provided the engineer is satisfied that the contractor has not gone deeper than what was unavoidable.

2.19 SPECIFICATIONS FOR BLASTING

2.19.1 Where hard rock is met with and blasting operations are considered necessary, the contractor shall obtain the approval of the engineer in writing for resorting to blasting operation.

Note : In ordinary rock blasting operations shall not be generally adopted. However, the contractor may resort to blasting with the permission of the engineer, but nothing extra shall be paid for such blasting operations.

The contractor shall obtain license from the competent authority for undertaking blasting work as well as for obtaining and storing the explosive as per the * Explosive Act, 1884 as amended upto date and Explosive Rules, 1983. The contractor shall purchase the explosive fuses, detonators, etc. only from a licensed dealer. Transportation and storage of explosive at site shall conform to the aforesaid Explosive Act and Explosive Rules. The contractor shall be responsible for the safe custody and proper accounting of the explosive materials. Fuses and detonators shall be stored separately and away from the explosives. The engineer or his authorised representative shall have the right to check the contractor's store and account of explosives. The contractor shall provide necessary facilities for this.

The contractor shall be responsible for any damage arising out of accident to workmen, public or property due to storage, transportation and use of explosive during blasting operation.

SECTION 4
CONCRETE WORK

4.0 The concrete can be designed in grades denoting **by volumetric proportion of the constituents' characteristic compressive strength. The concrete by volumetric proportion or nominal mix concrete** of the constituents as well as **design mix** denoting compressive strength as detailed in this section.

4.1 Material

4.1.1 Water, cement, lime, fine aggregate or sand, surkhi, cinder and fly ash shall be as specified in Section 0.

4.1.2 Coarse aggregate

4.1.2.1. 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 / authorised 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. It shall conform to IS - 383 unless otherwise specified.

b) Gravel - It shall consists 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 soil materials 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 bricks / brick bats. They shall be homogenous 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 and 20% when used in lime concrete. It shall conform to IS - 383 unless otherwise specified.

d) Lightweight aggregates such as sintered fly ash aggregate may also be used provided the engineer is satisfied with the data on the proportion of concrete made with them.

4.1.2.2 Deleterious material - Course aggregate shall not contain any deleterious material, such as pyrites, coal, lignite, shale or similar laminates 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 shall not contain any material liable to attack the steel reinforcement. Aggregates which are chemically reactive with alkali of cement shall not be used. The maximum quantity of deleterious material shall not more than five per cent of the weight of coarse aggregate when determined in accordance with IS - 2386 part II.

4.1.2.3. Size and grading

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

(a) Nominal sizes of graded stone aggregate or gravel shall be 40, 20,16, or 12.5 mm as specified. For any one of the nominal sizes, the proportion of other sizes as determined by the method prescribed in Annexure 4 -A.1. and shall be in accordance with Table 1.

Table 1 -Graded stone aggregate

IS Sieve Designation	Percentage passing (by weight) for nominal size of			
	40 mm	20 mm	16 mm	12.5 mm
75 mm	100	-	-	-
37.5 mm	95 to 100	100	-	-
19 mm	-	95 to 100	100	100
16 mm	-	-	90 to 100	-
11.2 mm	-	-	-	90 to 100
9.5 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
2.36 mm	-	-	-	-

Concrete work

(b) Normal 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 Annexure 4-A.1 shall be in accordance with Table 2.

Table 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
75 mm	100	-	-	-	-	-
63 mm	85-100	100	-	-	-	-
37.5 mm	0-30	85-100	100	-	-	-
19 mm	0-5	-20	85-100	100	-	-
16 mm	-	-	-	-85-100	100	-
11.2 mm	-	-	-	-	85-100	100
9.5	-	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 sizes 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 the method prescribed in Annexure 4 – A .1 shall be in accordance with Table 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 3.

Table 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 –6 -12	63	9	-	3	-	-
1 –6 -12	40	-	9	3	-	-
1 –5 -10	63	7 ½	-	2 ½	-	-
1 –5 -10	40	-	7 ½	2 ½	-	-
1 -4 -8	63	6	-	2	-	-
1 -4 –8	40	-	6	2	-	-
1 -3 –6	63	4 ½	-	1 ½	-	-
1 -3 –6	40	-	4 ½	1 ½	-	-
1 -3 –6	20	-	-	4 ½	-	-
1 -2 –4	40	-	2 ½	1	-	½
1;2 –4	20	-	-	3	-	1
1 -2 –4	12.5	-	-	-	3	-
1 -1 ½ -3	20	-	-	2	-	1

Note -(i) The proportions indicated in Table 3 above are by volume when considered necessary, these proportions may be varied marginally by engineer 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. If single size coarse aggregates are not premixed at site to obtain the graded coarse aggregate required for 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 be40 mm and its grading shall be as specified in the Table 4 when tested for sieve analysis by the method prescribed in Annexure 4 – A .1.

Table 4 -Brick aggregate

IS Sieve Designation(by weight)	Percentage passing
75 mm	100
37.5 mm	95-100
19.0 mm	45-100
4.75	0-5

Note -Coarse aggregate for cement concrete shall generally conform to para 4.2.1 of IS - 456 and fine aggregate shall conform to IS - 383.

4.1.2.4. 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.

4.1.2.5. Testing - Coarse aggregate shall be tested for the following (as per IS - 2386)

(a) Determination of particle size and shape(Annexure 4 – A.1)

(b) Estimation of organic impurities (as per IS - 2386-Part II)
(c) Surface moisture (Annexure 4 – A.2)
(d) Determination of 10% fine value (Annexure 4 – A.3)

4.1.2.6. 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 aggregates nominal size below 40 mm.

4.1.3. Admixtures - When required, admixtures of approved quality shall be mixed with concrete, as specified. The admixtures shall conform to IS - 9103.

4.2. SPECIFICATIONS FOR CEMENT CONCRETE

4.2.0. This shall be prepared by mixing graded stone or brick aggregate of nominal size as specified with fine aggregate and cement in specified proportions with required quantity of water. The grading and quality of aggregates shall be such as to give minimum compressive strength of 140 kg/cm² and 210 kg / cm² at 7 days and 28 days respectively in case of mix 1 -2 -4, (One cement - two Coarse sand - four stone aggregate).

One sample consisting of 6 cubes 15x15x15 cm shall be taken for every 15 cubic metre or part thereof cement concrete 1 -2 -4. The cube tests shall not be carried out in case the quantity of cement concrete placed on any day is less than 15 cubic metre unless otherwise specific. For other details, refer section on R.C.C. work.

4.2.1. Proportioning - It shall be done by volume. Boxes of suitable size shall be used for measuring sand and aggregate. The internal dimensions of the boxes shall be generally 35 X 25 X40 cm deep or as otherwise approved by the engineer. The unit of measurement of cement shall be a bag of 50 kg. and this shall be taken as 0.035 cubic metre. 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 for mortar.

4.2.2. Preparation - This shall be prepared by mixing coarse aggregate, fine aggregate and cement in specified proportions with required quantity of water. Nominal size and quality of aggregate shall be as specified.

Except where brick aggregate is used in cement concrete, minimum compressive strength on works test for different concrete mixes shall be as specified for various grades prepared by volume basis, in Table 5 below. The work test shall be carried out for every 15 cum of a day's concreting unless otherwise specified.

Table 5

Concrete mix	Min compressive strength on15 cm cube in Kg / cm²	
	7 days strength	28 days strength

1 -1 -2	210	315
1 -1½ -3		265
1 -2 -4	140	175

4.2.2.1. 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 writing subject to adding 10% extra cement. When hand mixing is permitted, it shall be carried out on a watertight 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 1½ to 2 minutes, for hydrophobic cement it may be taken as 2½ to 3 minutes.

4.2.2.2. 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 6.

Table 6

Nominal size of mixer (T, NT or R), litre	Minimum inside width of hopper feeding edge in mm
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 center 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 center line of the chute plate of the hopper when in discharge position, should be as large 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, there should be at least one and 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

4.2.2.3. 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 halves of the batch shall not be more than the following limits -

Cement	8%
Fine aggregate	6%
Coarse aggregate	5%

4.2.2.4. 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. 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 clean with water.

4.2.2.5 Hand mixing - When hand mixing has been specifically permitted in exceptional circumstances by the engineer in writing, subject to adding 10% extra cement, it shall be carried out on a smooth, clean and water tight platform of suitable size. Measured quantity of sand shall be spread evenly on the platform and the cement shall be dumped on the sand and distributed evenly. Sand and cement shall be mixed intimately with spade until mixture is of even colour throughout. Measured quantity of coarse aggregate shall be spread on top of cement sand mixture and mixing done by shoveling and turning till the coarse aggregate gets evenly distributed in the cement sand mixture. Three quarter 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 it 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.

4.2.3. Workability - The quantity of water to be used for each mix shall be such that the concrete is of adequate workability for the placing conditions of the concrete and can properly be compacted with the means specified. Generally, the quantity of water to be used for each mix of 50 Kgs cement shall not be more than 34 litres for 1 -3 -6 mix, 30 litres for 1 -2 -4 mix, 30 litres for 1 -1½ -3 mix and 25 litres for 1 -1 -2 mix. In case of vibrated concrete, the quantity of water may be suitably reduced to avoid segregation. The quantity of water shall be regulated by carrying out regular slump tests as described in annexure 4.A.4. The slump and workability for different kind of works shall be as per table 7 below

Table 7

Placing conditions.	Degree of workability	Value of workability
Concreting of shallow Sections with vibration	Very low	0.75-0.80 Compacting factor.
Concreting of lightly reinforced reinforced section with vibration.	Low	Slump up to 25 mm, 10-5 Seconds, vee bee time 0.8-0.85 compacting factor.
Concreting of lightly reinforced section without vibration or heavily reinforced sections with vibration.	Medium	25-75 mm, slump for 20 mm aggregate.
Concreting of heavily reinforced sections without vibration.	High	75-125 mm slump for 20 mm aggregate.

Note - Where considered necessary, the workability of the concrete my also be ascertained by compacting factor test and vee-bee censistometer method as specified in IS - 1199. For suggested ranges of value of workability of concrete by the above methods, reference may be made to IS - 456-2000.

4.2.4. Transportation - 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.

4.2.5. 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.

4.2.6. 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 specifications for concrete vibrators (immersion type). To prevent segregation, over vibration shall be avoided. The use of mechanical vibrator may be relaxed by the engineer at his discretion for certain items and permit hand compaction. Hand compaction shall be done with the help of tamping rods. 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 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.

4.2.7. Construction joints - Connecting 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. Number of such joints shall be kept minimum. oints shall be kept as straight as possible.

4.2.7.1. 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 2kgs. of cement per sq m 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

4.2.7.2. 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 corners and close spots; work, thereafter, shall proceed in the normal way.

4.2.8. Concreting under special conditions

4.2.8.1 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) and IS - 7861(Part II) respectively. Concreting shall not be done when the temperature falls below 4.5º C. 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.

4.2.8.2 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. The concrete shall contain at least 10% more cement than that required for the same mix placed in dry conditions, the quantity of extra cement varying with conditions of placing with prior written permission of the engineer. Such extra cement will be paid extra. The volume of coarse aggregate shall not be less than 1½ times nor more than twice the fine aggregate and slump not less than 100 mm nor more than 180 mm. Where found necessary to deposit any concrete under water, the method, equipment, materials and mix shall first be got approved by the engineer. Concrete shall be deposited continuously until it is brought to required height. While depositing, the top surface shall be kept as nearly level as possible and the formation of heaps shall be avoided. The concrete shall be deposited under water by one of the approved methods such as tremie method, drop bottom bucket, bags, grouting etc. as per details given in IS - 456-2000. If it is necessary to raise the water after placing the concrete, the level shall be brought up slowly without creating any waves or commotion tending to wash away cement or to disturb the fresh concrete in any way

4.2.9. Curing - When the concrete begins to harden i.e. two to three hours after compaction, the exposed surfaces shall be kept damp with moist gunny bags, sand or any other material approved by the engineer 24 hours after compaction, the exposed surface shall be kept continuously in damp or wet conditions by ponding or by covering with a layer of sacking, canvass, hessian or similar absorbent materials and kept constantly wet for atleast 7 days where ordinary portland cement is used and 10 days, where portland pozzolona cement is used from the date of placing of concrete. For concrete work with other types of cement, curing period shall be as directed by the engineer.

Approved curing compounds may be used in lieu of moist curing with the permission of the engineer. Such compounds shall be applied to all exposed surfaces of the concrete as soon as possible after the concrete has set

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

4.2.9.2 Over the foundation concrete, the masonry work may be started after 48 hours of its compaction but the curing of exposed surfaces of cement concrete shall be continued along with the masonry work for atleast 7 days. And where cement concrete is used as

base concrete for flooring, the flooring may be commenced before the curing of 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.

4.2.10. Testing of concrete will be done as described in section on R.C.C

4.2.11. From work - Form work shall be as specified in R.C.C section and shall be paid for separately unless otherwise specified.

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

4.2.13. Measurements

4.2.13.1. 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. Area shall be worked out to nearest 0.01 square metre and the cubic contents of consolidated concrete shall be worked out nearest 0.001 cubic metres. Any work done in excess over the specified dimension or as required by engineer be ignored.

4.2.13.2. Concrete work executed in the following conditions shall be measured separately -

a. At or near the ground level
b. Work in liquid mud
c. Work in or under foul positions

4.2.13.3. 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 two specified heights or depths with reference to plinth level / defined datum level

4.2.13.4. No deduction shall be made for the following -

a. Ends of dissimilar materials for example beams, girders, rafters, purlins trusses corbels and steps upto 500sq in cross sections.
b. Opening upto 0.1sq metre (1000sq.cm).
c. Volume occupied by pipes, conduits, sheathing etc. not exceeding 100sq cm each in cross sectional areas.
d. Small voids such as shaded portions in Figure when these do not exceed 40sq cm each in cross section.

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

4.2.13.5. 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 landing)
k) Arches
l) Domes, vaults
m) Shell roof, arch ribs and folded plates
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, plian window sills and the like
s) Cornices and moulded windows sills.
t) Louvers, fins, facia.

4.6 SPECIFICATIONS FOR REINFORCED CEMENT CONCRETE WORK

4.6.0. General - Reinforced cement concrete work may be cast-in-situ or Precast as may be directed by engineer 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 (Centring and shuttering)
b) Reinforcement
c) Concreting - 1) Cast-in-situ 2) Precast

4.6.1 Materials

4.6.1.1 Water, cement, fine and coarse aggregate shall be as specified under respective clauses of mortars and section 04-concrete work as applicable.

4.6.1.2 Steel for reinforcement

4.6.1.2.1 The steel used for reinforcement shall be any of the following types -

a) Mild steel sand medium tensile bars conforming to IS -432 (part I)
b) Hard drawn steel write conforming to IS -432 (part II)

High strength deformed steel bars conforming to IS - 1786

c) Hard drawn steel wire fabric conforming to IS - 1566
d) Structural steel section conforming to IS - 2062 - 1999

4.6.1.2.2 Types and grades - Reinforcement supplied in accordance with this standard shall be classified into the following types -

a) Mild steel bars - It shall be supplied in the following two grades
i) Mild steel bars grade I designated as Fe 410-S
ii) Mild steel bars grade II designated as Fe 410-O.

b) Medium tensile steel bars, grade II designated as Fe-540-W-HT.

4.6.1.2.3 Mild steel and medium tensile steel - Physical requirement are given in the following Table 11

Table 11

Sl No	Type and nominal size Of bars	Ultimate tensile stress N/mm^2 minimum	Yield stress N/mm^2 minimum	Elongation Percent
1	Mild steel grade I For bars upto and including 20 mm	410	250	23
	For bars over 20 mm upto and Including 50 mm	410	240	23
2	Mild steel grade I For bars upto and including 20 mm	370	225	23
	For bars over 20 mm upto and Including 50 mm	370	215	23
3	Medium tensile steel For bars upto & including 16 mm	540	350	20
	For bars over 16 mm, upto And including 32 mm	540	340	20
	For bars over 32 mm, upto And including 50 mm	510	330	20

Elongation percent on gauge length 5.65 $\sqrt{so}$ where so is the cross section area of the test piece.

Note - 1. Grade (II) Mild steel bars are not recommended for the use in structures located in the earthquake zone subjected to serve damage and for structures subjected to dynamic loading (other than wind loading) such as railway and highway bridges.
2. 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. 12 of the mass / weight calculated on the basis that the masses of the bar / wire of nominal diameter and of density 0.785 kg / cm^3 or 0.00785 kg / mm^3.

Table 12

(Tolerance on nominal mass)

Nominal size In mm	Tolerance on the nominal mass percent		
	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
c) over 16	± 3	-4	± 4

+ for individual sample plus tolerance in not specified

(x) for coil batch tolerance is not applicable

Tolerance shall be determined in accordance with method given in IS 1786-1985

Tests - Following type of lab test shall be carried out

1) Tensile test - This shall be done as per IS 1608
2) Bend test - This shall be done as per IS 1599
3) Re-test - This shall be done as per IS 1786
4) Rebend test -This shall be done as per IS 1786

Should any one of the test pieces first selected fail to pass any of the tests specified above, two further samples shall be selected for testing in respect of each failure. Should the test pieces from both these additional samples pass, the materials represented by the test samples shall be deemed to comply with the requirement of the particular test. Should the test piece from either of these additional samples fail, the material represented by the test samples shall be considered as not having complied with standard.

High strength deformed bars & wires shall conform to IS -1786. The physical properties for all sizes of steel bars are mentioned below in Table 13.

Table 13

Sl. No	Property	Grade		
		Fe 415	Fe 500	Fe 550
1	0.2% proof Stress/Yield stress,min. N/mm²	415	500	550
	Elongation, percent min. on guage Length 5.65 $\sqrt{A}$, Where A is the X-sectional Area of the test piece	14.5	12	8
3	Tensile strength	10 % more than actual 0.2 % proof stress but not less than 465 N/mm²	8 % more than actual 0.2 % proof stress but not less than 545 N/mm²	6 % more than actual 0.2 % proof stress but not less than 585 N/mm²

Tests - Selection and preparation of test sample. All the tests pieces shall be selected by the engineer or his authorised representative either-

a) From cutting of bars

or

b) If he so desires, from any after it has been cut to the required or specified size and the test piece taken from 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 or his authorised 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 deductions 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 - This shall be done as per IS - 1599.

Re-test - This shall be done as per IS - 1786.

4.6.1.3 Stacking and storage - Steel for reinforcement shall be stored in such a way as to prevent distorting and corrosion. Bars of different classifications, sizes and lengths shall be stored separately to facilitate issue in such sizes and lengths to cause to minimum wastage in cutting from standard length.

4.6.2 SPECIFICATIONS FOR FORMWORK (CENTRING & SHUTTERING)

4.6.2.1 - 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.

4.6.2.2 - Design & tolerance in construction - Form work shall be designed and constructed to the shapes, lines and dimensions shown on the drawings with the tolerances given below.

a)	Deviation from specified dimensions of cross section of columns and beams		+ 12 mm
b)	Deviation from dimensions of footings		+ 12 mm
	i)	Dimension in plan	+ 50 mm
	ii)	Eccentrically in plan	0.02 times the width of the footings in the direction of deviation but not more than 50 mm
	iii)	Thickness	+ 0.05 times the specified thickness.

(Note – Tolerance apply to concrete dimensions only, and not to positioning of vertical steel or dowels.)

4.6.2.3. **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.

Forms 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.

4.6.2.3.1 Material for form work

a) Propping and centring - All propping and centring should be either of steel tubes with extension pieces or built up sections of rolled steel.

4.6.2.3.2 Centring/Staging - Staging should be as designed with required extension pieces as approved by engineer to ensure proper slopes, as per design for slabs /beams etc. and as per levels as shown in drawings. All the staging to be either tubular steel structure with adequate bracings as approved or made of built up structural sections made from rolled structural steel sections

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

b) Form work and concreting of upper floor shall not be done until concrete of lower floor has set atleast for 14 days.

4.6.2.3.3. 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, rubberised lining of material as approved by the engineer shall be provided in the joints.

Steel shuttering used for 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 oints RS, 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.

4.6.2.3.4 From 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 centring exceeds 3.50 meters, the prop may be provided in multi-stages. A typical detail of multistage shuttering is given in Fig. 9.

4.6.2.3.5 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 meter (1 to 250) or as directed by the engineer, 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.

4.6.2.3.5.1 Typical arrangement of form work for 'Beams, columns and walls' are shown in Figure 1 to 8 and form secured by wall ties is shown in Fig.3.

4.6.2.3.6. Walls - The forms faces have to be kept at fixed distance apart and an arrangement of wall ties with spacer tubes or bolts is considered best. 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 forms.

4.6.2.3.7 Removal of form work (stripping time) - In normal circumstance and where ordinary portland cement is used, forms may generally be removed after the expiry of the following periods -

a) Walls ,columns and faces of all structural members 24 to 48 hours as many be decided by the engineer

b) Slab

i)	Spanning upto 4.50 M	7 days
ii)	Spanning over 4.50 M	14 days

c) Beams and arches

i)	Spanning upto 6 M	14 days
ii)	Spanning over 6 M & Upto 9 m	21 days
iii)	Spanning over 9 M	28 days '

Note 1 - For the other types of cement, the stripping time recommended for ordinary portland cement may be suitably modified. If portland pozzolana or low heat cement has been used for concrete, the stripping time will be 10/7 of the period stated 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 of the slabs, beam or arch as the case may be together with any live load likely to occur during curing of further construction.

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

Note 4 - In case cantilever slabs and beams, the centring 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.

4.6.2.4. Surface treatment

4.6.2.4.1. Oiling the surface - Shuttering gives much longer service life in 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 centipoise.

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

4.6.2.4.2 The design of form work shall conform to sound engineering practices and relevant IS codes.

4.6.2.5 Inspection of form work - The completed form work shall be inspected and approved by the engineer before reinforcement bars are placed in position. Proper from work should be adopted for concreting so as to avoid honey combing, blow holes, grout loss, stains or discolouration 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.

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

4.6.2.5.1. Erection of form work (centring 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.

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.

d) 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.

e) 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 device and bracing shall be tightened.

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

g) 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 centralising beams placed in the forkheads.

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

i) Double wedges shall be provided for adjustment of the form to the required position wherever any settlement / elastic shortening 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 their shifting.

j) No member shall be eccentric upon vertical member.

k) The number of nuts and bolts shall be adequate.

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

m) Cantilever supports shall be adequate.

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

o) Guy ropes or stays shall be tensioned property.

p) There shall be adequate provision for the movement and operation of vibrators and other construction plant and equipment.

q) Required camber shall be provided over long spans.

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

4.6.2.6 Measurements

4.6.2.6.1. General - The form work shall include the following;

a) Splayed edges, notchings, 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) Filling to form stop chamfered edges of splayed external angles not exceeding 20 mm 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 concrete.
g) Dressing with oil to prevent adhesion and
h) Raking or circular cutting.

4.6.2.6.2 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 and precast shelves,
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, girders, bressummers and cantilevers.
e) Columns, pillars, posts and struts.
f) Stairs (excluding landing) except Spiral staircase.
g) Spiral staircase (including landing).
h) Arches.
i) Domes, vaults, shells roofs, archribs and folded plates.
j) Chimneys and shafts.
k) Well steining.
l) Vertical and horizontal fins individually nor forming box, louvers and bands.
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) Comices and mouldings.
p) Small surfaces, such as cantilevers ends, brackets and end of steps, caps and boxes to pilasters and columns and like.
q) Chullah hoods, weather shades, chajjas, corbels etc. including edges and
r) Elevated water reservoirs.

4.6.2.6.3 Centring, and shuttering where exceeding 3.5 meter height in one floor shall be measure and paid for separately.

4.6.2.6.4 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.

4.6.2.6.5. No deductions from the shuttering due to the openings / obstructions shall be made if the area of such openings / obstructions does not exceed 0.1 square meter. Nothing extra shall be paid for forming such openings.

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

4.6.3. SPECIFICATIONS FOR REINFORCEMENTS IN CONCRETE

4.6.3.1 General requirements - Steel conforming to para 4.6.1.2. for reinforcement shall be clear and free from loose milscales, dust, loose rust, coats of paints, oil or other coatings 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 used for removing the rust.

4.6.3.1.1 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. Preferably bars of full length shall be used. Necessary cutting and straightening is also included. Over lapping of bars, where necessary shall be done as directed by the engineer. The overlapping bars shall not touch each other and these shall be kept apart with concrete between them by 25 mm or 1 ¼ 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. But in no case the over lapping shall be more than 50% of cross sectional area at one section.

4.6.3.1.2 Bonds and hooks forming end anchorages - Reinforcement shall be bent and fixed in accordance with procedure specified in IS 2502, code of practice for 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 of the bar

U – Type Hook

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 drawing.

b) Bends - Bend forming anchorage to a M.S. plain bar shall be bent with an 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.

4.6.3.1.3 Anchoring bars in tension - Deformed bars may be used without end anchorages provided, development length requirement is satisfied. Hooks should normally be provided for plain bars in tension. Development length of bars will be determined as per clause 25.2.1 of IS - 456-2000.

4.6.3.1.4 Anchoring bars in compression - The anchorage length of straight bar in compression shall be equal to the 'Development length' of bars is compression as specified in of IS - 456-2000. The projected length of hooks, bends and straight lengths beyond bend, if provided for a bar in compression, shall be considered for development length.

4.6.3.1.5 Binders, stirrups, links and the like - 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.

4.6.3.1.6 Welding of bars - Whenever facility for electric arc 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. Welding shall be as per IS - 2751 for mild steel bars and for cold worked bars.

4.6.3.2 Placing in position

4.6.3.2.1 Fabricated reinforcement bars shall be placed in position as shown in the drawings or as directed by the engineer. The bars crossing one another shall be tied together at every intersection with two stands 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.

Track welding in crossing bars shall also be permitted in lieu of bending with steel wire if approved by engineer.

4.6.3.2.2. The bars shall be kept in correct position by the following methods -

a) In case of beam and slab construction precast cover blocks of cement mortar 1 -2 (1 cement - 2coarse 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 reinforcement.

b) In case of cantilevered and doubly reinforced beams or slabs, the vertical distance between the horizontal bars shall be maintained by introducing chairs, spacers or support bars of steel at 1.0 meter 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 suitably tied to the reinforcement to ensure that they are in correct position during concreting.

d) In case of R.C.C. structure such arches, domes, shells, storage tanks etc. a combination of cover blocks, spaces and templates shall be used as directed by engineer.

4.6.3.2.3. Tolerance on placing of reinforcement - Unless otherwise specified by the engineer, reinforcement shall be placed within the following tolerances -

Tolerance in spacing

		Tolerance in spacing
a)	For effective depth 200 mm or less	± 10
b)	For effective depth More than 200 mm	± 15

The cover shall in no case be reduced by more than one third of specified cover or 5 mm which ever is less.

4.6.3.2.4. 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 bars diameters for plain mild steel or 6 bar diameters for deformed bars. Care shall also be taken when bending back bars to ensure that the concrete around the bars in not damaged.

4.6.3.3 Measurements - Reinforcement including authorised spacer bars and lappages shall be measured in length of different diameters, as actually (not more than as specified in the drgs.) used in the work nearest to a centimeter and their weight calculated on the basis of standard weight given in Table – 14 below. Wastage and unauthorised overlaps shall be paid for. Annealed steel wire required for binding or tack welding shall bot be measured, its cost being included in the rate reinforcement.

Wherever 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 and measured separately and paid for.

Table 14

Cross-sectional area and mass of steel bar

Nominal size mm	Cross sectional area sq.mm	Mass per metre run kg
6	28.3	0.222
7	38.5	0.302
8	50.3	0.395

10	78.6	0.617
12	113.1	0.888
16	201.2	1.58
18	254.6	2.00
20	314.3	2.47
22	380.3	2.98
25	491.1	3.85
28	616.0	4.83
32	804.6	6.31
36	1018.3	7.99
40	1257.2	9.85
45	1591.1	12.50
50	1964.3	15.42

Note - These are as per clause 5.2 of IS 1786.

4.6.3.4. 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, as required of directed including tack welding on crossing of bars in lieu of binding with wires.

4.6.4 SPECIFICATIONS FOR CONCRETING

4.6.4.0. The concrete shall be done as specified. The proportion by volume of ingredients shall be as specified.

4.6.4.1 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 n[prescribed in chapter " concrete under para 4.2.3 workability"

4.6.4.1.1 Where considered necessary, the workability of the concrete may also be ascertained by compacting factor test and VEE BEE consistometer method specified in IS - 1199. For suggested ranges of values of workability of concrete by the above two methods, reference may be made to IS - 456.

4.6.4.2 Placing of concrete

4.6.4.2.1. Concreting shall be commenced only after engineer has inspected the centering, shuttering and reinforcement as placed and passed the same. Shuttering shall be clean and free from all shaving, saw dust, pieces of wood, or other foreign material and surfaces shall be treated as prescribed in 4.5.2.4

4.6.4.2.2 In case of concreting of slabs and beams, wooden plank or cat walks of chequerred MS plates or bamboo chlies 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.

4.6.4.2.3 In case of columns and walls, 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.

4.6.4.2.4 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 case of columns and walls, the shuttering shall be so adjusted that the vertical drop of concrete in not more than 1.5 metres at a time.

4.6.4.2.5 During cold weather, concreting shall not be done when the temperature falls below 4.5° c. the concrete placed shall be protected against frost by suitable converting. Concrete damaged by frost shall be removed and work redone.

4.6.4.2.6 During hot weather precaution shall be taken to see that the temperature of wet concrete does not exceed 38°C. no concrete shall be laid within half of the closing time of the day, unless permitted by the engineer.

4.6.4.2.7 It is necessary that the time taken between mixing and placing of concrete shall not exceed 30 minutes so that the initial setting process is not interferred with

4.6.4.3 Compaction

4.6.4.3.1 Concrete shall be compacted into dense mass immediately after placing by means of mechanical vibrators designed for continuous operations. The engineer may however relax this conditions 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 from. 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 deaeration 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.

4.6.4.3.2 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 vibrators. 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. within 30 minutes of addition of water to the dry mixture.

4.6.4.4 Construction joints

4.6.4.4.1 Concreting shall be carried out continuously upto the construction joints, the position and details of which shall be as shown in structural drawing or as indicated in Fig. 26 or as directed by engineer. Number of such joints shall be kept to minimum. The joints shall be kept at places where the shear force is the minimum. These shall be straight and shall be at right angles to the direction of main reinforcement.

4.6.4.4.2 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.

4.6.4.4.3 When stopping the concrete on a vertical plane in slabs and beams, an 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.

4.6.4.4.4 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 meter shall then be applied on the roughened surface before fresh concrete is laid.

4.6.4.5 Expansion joints - Expansion joints shall be provided as shown in the structural drawings or as indicated in Fig. 10 to 25 or as directed by engineer, 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 upto two places of decimal stating the depth and width of joint.

4.6.4.6 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. After 24 hours of laying of concrete, the surface shall be cured of ponding with water for a minimum period of 7 days from the date of placing of concrete.

4.6.4.7 Finishing

4.6.4.7.1 In case of roof slabs the top surface shall be finished even and smooth with wooden trowel, before the concrete begins to set.

4.6.4.7.2 Immediately on removal of forms, the R.C.C work shall be examined by the engineer, 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 4.6.4.9.4 for visual inspection test.

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

1) Surface defects which require repair when forms are removed, usually consist of bulges 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 preferable slightly undercut to provide a key at the edge of the path.

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 10 mm 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 material 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) 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 surface for the purpose of this specification.

Where such exposed surface exceeding 0.5 sqm in each location is not plastered with cement mortar 1 -3 (1 cement - 3 fine sand) 6 mm thick, necessary deduction shall be made for plastering not done.

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.

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

4.6.4.8 Strength of concrete - The compressive strength on work tests for different mixes shall be as given in table 15 below -

Table 15

Concrete mix	Compressive strength in

(Nominal mix on volume basis)	(kg/sq cm)	
	7 days	28 days
1:1:2	210	315
1:1 ½ : 3	175	265
1:2:4	140	210

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

(a) Raft, footing, bases of columns etc. and mass concrete.
(b) walls (any thickness) including attached pilasters, buttresses, plinth and string course, fillets 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 waistless 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 course, 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.

4.6.4.11.4 No deduction shall be made for the following -

(a) Ends of dissimilar materials (e.g. oists, beams post griders, rafters, 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 linthels or sills. No extra labour for forming such opening or voids shall be paid for.

(c) The volume occupied by reinforcement.

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

4.6.4.11.5 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 bream.

(b) Beams shall be measured from face to face of columns and shall include haunches, if any, between columns and beam. The depth of the bottom of beam shall be from the bottom of slab to the bottom of beam and slabs 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 measurement shall be taken through.

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

4.6.4.12. 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 drawing by the designer. Whenever these are not specified, the permissible tolerance shall be decided by the engineer after consultations with the Designer, if necessary.

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

(a) If the actual dimensions 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 measurements.

(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 dimension of engineer shall be final. For the purpose of payment, however, the clarification as given in para a, b & c above shall apply

4.6.4.13 Rate

4.6.4.13.1. The rate includes the cost of materials and labour involved in all the operations described above except for the cost of centring and shuttering.

4.6.4.13.2 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 the specified compressive strength.

4.6.4.13.3 Where throating or plaster drip or moullding 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 measured in running metres direct to a cm of the edge of chajja.

4.6.4.13.4 No extra payment for richer mix which projects into any meter 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 drawing. The payments for work done under items of different mixes shall be limited strictly to what is indicated in the structural drawings.

SECTION 5
STONE WORK

5.1 Stone

5.1.1 Requirements of a good structural stone - Structural stones should primarily be (a) strong against crushing, (b) durable, (resistance to weather), (c) good in appearance (colour), (d) susceptible of being quarried in large sizes, and (e) fire resisting.

The strength of a stone depends upon its density and weight.

5.1.3 Quality of good stone and comparative strength - A stone of igneous origin is stronger than one of sedimentary formation. Stones with silicates as binding material will weather better than those with calcareous binding material. Generally, crystalline stones are hard and compact and are superior to non-crystalline stones. Finer the crystalline structure, stronger and more durable is the stone. An examination of old structure, where it has been used will indicate durability. If tool marks are visible, the edges or corners are still sharp and true and the surface hard showing no signs of deterioration, the stone may