calibration procedure is in place. The use of elector-mechanical weighing and metering systems, that is, load cells, flow meters, magmeters, etc, is preferable over purely mechanical system, that is, knife edge and lever systems.

(v) Plant mixers where present and truck mixers used shall be in an operational condition.

5.9.7.2 ***Immediate Control :*** Immediate control is concerned with instant action to control the quality of the concrete being produced or that of deliveries closely following. It includes the production control and product control.

(i) *Production Control :* The production of concrete at each plant shall be systematically controlled. This is to ensure that all the concrete supplied shall be in accordance with these requirements and with the specifications that has formed the basis of the agreement between the producer and purchaser.

Each load of mixed concrete shall be inspected before dispatch and prior to discharge.

The workability of the concrete shall be controlled on a continuous basis during production and any corrective action necessary taken.
For each load, written, printed or graphical records shall be made of the mass of the materials batched, the estimated slump, the total amount of water added to the load, the delivery ticket number for that load, and the time the concrete was loaded into the truck.

Regular routine inspections shall be carried out on the condition of plant and equipment including delivery vehicles.

(ii) *Product Control :* Concrete mixes shall be randomly sampled and tested for workability and where appropriate, plastic density, temperature and air content. Where significant variations from target values are detected, corrective action shall be taken.

It is important to maintain the water cement ratio constant at its correct value. The amount of added water shall be adjusted to compensate for any observed variations in the moisture contents in the aggregates. Suitable adjustments should also be made in masses of the aggregates due to this variation (see IS 456). Any change in water content due to change in aggregate grading shall be taken care of by forward control by suitable modifications to mix design.

5.9.7.3 ***Retrospective Control :*** Retrospective control is concerned with those factors that influence the control of production. Retrospective control may cover any property of materials or concrete, such as aggregate grading, slump, or air content, but is particularly associated with 28-day cube strength because by its very nature it is not property which can be measured ahead of, or at the time of, manufacture.

5.9.7.4 ***Mix Performance :*** The producer shall be responsible for ensuring that suitable control procedures are in place ensure the following.

(i) *Design Mixes :* A quality control system shall be operated to control the strength of design mixes to the levels required as per IS 456 and shall be based on random tests of mixes which form the major proportion of production. The system shall include continuous analysis of results from cube tests to compare actual with target values together with procedures for modifying mix proportions to correct for observed differences. Compressive strength testing shall be carried out using a machine that meets the requirements of IS 14858.

(ii) *Prescribed Mixes :* Periodic and systematic checks shall be made to ensure that the cementitious material contents of prescribed mixes comply with their mix descriptions.

5.9.7.5 ***Stock Control of Materials :*** The producer shall operate a materials stock control procedure to enable verification of total quantities used and to confirm that only approved materials have been received.

5.9.7.6 ***Complaints :*** The producer shall have a procedure in place to enable the diagnosis and correction of faults identified from complaints.

5.9.8 Order Processing

A competent person to interpret the specified requirements and relate these to mix design criteria shall systematically review specification and orders supplied by the purchaser. These shall be formally recorded together with any modification to the specification resulting from subsequent agreed documentation to ensure that the plant operator is given the correct instructions for batching and mixing. When mixes or materials are offered as alternatives to requested mixes or where there is no specification supplied by the purchaser, orders whether received verbally or in writing, shall be agreed with the purchaser and the fact recorded. Alternatives to the mix description or compliance requirements in the purchaser's specification shall be clearly identified in the quotation.

5.9.9 Records

Records shall be maintained by the producer to provide confirmation of the quality and quantity and quantity of concrete produced. The records shall be retained for the purposes of these requirements for a period of at least one year. They shall cover the following aspect:

(a) Production and delivery:
  (i) Batching instruction
  (ii) Batching Records,
  (iii) Delivery tickets, and
  (iv) Equipment calibration and plant maintenance.

(b) Materials and production control:
  (i) Concrete production and materials purchase, usage and stocks, and
  (ii) Certificates or test results for materials.

(c) Production quality Contol: Control test results.

5.10 PLACING CONCRETE BY PUMPING

5.10.1 General

Concrete conveyed by pressure through either rigid pipes or flexible hoses and discharged directly into the desired area is termed as pumped concrete.

Method of applying pressure to concrete is by pumps. Pumps to be used shall be either of the two types as mentioned below:-

(A) Piston type pumps
(B) Squeeze pressure type pumps.

Compressed air pressure pumps shall not be used in the works.

5.10.2 Pumping Equipments

5.10.2.1 ***Piston Pumps*** : Piston pump to be used in the works shall consist of a receiving hopper for mixed concrete, an inlet valve, an outlet valve, and the pump shall be a twin-piston pump.

The two pistons shall be so arranged that one piston retracts when the other is moving forward and pushing concrete into the pipe line to maintain a reasonably steady flow of concrete. Single piston pumps shall not be acceptable.

Inlet and outlet valve shall be any one of the following types:-

- Rotating plug type
- Sliding plate type
- Guided plunger type
- Swing type
- Flapper type

- Or any combination of the above.

The pistons shall be mechanically driven using a crank or chain or hydraulically driven using oil or water.

The receiving hopper shall have a minimum capacity of 1.0 cum and the hopper shall be fitted with remixing rotating blades capable of maintaining consistency and uniformity of concrete.

The primary power for pumps may be supplied by gasoline, diesel, or electric motors.

The primary power unit and the pump unit may be truck, trailer or skid mounted.

5.10.2.2 ***Squeeze Pressure Pumps :*** Squeeze pressure pumps shall consist of a receiving hopper fitted with re-mixing blades. Re-mixing blades shall be such that these can push the concrete into the flexible hose connected at the bottom of the hopper.

The flexible hose shall pass through a metal drum around the inside periphery of the drum and come out through the top part of the drum.

The drum shall be maintained under a very high degree of a vacuum during operation. The drum shall be so fitted with hydraulically operation metal rollers., which when rotating, create a squeeze pressure on the flexible hose carrying concrete and forces the concrete out into the pipe line.

5.10.2.3 ***Effective Range and Discharge of Pumps :*** Effective range of pumps to be used in the work shall be decided after studying the site conditions. However, the minimum horizontal range shall not be less than 150 metres and minimum vertical range shall not be less than 50 metres.

Selection of pumps bases on discharge capacity shall be decided after studying the requirements for the project. Discharge capacity shall be worked out by the contractors and approval obtained from the Engineer-in-Charge. As a guide line figure the contractor may assume a discharge capacity of 15 cubic metre/hour/pump.

5.10.2.4 ***Pipe Lines :*** All concrete carrying pipe lines shall generally be rigid pipe lines. Flexible pipe lines may only be used at bend curves in lines or at discharge ends if required. Placements of flexible units shall be done judiciously and connected to the pipe lines only when it meets the approval of the Engineer-in-Charge.

(i) ***Rigid Line/ Hard Line/ Slick line :*** Such lines shall be made either of steel or plastic. Aluminum alloy pipes shall not be used.

Minimum pipeline diameter shall be 100 millimeters and shall have normal maximum length of 3 metre in each section connected through couplers.

(ii) ***Flexible Pipe Line*** *:* Flexible lines shall be made out of rubber or spiral wound flexible metal or plastic. The pipe shall again be such that they are in sections of 3 metre length each and connected through couplers. These pipes shall be such that they are interchangeable with rigid lines. While installing flexible units, care shall be taken that there are no links in the pipeline, which is a normal tendency with these pipes having diameter 100 mm and above.

5.10.2.5 ***Couplers :*** Couplers to be used for connecting pipe line sections (either hard or flexible) shall have adequate strength to withstand stresses due to handling, misalignments, poor support to pipe lines etc.

For horizontal runs of pipes and for vertical run upto 30 metre height the couplers shall be rated for a minimum pressure of 35 kg/ cm square. Couplers used for rising runs between 30 metre and 50 metre heights shall have a minimum pressure rating of 50 kg/cm square. Couplers shall be designed to allow for replacement of any pipe section without displacing other sections. These

shall provide for the full internal cross section. These shall provide for the full internal cross section with no constructions or service. Which may disrupt the smooth flow of concrete. For pipelines of size 150mm and above, double togged type coupler with a thick rubber gasket and secondary wedge-take-up is recommended. Types of couplers that may be used shall be any of the following:-

- Grooved end coupler
- One piece extended lever swing type couplers
- And full flow oil line type couplers.

5.10.2.6 ***Other Accessories :*** Other accessories which shall be catered for, are as under:-

(a) Back up pump of rigid and flexible pipes of varying lengths of similar rating/specifications

(b) Curved sections of rigid pipes

(c) Swivel joints and rotary distributors

(d) Pin and gate valves to prevent back flow in pipe lines

(e) Switch valves to direct the flow into another pipe line

(f) Connection devices to fill forms from the bottom up

(g) Splints, rollers, and other devices for protection of conduit over rock concrete Reinforcing steel and form and to provide lifting and lashing points in the pipe line.

(h) Transitions for connecting different sizes of pipe sections

(i) Air vents for downward pumping.

(j) Clean out equipment.

For concreting of columns, walls and scattered small placement, recommendation is made for special cranes or power controlled booms carrying pipe lines with a pendant type concrete delivery hose.

5.10.2.7 Lubricating of Pipe Line

Before pumping concrete into the pipeline, the line shall be lubricated with a properly designed mortar/grout lubricant. This shall be ensured by starting the pumping operation with a properly designed mortar, or with a batch of regular concrete with the coarse aggregate omitted. The quantity of mortar required as lubricant is dependent on the smoothness and cleanliness of the pipelines. As a guide line, for a 100 mm diameter pipe line of 100 metre length, 0.08 cum to 0.10 cum of mortar should normally be adequate, but this shall not be taken as specified, and the contractor shall establish his requirements.

The quantity of mortar that comes out of the delivery end of the pipeline shall not be used in place of the concrete work. However, with the approval of Engineer-in -Charge, this mortar may be used as bedding mortar against construction joints. The rest of the mortar shall be wasted.

Lubrication shall be maintained as long as the pumping of concrete continues.

5.11 GUIDELINES FOR FIELD PRACTICE

5.11.1 *General Precautions*

(i) Proper planning of concrete supply, pump locations, line layout, placing sequence and the entire pumping operation will result in savings of time and expense.

(ii) The pump shall be placed as near the placement area as practicable. The surrounding area of the pump shall be free of obstructions to allow for movement of concrete delivery trucks. The surface must be strong enough to withstand the loaded trucks operating on it. If the surface is a suspended slab, the truck route shall be adequately supported in consultation with the Engineer-in-Charge.

(iii) Pipe lines from the pump to the placing area shall be laid with minimum number of bend. For large placement areas, alternate lines shall be installed for rapid connection when required. A flexible pipe at the discharge end will permit placing over a large area directly without re-handling of pipelines. The pipeline shall be firmly supported.

(iv) If more than one size of pipe must be used, the smaller diameter pipe shall be placed at the pump end and the larger diameter at the discharge end.

(v) When pumping downwards, an air release valve shall be provided at the middle of the top bend to prevent vacuum or air buildup. Similarly, while pumping upwards, a no-return valve shall be provided near the pump to prevent the reverse flow of concrete.

(vi) It is essential that direct radio/telecommunication be maintained between the pump operator and the concrete placing crew. Good communication between the pump operator and the batching-plant is also essential. The placing rate shall be estimated by the pump operator so that concrete can be ordered at an appropriate delivery rate.

(vii) The pump shall be started for a check run and operated without concrete to ensure that all moving parts are in operation properly. Before placing concrete, the pump shall be run with some grout/mortar for lubricating the line.

(viii) When concrete is received in the hopper, the pump shall be run slowly until the lines are completely full and the concrete is steadily moving. A continuous pumping must be ensured, because, if the pump is stopped, concrete in the line may be difficult to move again.

(ix) When a delay occurs because of concrete delivery or some form repair works or for any other reason, the pump shall be slowed down to maintain some movement of concrete in the pipe line. For longer delays, concrete in the receiving hopper shall be made to last as long as possible by moving the concrete in the lines occasionally with intermittent strokes of the pump. It is sometimes essential to run a return line back to the pump so that concrete can be re-circulated during long delays.

(x) If after a long delay, concrete cannot be moved in the line, it may be necessary to clean out the entire line. However, quite often only a small section of pipe line may be plugged and requires cleaning. The pump operator who know such details as the length of line, age of concrete in the line etc., should be depended upon to aid in deciding the appropriate section to be cleaned.

(xi) When the form is nearly full, and there is enough concrete in the line to complete the placement, the pump shall be stopped and a “go devil” inserted at the appropriate time so that concrete ahead of the go-devil shall be forced completion of the work. The go-devil shall be forced through the pipeline to clean it out. Use of water pressure is a safer method. The go-devil shall be stopped at the discharge end to ensure that water does not spill on the placement area, if air pressure is used, extreme care shall be taken and the pressure must be carefully regulated. A trap shall be installed at the end of the line to prevent the go-devil being ejected as a dangerous projectile. An air release valve shall also be installed in the line to prevent air pressure build up.

(xii) It is essential to clean the line after concrete placing operation is complete. Cleaning shall be done in the reverse direction from the form work end to the pump-end where the concrete in the
line can be dumped in bucket. After removal of all concrete, all pipe lines and other equipments shall be cleaned thoroughly and made ready for the next use.

5.11.2 Submittals

Along with their bid the contractors shall be required to submit the following information regarding the equipments proposed to be used by them:-

(i) Type, number, capacity, range, mounting, nature of primary power used and the operating weight of pump and mounting.

(ii) Manufacturer's specifications for pipe lines giving pressure ratings, sizes and material for straight and curved sections.

(iv) Manufacturer's certificates.

5.11.3 Sampling and Testing (Materials)

5.11.3.1 *Aggregates*

(i) Supplier of aggregates shall furnish the following information before the material is delivered to site:-
- Precise location of source from where the material is to be supplied.
- Trade group of principal rock type as per table 5.7 below :
- Presence or reactive minerals

TABLE 5.7

Trade group name of Aggregates to be used for concrete	: Granite, Gabbro, : Dolerite, Rhyolite, Basalt, Quartzite, Gneiss.

(ii) The supplier shall also furnish reports on test results giving the following information for approval to Engineer-in-Charge before delivery of material at site:-
Specific gravity Bulk
density Moisture
content Absorption
Value Aggregate
crushing strength
Aggregate impact
value Abrasion value
Flakiness index
Elongation index
Limits of deleterious substances in the aggregate
Soundness of aggregate
Potential reactivity of aggregates.

All tests shall be conducted in accordance with IS 2386 (Part-I to VIII).

(iii) Change in quality of aggregate as per trade group name shall not be acceptable in the work. Change in source of aggregates shall also not be acceptable under normal circumstances, even if the aggregate belong to the same trade group. Engineer-in-Charge may with his discretion allow a change in the source. But, in that case, all test mentioned in para 5.8.9.1.2 above shall have to be repeated for the aggregates form the changed source and

the test results submitted to Engineer-in-Charge for his approval before the delivery of material at site.

(iv) In addition to above, the following tests have to be performed on representative samples from every lot of aggregate after delivery at site. These test results are to be submitted to the Engineer-in-Charge for his approval. Acceptance criteria for aggregates shall be based on the
results of this set of tests only. If in the opinion of the Engineer-in-Charge, the test results are not with in permissible limits, the lot of aggregates from which the samples have been obtained for testing shall stand rejected and the material shall be removed from the site.

Mandatory tests on Aggregates at site

Tests	*Nos. of test on each 50 cum of Material or part thereof*
1. Specific gravity	3
2. Bulk density	3
3. Aggregate crushing strength	3
4. Limits of deleterious substances	3
5. Aggregate impact value	3

Mean value of the results from above test shall be taken as the representative value and the acceptance criteria shall be based on these. All test procedures and computations for test results shall be as per IS 2386.

(v) All other tests in para iv being in compliance with requirements set in specifications, if only the limits of deleterious substances do not meet the requirements, and attempt may be made to wash the aggregate to bring the limits within permissible values. Under such circumstances, moisture content check shall be made and allowance made before batching.

(vi) Apart from mandatory tests specified above, the Engineer-in-Charge may at his discretion, call for any additional tests that he may consider necessary. Sampling, procedure and computations for such test shall be done in accordance with IS 2430 and IS 2386 as applicable.

5.11.3.2 ***Cement*** *:* Supplier of cement shall furnish the following documents before the cement is delivered to site:-

(i) Certificate confirming that chemical composition and physical characteristics are within the stipulated values for types of cement supplied as per relevant codes.

(ii) Certificate confirming that the chloride content in the cement is not in excess of 0.05 percent of mass of cement.

(iii) If during subsequent testing of cement supplied in lots any of the properties are found to be outside the acceptable limits, the lot of cement shall be rejected.

(iv) Each 1000 bags or part thereof the cement or each wagon load of cement shall constitute one lot of cement for the purpose of conducting tests at site before cement is accepted.

(v) Samples for testing at site shall be taken at random from 2% of the total quantity supplied in one lot. For cement supplied in bags, samples shall be drawn from minimum of 5 bags and the 2% value shall be rounded off to the next higher integer.

For bulk cement, sampling shall be done with the help of slotted sampler to be as per IS 3535.

(vi) Results of test conducted on samples drawn shall be submitted to the Engineer-in-Charge for his approval. If in the opinion of the Engineer-in-Charge, the test results are not within permissible limits, the lot of cement from which samples have been obtained from testing shall stand rejected and the material shall be removed from site.

(vii) Following tests shall be conducted at site on each lot of cement delivered:-

Mandatory tests	*Number of test per lot*
1. Consistency of standard cement paste	5
2. Initial and final setting time	5 each
3. Compressive strength test	10

Mean values of the results from the above results shall be taken as the representative value and the acceptance criteria shall be based on these test. All test procedures and computation of test results shall be as per IS 4031.

(viii) Apart from mandatory tests specified above, the Engineer-in-Charge may at his discretion, call for any additional tests that he may consider necessary. All such tests shall be done on representative samples taken from each lot and testing and computation of test results shall be done as per IS 4031.

5.11.3.3 *Water*

(i) Water to be used in manufacturing and curing of concrete shall be tested before use. All such test results shall be submitted to the Engineer-in-Charge for his approval before water is used.

(ii) Manufacturer/ Contractor responsible for curing concrete shall identify and inform the Engineer-in-Charge, precisely the location of source of water intended to be used. Each such source of water shall be separately tested. In the event of a change in the source of water all tests specified herein shall have to be repeated.

(iii) In the event water is drawn from tube wells or open-wells, water samples shall be tested for seasonal fluctuations in water table or at intervals to be directed by the Engineer-in-charge.

(iv) Water sample from each source shall be tested as under:-

Test	*Number of test for each source*
Acidity	3
Alkalinity	3
Presence of solids	3

Mean values of the above test shall be taken as the representative value and the acceptance criteria shall be based on these test results. All testing procedure and computation of test results shall conform to IS 3025.

5.11.3.4 *Admixtures*

(i) Suppliers of Admixtures for concrete shall supply the following before any admixtures is approved by the Engineer-in-Charge for their used:-

Certificate confirming that the use of a particular brand of admixture shall not be harmful to concrete in any way.

Certificate confirming the exact dosage of admixture of a particular brand. Certificate stating the specific purpose for which the admixture is to be used.

Special precautionary measures to be taken in the manufacturer of concrete when using the particular brand of admixture.

Certificate confirming that the admixture conforms to specifications of IS 9103 or to ASTM-C260, ASTM – C10, ASTM – C 595 or to ASTM- C 618.

(ii) Engineer-in-Charge at his discretion may require tests to be performed to reconfirm the characteristic properties of any admixture. All such tests shall be done in accordance with IS: 9103.

(iii) All tests described in paras 5.4.8 to 5.4.10 above shall be done at the site laboratory or at a laboratory to be identified by the Engineer-in-Charge depending on the test to be conducted.

(iv) All test shall be done in the presence of a representative nominated by the Engineer-in-Charge and a representative of the concrete Manufacturer/ Contractor when tests are performed at the site laboratory. All observation and reports of test shall be jointly signed by the two representatives before the test results are submitted to the Engineer-in-Charge.

(v) Expenses for all materials used for testing, sampling procedures and testing including preparing reports shall be borne by the concrete Manufacturer/ Contractor.

(vi) Rate of concrete is inclusive of cost of admixtures. The contractor shall not be paid anything extra for admixtures required for achieving direct workability without any change in specified water cement ration for RCC/CC work.

5.11.4 Sampling and Testing for Quality Control of Fresh Concrete

Fresh concrete shall be tested for

(a) Slump

(b) Compacting Factor/ Workability

(c) Consistency

(d) Weight per cubic metre, cement factor and air content

5.11.4.1 *Slump*

(i) For concrete totally mixed in a central plant, slump shall be checked at:-

(a) Immediately during loading of trucks

(b) Point of discharge from the delivery truck

(c) Final placement location

(d) At placement location the slump measured shall conform to the design slump. Manufacturer of concrete shall adjust for loss of slump in transit and establish the requirements of design mix. All slump measurements shall be done within a period of 20 minutes from the time cement is added to the mixer. Placement contractor shall transport concrete from truck discharge point to actual placement location within 10 minutes of delivery, before the final slump reading is taken at placement location.

(ii) For concrete entirely mixed in transit or for shrink mix concrete, slump reading shall be taken at:-

(a) Point of discharge from delivery trucks

(b) Final placement location

In this case also, the slump measured at the final placement location shall conform to the design slump. The placement contractor shall be responsible for transporting concrete from delivery truck discharge point to final placement location within 10 minutes. However, in this case, the truck shall discharge the concrete within 1 hour and 30 minutes from the time cement is added in the mixer and slump measured at point of discharge immediately on delivery. Manufacturer of concrete shall ensure that the final slump measurement corresponds to the ordered slump.

(iii) For measuring concrete slump at point of discharge from delivery trucks, samples shall be taken from concrete omitting the first and the last 15% of the load. For concrete delivery of placed by pumping, sampling shall be similar to those specified for delivery trucks.

(iv) Slump measurements of ready mix concrete transported by buckets shall be at locations specified in para 5.11.4.1 with same limits on time. Sampling from buckets shall be such that the buckets containing discharge from mixer for the last 15% are omitted.

(v) At placement locations, samples for checking slump shall be collected from every 20 cum of concrete or part thereof placed at location for each type to concrete.

(vi) For all slump checks in the field at least two recordings shall be made and the average value taken as the recorded slump.

(vii) Slump checks for concrete in the laboratory shall be carried out as and when required by the manufacturer of concrete during the mix design stage and during the progress of work for control on field results.

(viii) Slump readings shall only be a guideline for concrete consistency and shall not be taken as the acceptability criteria for concrete placed at location. All slump test shall be carried out in accordance with IS 1199.

5.11.4.2 ***Compacting Factor***

(i) For concrete whose ordered slump is 50 mm or less, compacting factor test shall be conducted at both field and central batch plant in addition to slump tests mentioned above.

(ii) Compacting factor check shall be done in field only at placement location, and shall also be conducted at central batch plant if concrete is totally mixed in plant.

(iii) For this test, sampling shall be done as for slump measurements in field and within the same frame as for slump test.

(iv) Only one compaction factor test shall be conducted for every 20 cum of concrete or part thereof placed at location for each type of concrete. Since the test is sensitive, every care shall be taken to conduct this test totally in compliance with procedure mentioned in IS 1199.

(v) Laboratory tests for determining compacting factor of concrete shall be done as per manufacturer's requirements for establishing and controlling the design mix of concrete.

(vi) Compacting factor test shall not be taken as an acceptance criteria and shall be treated only as a guideline to workability of concrete.

5.11.4.3 ***Consistency of Concrete :*** This test shall be performed only at the batching plant laboratory using a Vee -Bee Consist meter, for determining and predicting the slump of concrete. Number and frequency of these tests shall be based on requirements of the manufacturer of concrete. Care shall be taken in producing mix design of required characteristic strengths of concrete within limits of Vee-Bee - Degrees between 1.6 and 4.5 for concrete transported and placed by normal method and between 0.8 and 3.5 for concrete transported and placed by pumping methods.

5.11.4.4 ***Weight, Cement Factor and Air contents Test*** *:* Freshly mixed concrete for every type shall be tested in the batch plant laboratory for each batch of concrete produced to determine weight per cubic metre of freshly mixed concrete, cement factor in concrete and the air content of the concrete. Frequency and number of test shall be finalized by the manufacturer of concrete in consultation with the Engineer-in-Charge for his requirement of the mode of measurement of concrete produced.

The Engineer-in-Charge may at his discretion require further tests over and above those specified above in para 5.11.4.1 to be conducted on fresh concrete. The manufacturer and the placement contractor shall have to comply with all such requirements.

5.11.5 Sampling and Testing for Quality Control of Hardened Concrete

(i) Test on cube crushing strength of concrete in accordance and compliance with IS 456 and IS 516 shall done as under:-

(a) Sample of fresh concrete shall be taken from concrete at central batch plant mixer while loading delivery trucks or other transport and also from concrete transported to placement location.

(b) Test on specimens made form samples collected at placement location shall be considered as field test specimens and results therefrom shall be the criterion of concrete strength. Test in specimens made from samples at the batch plant shall only be taken as guidelines test. Only in the case of doubtful result, the Engineer-in-Charge may refer to such guideline results for deciding on the quality of concrete.

(c) For truck mix concrete and shrink mix concrete guideline test specimens shall be made from samples collected at discharge location from mixing trucks. For this purpose first and last 15% of the load shall be omitted while collecting samples.

(d) Frequency of sampling shall be as given below in Table 5.8 for each grade of concrete of different workability's and for each type of specimens (field test specimens and guideline test specimens) for conducting 28 days crushing strength tests.

TABLE 5.8

Quantity of concrete Delivered (cum)	*Number of samples*
Less than 5	1
6 to 15	2
31 to 50	3
51 and above sample for each	4 plus one additional 50 cum or part thereof

Each sample shall be of adequate quantity so that a minimum of 3 specimen cubes can be made test of the sample in accordance with IS 516.

(e) All test specimens shall be made compacted cured and tested in compliance with IS 516 and test result interpreted in accordance with IS 456 for acceptance of concrete strength, field specimens test results shall not be less than values given in Table 5.6.

(f) In addition to 28 day crushing strength test on specimens made at frequencies specified in para 4 above, early strength tests at 7 days shall also be conducted on field specimens as well as guideline test specimens. Frequency of sampling for this set of test shall also be same as those specified in Table 5.8 above. 7 day strength shall conform to values given in Table 5.5. But these test results even if conforming to specified values shall only be taken a guideline values for projecting concrete strength and shall not be construed as conforming to specifications.

(g) For each grade of concrete and for all workability conditions with different water – cement ratios and compositions of admixtures, preliminary test shall be conducted for crushing strength on finalization to design mix for each type of concrete. Such test shall be conducted both at 7 days and 28 days under laboratory conditions. Six test specimens shall be made for 7 days test and six test specimens shall be made for 28 days test.

Average of the six test results of different periods shall not be less than those specified in Table 5.5.

(h) Crushing strengths on cubes shall also be conducted during the process of finalization of concrete design mix. Frequency and number of such tests shall be as per Mix of requirements of concrete manufacturer.

(i) All test specimens for conducting crushing strength shall be properly labeled for identification indicating:-

(i) Date of making specimen

(ii) Grade of concrete

(iii) Placement location exact

(iv) Purchasers order number

(j) In addition to crushing strength test on concrete, the Engineer-in-Charge may call for other tests on hardend concrete. The placement contractor and the manufacturer of concrete shall comply with all such instructions.

(ii) Non-destructive Tests

(a) When the 28 days crushing values on field specimens and/ or specimens and/or specimens made for guideline test fall short of specified values, or in case of doubtful placement of concrete, the Engineer-in-Charge shall call for non-destruction tests on the structure. Such tests may be any one or a combination of the following:-

- Rebound hammer test
- Windsor Penetration Probe test
- Pulse velocity (sonic or Ultrasonic) test
- Core test
- Load test

(b) Interpretation of rebound hammer, Windsor Probe and Pulse velocity test results shall rest with the Engineer-in-Charge.

(c) Core test, if ordered by the Engineer-in-Charge, shall be done in accordance with IS 516. Samples for such test shall be taken from locations to be identified by the Engineer-in-Charge and such samples shall be collected in compliance with IS:1199.

(d) If felt necessary, the Engineer-in-Charge may instruct load testing for any part of the structure based on doubtful concrete strengths. Such test shall be carried out as per details to be provided by the Engineer-in-Charge in consultation with the structural consultants.

(e) The concrete manufacturer/ concrete placement contractor shall arrange for all test to be conducted in accordance with these specifications, including all necessary tools, plants, equipment and material, and shall be responsible for conducting all test at his cost.

(f) All test conducted at the filed laboratory shall be carried out by qualified technicians employed by the concrete manufacturer/ concrete placement contractor, in presence of authorized representative of the Engineer-in-Charge. All test reports and observation reports shall be jointly signed by the Engineer-in-Charge authorized representative and the technician conducting such test.

(g) Engineer-in-Charge shall alone decide where such tests are to be conducted. He may instruct tests to be conducted at laboratories other than the field laboratory and such instructions shall be followed without claiming extra charges on this account.

(h) The Concrete Manufacturer/ Placement contractor shall set up a laboratory at this own expense which shall have facilities, for conducting all necessary field test on materials and field and laboratory test on concrete. The laboratory shall be staffed by the concrete Manufacturer/ Placement Contractor with qualified and experienced scientists and technicians.

5.12 EXPANSION JOINT SYSTEM

5.12.1 FLOOR JOINT

5.12.1.1 General requirement of material

The expansion joint system will be of extruded aluminum base members, self aligning /self centering arrangement and support plates etc. as per ASTM B221-02. The system shall be such that it provides floor to floor/ floor to wall expansion control system for various vertical locations in load application areas that accommodate multi directional seismic movement without stress to its components. The system shall consist of metal profiles with universal aluminum base member designed to accommodate various project conditions and finish floor treatments. The cover plate shall be designed of width and thickness required to satisfy projects movement and loading requirements and secured to base members by utilizing manufacturer's pre-engineered self centering arrangement that freely rotates/ moves in all directions. The self-centering arrangements shall exhibit circular sphere ends that lock and slide inside the corresponding aluminum extrusion cavity to allow freedom of movement and flexure in all directions including vertical displacement. Provision of moisture barrier membrane in the joint system to have water tight joint is mandatory requirement. The scope of work includes all labour, materials, equipments and services and perform all operations required for complete installation of expansion joint system.

5.12.1.2 Performance Requirement: Material and works shall conform to the latest edition of reference specifications as specified in the item and to all applicable codes and requirement of local authorities having jurisdiction.

5.12.1.3 Approval of expansion joint system : Sample of expansion joint system along with manufacturers latest published literature for material specified herein, material test reports, shop drawings etc. shall be submitted for obtaining approval before material are delivered at the site. The expansion joint cover assembly should be from one source (from single manufacturer)

5.12.1.4 Installation of expansion joint system: In all cases the manufacturer's standard written instruction or specific instructions for installation shall be followed.

5.12.1.5 Measurement : The length of expansion joint shall be measured, correct to a cm.

5.12.1.6 Rate : The rate shall be inclusive of all material and labour involved in providing & fixing of expansion joint.

5.12.2 WALL JOINT

5.12.2.1 General requirement of material

The expansion joint system related with wall joint (internal/ external) shall be of extruded aluminum base members, self aligning / centering arrangement and support plates as per ASTM B221-02. The material shall be such that it provides an Expansion joints systems suitable for vertical wall to wall/ wall to corner application, both new and existing construction in office buildings & complexes with no slipping down tendency amongst the components of the joint system. The Joint System shall utilize light weight aluminum profiles exhibiting minimal exposed aluminum surfaces mechanically snap locking the multicellular to facilitate movement. (Material shall confirm to ASTM 6063)