

# **SPECIFICATIONS FOR MATERIALS**

## **1. Water:**

Water for mixing cement mortar or concrete shall not be salty or brackish and shall be clean, reasonably clear and free from objectionable quantities of silt and traces of oil, acid and injurious alkaline, salts, organic matter and other deleterious materials which will either weaken the mortar or concrete or cause efflorescence or attack the steel in R.C.C. Water shall be obtained from sources approved by the Engineer-in-charge. Sources of water shall be maintained at such a depth and the water shall be withdrawn in such a manner as to exclude silt, mud, grass or other foreign materials. Containers for transport, storage and handling of water shall be neat and clean.

### **Water for curing cement mortar or concrete.**

Water for curing mortar or concrete should not be too acidic or too alkaline. It should have a PH value ranging between 4.5 to 8.5. It shall be free of elements which significantly affect the hydration reaction or otherwise interfere with the hardening of mortar or concrete during curing or those which produce objectionable stains or other unsightly deposits on concrete or mortar surfaces. Hard and bitter water containing more than 100 P.P.M. of sulphates shall not be used for curing purpose.

Sea water and water containing over 3 percent of chloride salts should not be used for curing reinforced concrete work.

Portable water will generally be found suitable for curing cement mortar or concrete.

## **2. Cement:**

### **General:**

The contractor shall procure ordinary Portland cement for the entire work from open market, from the manufacturing company directly, having major cement plant with yearly production more than one lakh M.T. or from the authorized dealer of such company. Only ordinary Portland cement conforming I.S. 269-1989 shall be used for entire work.

The cement older than six months or the period as specified in I.S. shall not be used on work except with the written permission of the Engineer-in-charge. The samples of the cement older than six months shall be tested by quality control unit or GERI. at the contractor's cost. If the test results are in accordance to the I.S. specification, then the Engineer-in-charge will permit to use such cement. The contractor shall have to remove the discarded cement at his own cost and no claims on account of purchase cost of discarded cement, its transportation and stacking cost shall be entertained.

The Engineer-in-charge and the contractor shall jointly maintain cement consumption register in which the receipt of cement and its use shall be noted day to day and shall be signed by both i.e. representatives of contractor & Engineer-in-charge. The cement shall be provided at the site of work satisfactory storage for not less than 3 months average consumption of cement and shall keep the cement stored in manner that will satisfy.

The cement shall be tested before use as required by the Engineer-in-charge. Sampling and testing will be done by the department. No cement shall be used until notice has been given

that the test result are satisfactory. Cement older than 90 days shall not be used unless the test results satisfy the minimum strength requirements. Cement shall for its physical requirement conform I.S.-269- where ordinary Portland cement in used. For every 50 (fifty) MT of cement received at site 1 (one) bag will have to be tested. All other tests suggested by the Engineer-in-charge shall be carried out as per I.S. and they shall be conformed to the provision made in I.S. cement shall be measured by weight in tone (M.T.) as the Unit.

### **3. Fine Aggregate (Sand):**

#### **General:**

All fine aggregate work shall be natural sand or crushed stone screenings, sand shall be clean, well graded, hard, strong, durable and gristly particles free from injurious amounts of dust, clay, canker nodules, soft or flaky particles, shade, alkali, organic matter, loom, mica or other deleterious substances and shall be approved by the Engineer. The maximum size of particles shall be limited of 4.75 mm (about 3/16"). Where best trap sand available in the region contains murrum or literate particles, such particles may be allowed up to 5 percent.

When the quality of fine aggregate is doubtful it shall be tested for clay, organic impurities and other deleterious substances as laid down in I.S. 383. It shall not contain deleterious materials in such quantity as to reduce the strength or durability and the mortar or to attack the reinforcement in the case of reinforced concrete work. Sea sand shall not be used. The gradation of fine aggregate for concrete shall be within limits given in the I.S. 383. The fineness modulus may range between 2.0 to 3.0

### **4. Stone Coarse Aggregate: (Metal / Kapchi)**

#### **Quality:**

Coarse aggregate shall consist of crushed black trap stone only. It shall be uncoated hard, strong, dense and durable it shall be free from disintegrated stones, soft flaky and elongated particles, salt alkali, vegetable matter and other deleterious materials and such quantities as to reduce the strength and durability of the concrete or harmful to steel reinforcement.

Deleterious materials	Maximum % by weight	
	Uncrushed	Crushed
Coal and lignite	1.00	1.00
Clay jumps.	1.00	1.00
Soft fragments.	3.00	-
Materials passing 75 micron I.S. sieve.	3.00	3.00

The amount of deleterious materials in coarse aggregate shall not exceed the percentage limits given below and the sum of the percentage of the deleterious material shall not exceed the following limits.

#### **Grading:**

The grading of single sized aggregate and graded aggregate of normal size shall be as per table 11 of I.S. 383-1999 referred below:

I.S. Sieve designation	PERCENTAGE PASSING FOR SINGLE SIZED AGGREGATE NOMINAL SIZE						PERCENTAGE PASSING FOR GRADED AGGREGATE OF NOMINAL SIZE.			
	63 mm	40 mm	20 mm	16 mm	12.5 mm	10 mm	40 mm	20 mm	16 mm	12.5 mm
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
80 mm	100	-	-	-	-	-	100-	-	-	100
63 mm	85 to 100	100	-	-	-	-	-	-	-	-
40 mm	0 to 30	85 to 100	100	-	-	-	95 to 100	100	-	-
20 mm	0 to 5	0 to 20	85 to 100	100	-	-	30 to 70	95 to 100	100	100
16 mm	-	-	-	85 to 100	100	-	-	-	90 to 100	-
12.5	-	-	-	-	85 to 100	100	-	-	-	90 to 100
10 mm	0 to 5	0 to 5	0 to 20	0 to 30	0 to 45	85 to 100	10 to 35	25 to 55	30 to 70	40 to 85
4.75 mm	-	-	0 to 5	0 to 5	0 to 10	0 to 20	0 to 5	0 to 10	0 to 10	0 to 10
2.36 mm	-	-	-	-	-	0 to 5	-	-	-	-

- (a) The maximum size aggregate and gradation there of shall be adopted as directed by Engineer-in-charge for each particular item of work under question.
- (b) Coarse aggregate of a maximum size of 20 mm shall be used where the minimum clear distance between reinforcing bars is one inch i.e. 25 mm.
- (c) The coarse aggregate shall be of such size as shall be retained on mesh 4.75 mm.
- (d) The grading between the limits specified above shall be such as shall product a sense concrete of the specified proportion and consistency that will work readily into without segregation and without the use of excessive water content.

The frequency of test shall be 1 sample test for each 150 m<sup>3</sup> of coarse aggregate or part thereof.

## 5.0 RCC pipes (NP-2 CLASS) :

The NP-2 class pipe shall be reinforced concrete light duty non-pressure pipes conforming to I.S. 458-1991 & its latest revision. The material to be used in manufacturing of pipes shall be as per various I.S. referred in I.S. 458-1991 & its revision. The thickness of the wall shall

be as per I.S. criteria for conforming and inspection for lot of the pipes shall be in accordance with the provision laid down in I.S. 458-1991.

The tolerance in respect of length, diameter and wall thickness for pipes and sockets shall be as per I.S. 458-1991

All requisite test as described in I.S. 458-1991 shall be carried out in presence of Engineer-in-charge and that of authorized person of contractor. The testing charges shall be borne by the contractor.

## **6.0 BRICKS**

6.1 The bricks shall be hard or machine molded and made from suitable soils and kiln burnt. They shall be free from crack and nodules of free lime. They shall have smooth rectangular faces with sharp corner and shall be of uniform color. The bricks shall be molded with a frog of 100mm x 40mm and 10 mm to 20 mm deep on one of its flat sides. The bricks shall not break when thrown on the ground from a height of 600 mm.

6.2 Bricks shall be of regular and uniform size shape and color, uniformly burnt throughout but not over burnt (Slight over burning is acceptable in case of tolerance limit (+/-) 5 percent). They shall be free from cracks or other flaws. The depth of frog on flat face shall be 10 mm. They shall show fine-grained, uniform, homogeneous and dense texture on fracture and be free from lumps of lime, laminations, cracks, air holes, and soluble salts causing efflorescence or other defects. No part of brick shall be under burnt. They shall not break when thrown on the ground on their flat face in a saturated condition from the height of 600 mm.

The testing of bricks shall be done as per I.S. 3495 (Part-I to IV) 1992. After receiving the necessary test results of the bricks, the lot of the bricks, which were found substandard, shall be removed from the site within time specified by the Engineer-in-charge at his own cost.

6.3 The bricks shall be tested in the laboratory of the department or from district Laboratories of Gujarat Engineering Research Institute, Vadodara. Any kind of bricks shall not absorb water more than one sixth of their weight after one hour soaking by immersing in water. The average water absorption shall not be more than 20 % by weight.

6.4 The compressive strength of bricks shall not be less than 35 kg/cm<sup>2</sup>. The water absorption of bricks shall not exceed 20 percent by weight. Frequency of collection and testing of samples of bricks for compressive strength and water absorption test shall be at least one from a lot of 50,000 nos. of bricks or a fraction thereof.

The size of the conventional bricks shall be 222.5 x 105 x 70 mm

The following tolerances shall be permitted.

Length (+/-) 4.0 mm.

Width (+/-) 2.0 mm.

Height (+/-) 2.0 mm.

6.5 Only bricks of one standard size shall be used on one work.

## **7. REINFORCEMENT STEEL & BINDING WIRES:**

### **General:**

All reinforcement bars, plain, tor steel (TMT) etc. specified in item shall confirm to relevant IS standard i.e. IS : 432 for mild steel and medium tensile steel, IS : 1139 for deformed bars,

IS : 1786 for cold twisted bars etc. Wherever tested bars are to be used, certificate for the same from manufacturer shall be submitted. The testing of the reinforcement bar shall also be carried out in the GERI/ Government laboratory/ Govt. Approved Institute as directed by the Engineer-in-charge.

**(a) Plain bars :**

Plain bars to be used shall confirm to IS : 432. The general specification specified above shall be applicable. Re-rolled bars shall not be used. Wherever specified in drawing or where instructed plain bars shall be used.

**(b) Tor steel/HYSD/TMT (FE- 415)/CRS**

The general specifications as specified above shall be applicable. Bars shall confirm to IS : 1608-1995, IS : 432-1982, IS : 1786-2008 and IS 1716-1985.

Bars shall be clean, free from rust, dust, mud etc. If coils are there, they shall be first straightened. Bars shall be cut according to the cutting length specified/approved by department. Bars shall be bent gradually. Bars having crack or splits shall be rejected. Bars shall be bent cold, unless otherwise specified in case of higher diameter bars. If bar is bend wrongly, it should be straightened and re bend such that it does not injure the materials. If contractor, request factory cutting of bars as per design drawing will be permitted by the Engineer-in-charge.

Quantity of reinforcement bars in MT (metric ton) embedded in concrete shall be paid. Weight shall be computed on cutting length approved or given multiplied by standard weight of particular diameter of bars as per IS standards. Work shall have to be carried out as all levels. "Rate quoted shall inclusive of wastages, cost of binding wire etc. No separate payment will be made for binding wire. However laps, dowels etc., shall be paid as per drawing or as approved on site.

For the purpose of payment, the bar shall be measured correct up to 100 mm. length and weight payable worked out at the rate specified below:

1.	6 mm.	0.22 Kg./Rmt.	8.	20 mm	2.47 Kg./Rmt.
2.	8 mm	0.39 Kg./Rmt.	9.	22 mm	2.98 Kg./Rmt.
3.	10 mm	0.62 Kg./Rmt.	10.	25 mm	3.85 Kg./Rmt.
4.	12 mm	0.89 Kg./Rmt.	11.	28 mm	4.83 Kg./Rmt.
5.	14 mm	1.21 Kg./Rmt.	12.	32 mm	6.31 Kg./Rmt.
6.	16 mm	1.58 Kg./Rmt.	13.	36 mm	7.99 Kg./Rmt.
7.	18 mm	2.00 Kg./Rmt.	14.	40 mm	9.86 Kg./Rmt.

**Binding wires:**

The mild steel wires shall be of 1.63 mm or 1.22 mm (16 or 18 gauge) diameter. The use of black wire will be permitted for binding reinforcement bars. It shall be free from rust, oil paint, grease, loose scale or any other coating which may prevent adhesion to cement concrete. The wire coils shall be stored such as to avoid deterioration. No measurement will be taken of the wire used for binding and tying reinforcement bars. The rate for reinforcement steel and it's fabricate shall include the cost of binding wires used for the work. Welding of bars shall only be allowed only after the prior approval of the Engineer-in-charge.

**Testing of Steel:**

Various tests for reinforcement shall be carried out in GERI/ Govt. approved laboratory/ or Govt. laboratory as directed by the Engineer-in-charge and as under:

Frequency for steel testing (Physical properties) are as under as per IS 1786:1985.

Normal Size of bar	Quantity	
	Lot below 100 tonne.	Lot above 100 tonne
Under 10 mm	1 Sample from each 25 tonne	1 Sample from each 40 tonne
10 to 16 mm	1 Sample from each 35 tonne	1 Sample from each 45 tonne
Over 16 mm	1 Sample from each 45 tonne	1 Sample from each 50 tonne

However, the frequency of testing shall be decided by the Engineer-In-Charge as per necessity during the course of execution, but the frequency as mentioned above shall not be increased in any case. i.e. nos. of sampling and testing shall be more than as mentioned above.

For the chemical analysis of steel, the frequency shall be twice in a working season for each diameter bar and Brand and as decided by the Engineer-in-charge. Controlled concrete shall be used for the structures in grades designated as M-15 and M-20 Grade Concrete.

## 8.0 Mix Design

Mix design shall be carried out at GERI/ Government engineering college

- a) The contractor shall prepare mix design of concrete in accordance with IS 456-2000 and relevant codes to achieve desired strength durability and workability and using approved ingredients viz. cement, fine aggregates and water. The ingredients of concrete shall be got tested and approved by the Engineer-in- charge. The contractor shall get approval the mix design thus prepared by him from Engineer-in- charge and only after approval of Engineer-in-charge, the same shall be used for construction.
- b) The Engineer in charge shall check and carry out necessary tests on mix design given by the contractor in accordance with Para (a) above to determine its strength, workability durability as well as economy. For this purpose, the contractor shall submit mix design and its details prepared by him to the Engineer in charge well in advance of commencement of work as directed by the Engineer in charge.
- c) Department reserves right to accept or reject the mix design given by the contractor and also to direct him to use mix design given by Engineer in charge Decision in this regard shall be final and binding to the contractor.
- d) Over and above specified in (a) above, if required Engineer in charge shall make a test to determine the mix proportions required to produce the strength specified with the material to be used in the work. (The necessary ingredients shall be provided to department free of cost by contractor.)
- e) The mix shall be designed using representative samples of approved coarse and fine aggregates as well as cement and water to be made available by the Contractor to the Engineer in charge, to achieve the required workability, cohesion, strength and durability at minimum level of cement. Mix design studies and test will be carried out by the Dep't.
- f) The proportion of mix design ingredients shall be such that concrete has adequate workability for conditions prevailing on the work in question and can be properly compacted with the means available.
- g) During the execution of the work if the source of any ingredient of the concrete changes or in new working season, the Contractor shall inform the Engineer-in-Charge sufficiently in advance so as to allow him to proportion a new mix design to attain the specified strength of concrete. At that time the representative samples of approved ingredient shall be supplied by the Contractor to the Engineer-in- Charge without any extra cost.

- h) The details of mix design including the proportion of each separate size and grading of aggregates and actual cement level required shall be declared to the Contractor in writing by the Engineer-in-Charge.
- i) As a result, if there is any subsequent change in mix design, similarly the same shall be declared.

#### **Strength Requirement of Concrete:**

Ordinary Portland cement grade 53 conforming to IS: 12269 shall be used. The permission of Engineer- in-charge shall be obtained for other grade of concrete. The compressive strength requirements for the various grades of controlled concrete shall be as given in Table.

Grade of Concrete Compressive test strength in N/mm<sup>2</sup> on 150 mm cube in accordance with IS:456-2000

Minimum at 28 Days

<b>Grade of Concrete</b>	<b>Compressive test strength in N/mm<sup>2</sup> on 150 mm cube in accordance with IS:456-2000 Minimum at 28 Days</b>
M10	10
M15	15
M20	20
M25	25
M30	30

In all cases the 28 days compressive strength specified in Table shall along be the criterion for acceptance or rejection of the concrete. Where the strength of a concrete mix as indicated by tests lies in between the strength for the two grades specified in Table, such concrete shall be classified for all purposes as concrete belonging to the lower of the two grades between which its strength lies.

The compressive strength test of concrete shall be conducted on 150 mm x 150 mm x 150 mm molded cube. The design Mix for different classes of concrete to be used will be furnished by the department. Based on these mix proportion and by using the same materials as approved for use in the Structure of works, concrete mixes will be prepared in the Laboratory at frequent intervals and cubes 150 mm x 150 mm x 150 mm will be cast and tested for strength at 7 Days and 28 Days. These strengths shall be deemed as the standard strengths. The strengths shall be deemed as the standard strength.

The strength of test specimens cast from the concrete used on the permanent work shall be determined and these should be not less than 80 per cent of respective Standard strength mentioned above. The testing of cubes will be carried out as per relevant Indian Standard Specifications. 80 per cent of the test specimens shall fulfill the above stipulation. Also, coefficient of Variation shall not be more than 20 per cent. The set of test cubes shall consist of 3 cubes for testing for crushing strength, at 28 days Crushing strength.

#### **Proportioning Concrete:**

Except when it can be shown to the satisfaction of the Engineer-in-Charge that supply of properly graded aggregates of uniform quality can be maintained till the completion of the work, grading of aggregate shall be controlled by obtaining the coarse aggregate in different

sizes and blending them in the right proportions as required. Different sizes, however, shall be stacked in separate stockpiles. Required quantity of material shall be stockpiled several hours, preferably a day, before use. Grading of coarse and fine aggregates shall be checked as frequently as possible, frequency for a given job shall be determined by the Engineer-in-Charge to ensure that the suppliers are maintaining the uniform grading as approved for samples used in the preliminary tests. In proportioning concrete, the quantity of both cement and aggregate shall be determined by weight. Water shall either be measured by volume in calibrated tank or weight. All measuring equipment shall be maintained in a clean and serviceable condition. Their accuracy shall be periodically checked. b). To keep the specified water cement ratio constant as determined by mix design, moisture content in both fine and coarse aggregates shall be pre- determined by the Engineer-in-Charge. The amount of mixing water shall be adjusted to compensate for any variations noted in the aggregate IS: 2386-1977 (Part-III) shall be referred to make suitable arrangement in weight of water. Suitable adjustments shall also be made in the weight of aggregates to allow for variations in weight of aggregates due to variations in their moisture content.

**Mix Design and Testing:**

For Design Mix Concrete the mix design shall be designed according to IS 10262 and SP:23 to provide the grade of concrete having the required workability and characteristics strength less than appropriate values given in IS – 456. The design mix shall be such that it is cohesive and does not segregate and should result in dense and durable concrete and also capable of giving the finish as specified. For water retaining structures, the mix shall be also result in watertight concrete. The contractor shall be exercise great care while designing the concrete mix and executing the works to achieve the desired result.

The cement level for the controlled concrete shall be as under for the purpose of working out the rates to be quoted in Schedule – B

TABLE NO. 1

Resolution No. MIS102010/17/K-1, Dated; 30.07.18



However, depending on the technical requirement various size of aggregate may be required to be used in various components of the structure. In that case, the minimum cement level for various grade of concrete with various size of aggregate shall be as per IS 456-2000.

Actual cement level required for the aggregate to be used shall be determined by tests. The mix proportions shall be selected to ensure that the workability of the fresh concrete is

<b>Sr.No.</b>	<b>Grade of Concrete</b>	<b>Tentative Cement Level required in Kg for one Cubic Meter of Concrete</b> <b>Resolution No. MIS10 2010/17/K-1</b> <b>Dated; 30.07.18</b>
<b>1</b>	<b>2</b>	<b>3</b>
1	1:4:8	170 (Not Applicable for Mix Design)
2	1:3:6 (MSA 40mm)	205 (Not Applicable for Mix Design)
3	1:3:6 (MSA 20mm)	220 (Not Applicable for Mix Design)
4	M-15 (MSA 40mm)	280
5	M-15 (MSA 20mm)	300
6	M-20 (MSA 40mm)	330
7	M-20 (MSA 20mm)	360
8	M-25 (MSA-40mm)	360
9	M-25 (MSA-20mm)	380
10	M-30 (MSA-20mm)	410
11	M-35 (MSA-20mm)	425
12	M-40 (MSA-20mm)	440
13	M-45 (MSA-20mm)	450

suitable for the 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 required strength, durability and surface finish.

A mix shall be designed to produce the grade of concrete having the required workability and cohesiveness and characteristic strength not less than that stipulated in IS 456 -2000. However, due to change in design mix, if it becomes obligatory to use less or more cement per cubic meter of concrete, the Contractor shall do the same without claiming any extra cost for handling and using of cement. The contractor shall have to prepare the concrete mix design for a particular grade of concrete in GERI, Government Laboratory / Government Approved Laboratory as directed by Engineer- in-charge.

A concrete mix shall be designed to produce the particular grade of concrete having the required workability and characteristic strength not less than that stipulated in tender

specification. However, due to change in cement level of design mix, if it becomes obligatory to use more quantity cement per cubic meter of concrete w.r.t. cement level mentioned in above table No.1, the contractor shall do the same without claiming the extra cost for use of more quantity of cement w.r.t. approved mix design,

If due to change in cement level of design mix, it is obligatory to use less quantity cement per cubic meter of concrete w.r.t. cement level mentioned in the above table No.1, the amount (Cost) of quantity of cement used less w.r.t. cement level mentioned in the above table No.1, shall be recovered at **the baserate per metric tonne of cement from the bill/amount to be paid to the contractor.**

The strength requirements of the concrete mixes ascertained on 150 mm cubes as per IS:516 shall comply with the requirements of IS:456. The quantity of water shall be just sufficient to produce a dense concrete of required workability cohesiveness, durability and strength for the job. An accurate and strict control shall be kept on the quantity of water.

In the case of reinforced concrete work, workability shall be such that the concrete surrounds and properly grips all reinforcement. The degree of consistency, which shall depend upon the nature of work and methods of vibration of concrete, shall be determined by regular slump tests. Following slumps shall be adopted for different types of works.

Sr.No.	Type of Work	Slump allowed without any admixture
1	Mass concrete for RCC Raft Foundation, Footing and Retaining wall	45mm to 55mm
2	Pier, Pier Cap, Pedestal, Transition wall	25mm to 45mm
3	Thin RCC Section with congested steel	60mm to 70mm
4	Baffle walls, Chute Blocks and Sills	25mm to 40mm
5	CCLining works	50mm to 75mm

### **Production of Concrete:**

#### **Production of Aggregates**

Production of aggregate may include quarrying of the raw material and processing viz. transporting, crushing, screening and washing. Water used for washing aggregates shall be clean and free from alkali, salts and other impurities. After washing, fine aggregates must be stored in stockpiles with a free draining base for at least 3 days to ensure that aggregates delivered to the batching plant will have reasonably uniform moisture content. The storage and handling shall be in such a manner as to prevent inter-mixing of various sizes of aggregates required separately for grading purposes. No foreign matter shall be allowed to mixed up with the aggregates.

#### **Batching & Mixing plant:**

- a) The Batching and mixing shall be done with On-wheel Batching Plant or digital weighing

system Conventional mixer of required capacity. The prescribed amount of the various materials of concrete including water, cement, admixtures the groupings of fine aggregates and each individual size of coarse aggregate shall be measured and controlled within the specified limits of accuracy. The amount of water, cement and aggregate shall be determined by weighing. In the case of fine aggregates, the surface moisture shall be determined in accordance with the method prescribed in Appendix-D of IS: 456-2000 and its subsequent amendments or publications. In the case of coarse aggregates, percentage of free water shall be determined by weighing a representative sample, then surface drying each particle individually with a clean piece of cloth and reweighing.

- b) The proportion of various materials shall be changed as directed in order to maintain the desired quality of the concrete. The batching equipment shall be so constructed and operated that the combined inaccuracies in feeding and measuring the materials shall not exceed 1 ½ percent for water and cement and 2 percent for each size of aggregate.
- c) The operating performance of each scale or other measuring device shall be checked by standard test weight to be supplied by the Contractor and test weight shall be got calibrated by the Contractor and the test shall cover the ranges of measurements involved in the batching operations. Tests of equipment in operation shall be made at least once every fortnight and adjustments, repairs or replacement, be made as necessary to meet the specified requirement for accuracy of measurement.
- d) Aggregate shall not be batched for concrete or mortar when free water is dripping from the aggregate.
- e) Before the concreting operation start the Contractor shall provide communication facility in the form of wireless, walkie-talkie or telephone between the batching and mixing plant and sites of various concrete placements and got approved by the Engineer-in-Charge. It will be the Contractor's responsibility to keep this system in good and working condition throughout the construction period.

### **Mixing:**

- a) The Concrete ingredients shall be mixed thoroughly in mixers of satisfactory type and size which are so designed as to ensure uniform distribution of all the constituent materials throughout the mass at the end of the mixing period.
- b) The plant shall be so designed and operated that all materials entering the mixer can be accurately proportioned and readily controlled. The entire batch within the mixer shall be discharged before recharging. The volume of mixed materials per batch shall not exceed the rated capacity. A mixer will be considered unsatisfactory, if from three test of any one batch, a change in slump exceeding 25mm or a change in air content exceeding one percent is noticed between representative samples taken at different portions of the mixer discharges.
- c) For any one batch, uniformity of fresh concrete weight of air free mortar of two samples, one taken at the front and one at the end of the mixer discharges, when determined in accordance with the provision of the mixer performance test, the provision test, designation 26 in the Appendix, Concrete Manual-Eight Edition, Revised-1981, United States Bureau of Reclamation, shall not exceed 1.6 percent of the mean value. The adequacy of mixing shall also be determined in accordance with "Method of sampling and analysis of concrete as per

IS: 1199-1959 and its subsequent amendment. Excessive variation on the unit weight of air free mortar indicates that mixing time should be increased. Mixer efficiency tests shall be made at the start of a job or at such intervals as may be necessary to ensure compliance with the requirements for effective mixing. The minimum mixing time specified herein may be reduced if mixer efficiency tests confirm that the reduced time permits satisfactory mixing.

- d) The first concrete batch at the start of continuous mixing operation or after a lapse of 30 minutes in continuous mixing operation shall be made richer by the addition of extra cement as directed.
- e) For any one batch, the difference between the unit weights of coarse aggregate from concrete samples from the front and end of the mixer or mixer discharge, when determined in accordance with the above-mentioned mixer performance test shall not exceed 10 percent of the mean value.
- f) The mixing of each batch shall continue, for not less than the period stated in Table-I of IS: 457 – 1957 unless tests of mixer performance show that variation in the prescribed time is necessary or acceptable. Each mixer shall have a timing device for indicating the completion of the required mixing period
- g) The actual time of mixing shall be checked at least twice during each shift and the timing device shall be adjusted if there is error. The timing device shall be so interlocked with the discharge gate of the batch hopper that the timing does not start until the discharge gate is fully closed and all ingredients are in the drum. A suitable record shall be kept of the average time consumed in charging, mixing and discharging a batch during each run.
- h) The full contents of the drum shall be discharged quickly to avoid segregation.
- i) The minimum mixing periods specified are considered on the materials being fed into the mixer in a manner which will facilitate efficient mixing and an operation of the mixer at its designed speed. The following sequence of charging the mixer be adopted.
  - i. Five to ten percent of the total quantity of water required for mixing, adequate to wet the drum thoroughly, shall be introduced before the other ingredients in order to prevent any caulking of the cement on the blades or sides of the mixer.
  - ii. All dry ingredients (Cement, fine and coarse aggregate) shall be simultaneously fed into the mixer in such a manner that the period of flow for each ingredient is about the same. Eighty to ninety percent of the total quantity of water required for mixing shall be added uniformly along with the dry ingredients.
  - iii. The remaining quantity of water shall be added after all the other ingredients are in the mixer.
  - iv. Portion of the coarse aggregate, however, may be added last. This facilitates clearance of the chutes and removes any fine aggregate or cement adhering to the sides.
- j) Excessive mixing requiring additions of water to preserve the required concrete consistency shall not be permitted. Concrete which has been kept unused for more than 30 minutes after the addition of water shall be rejected
- k) When the mixer is stopped before placing again any ingredients in the mixer, all hardened concrete or mortar shall be removed from the inner surface of the mixer.
- l) The re-tempering of partially hardened concrete or mortar requiring renewed mixing with or without the addition of cement, aggregate or water shall not be permitted. In case of failure of batching/mixing plant / flori machine is allowed only for completion of work up to

joint in canal lining and structure with prior approval of Engineer-In-Charge.

**Temperature of Concrete and Weather Conditions:**

The temperature of concrete at the time of placement shall not exceed 320 C. Concreting operations shall be temporarily suspended during excessively hot weather when the air temperature exceeds 450 C or when conditions are such that the concrete cannot be placed at the required temperature. Wherever necessary, exposed surfaces of fresh concrete shall be adequately shaded to the direct rays of the sun and protected against premature setting or drying by curing under continuous fine spray of water.

**Transporting Concrete:**

- a) Concrete shall be transported from the mixing plant or batch mixer to the placing position by means of transit mixers as rapidly as practicable by methods that will prevent segregation or loss of ingredients or slump loss in excess of 25mm and/or a loss in air content of more than one percent before the concrete is placed in the works. The concrete shall be placed in in position within a period of 30 minutes. Irrespective of haul distance, suitable agitators or transit mixer shall be used for conveying concrete. Conveying concrete by head load shall not be permitted in any case.
- b) If buckets are used for conveying low slump concrete, they shall be capable of promoting discharge in controlled quantities without splashing or segregating and shall be of such capacity that there is no splitting of batches in loading buckets. Buckets shall be of the bottom dump type permitting an even and controlled flow into the forms or hopper without undue splashing or segregation. Conveying vehicles shall be designed to facilitate uniform delivery rather than quick dumping. For major pour use of crane and bucket for placement of concrete particularly in syphon structure will not be allowed where only concrete pumps or belt creates to achieve a minimum rate of placement of 15 to 20 cubic meter/ hour shall be used.
- c) Chutes used for conveying concrete shall be of such size and shapes as to ensure a steady uniform flow of concrete in a compact mass without separation or loss of ingredients and shall be protected from wind and sun where necessary to prevent loss of slump by evaporation and shall be furnished with a discharge hopper. Free fall or drop of concrete shall be limited to 150 cm. Chute section shall be made of or lined with metal and all runs shall have approximately the same slopes not flatter than 1 vertical to 2.5 horizontal. The required consistency of concrete shall not be changed in order to facilitate chuting. Where it becomes necessary to change the consistency, the mix shall be completely redesigned. Wherever there is a free fall within the conveying system, suitable baffle plates, splash boards or down spouts shall be provided to prevent segregation, splashing or loss of ingredients. Wherever it is necessary to hold the discharge end of a chute more than 3 meters above the level of the fresh concrete, a flexible down spout shall be used to break the fall and confine the flow. The lower end of the spout shall be held closed to the place of deposit. Wherever depositing is intermittent, a discharge hopper shall be provided. All chutes shall be thoroughly cleaned before and after each run. All wash water and debris shall be disposed of outside the forms. Use of chutes shall be allowed in exceptional circumstances and adverse placement condition only.
- d) Placement of concrete by pump cranes has made a rapid technological advancement. It is an acceptable method if properly planned and backed with appropriate state of art equipment and accessories. The principal requirement is to achieve requisite workability and strength at the prescribed cement level. Slump is the critical factor in concrete placement by

pumpcretes. In the context of attaining designed strength at the prescribed cement level and at the same time without raising water cement ratio for making the concrete mix workable enough for smooth pumping use of super plasticizers may become essential. If the Contractor chooses to deploy pumpcretes for concrete placement and uses super plasticizers for attaining the required workability within the requisite parameters evolved through mix design studies to the full satisfaction of Engineer-in-Charge, he shall be allowed to do so. Before using super plasticizers necessary approval from the Engineer-in-Charge shall be taken. No extra payment shall be made for such arrangements.

- e) Alternatively, properly designed Belt-cretes capable to cover of one monolith shall be allowed to be used for conveying concrete for placement in the structures. Belt-cretes shall ensure an adequate and steady uniform flow of concrete in a compact mass without any segregation and shall have a discharge hopper with a flexible down spout as to ensure concrete placement as close to the place of deposit as possible and in no case more than about a meter.
- f) Equipment used for transporting concrete from the mixer to the forms shall be maintained free from deposits of stiff concrete and leakage of mortar. Batch containers, transit mixers, agitators, chutes, concrete pumps, pipelines, belts and discharge hoppers shall be thoroughly cleaned after each run. All wash water and debris shall be disposed of outside the forms

### **Preparation for Placing Concrete:**

#### **General Requirement**

- a) Concrete shall not be placed until all form work required is completed, embedded parts, reinforcement if any, installed and checked and surfaces prepared for placing. No concrete shall be deposited until the foundation has been inspected and approved by Engineer-in-Charge/ competent authority.
- b) All surfaces of forms and embedded materials that have become encrusted with dried mortar or grout from concrete previously placed shall be cleaned of all such mortar or grout before fresh concrete is placed.

#### **Foundation surfaces**

- a) In the case of earth or shale foundations, all soft or loose mud and surface debris shall be scraped and removed. The surface shall be moistened to a depth of about 15 cm to prevent the Sub grade from absorbing water from the fresh concrete. Just before placing the concrete, the surface of the earth shall be tamped or otherwise consolidated sufficiently to prevent contamination of concrete during placing. If subsoil water is met with the foundation it shall be dewatered as directed till placing and setting of concrete. All concrete shall be placed upon clean damp surface, free from standing or running water and never upon soft mud, dried porous earth or upon fills that have not been subjected to approved rolling and desired compaction has been obtained
- b) Immediately before placing concrete, all surfaces of foundations upon or against which the concrete is to be placed shall be made free from standing water, mud and debris. The surface of absorptive foundation upon or against which concrete is to be placed shall be moistened thoroughly and kept sufficiently wet for at least 24 hours prior to placing concrete so that moisture will not be drawn from the freshly placed concrete. The cleaning and roughening of the surfaces of rock shall be performed by the use of high velocity air water jets, wet sand blasting, stiff brooms, picks or by other effective means. The washing and scrubbing process

shall be continued until the wash water collected in puddles are clean and free from dirt. In the final cleaning process, the wash water may have to be removed by sponges. If any drilled holes are left in the foundation surface which is no longer needed, the same shall be cleaned with air water jetting and filled up completely with cement slurry.

- c) Foundation of porous or free draining material shall be thoroughly compacted by flushing and by subsequent tamping or rolling if necessary. The finished foundation surface shall then be blanketed with a layer of tar paper or closely woven burlap, carefully lapped and fastened down along the seams so as to prevent the loss of mortar from the concrete.
- d) Before placing the concrete safe bearing capacity of the soil shall be checked.

### **Surface of Construction / Contraction joints**

- a) The surface of construction joints shall be clean, rough and damp but free from standing pools of water when receiving the next lift. Clean up shall comprise removal of all laitance loose or defective concrete, coating, sand, sealing compounds, if used and other foreign materials, if necessary by scraping, chipping or other suitable means. The contraction joints shall be provided at equal distance of not greater than 20 m in canal bed portion or as shown in the drawing.
- b) The surface of construction joints shall be cleaned by green cutting to remove laitance, if the next lift is planned to be placed within 3 to 4 days of the completion of the previous lift. Green cutting shall be done within 8 to 16 hours of laying concrete depending upon temperature, slump etc. If there is delay in placing the next lift, the surface shall be cleaned by wet sand blasting / high pressure water jetting just prior to placing next lift. Utilization of green cutting should be maximized. For effective green cutting, the compressed air pressure should not be allowed to fall below 6.33 kg/cm<sup>2</sup>. The water pressure should be sufficient to bring the water into effective influence of the air pressure. As an approximate estimate, the quantity of compressed air required by the green cutting gun is 2m<sup>3</sup> /second and the quantity of water 273 liters /minute. Without availability of sand blasting equipment in working condition concrete pouring shall not be allowed.
- c) The method used in disposing off waste water employed in cutting, washing and rinsing of concrete surface shall be such that the waste water does not stain, discolor or affect exposed surfaces of the structures. Method of disposal of waste water shall be subject to approval and at the cost of contractor.

### **Placing and Compacting Concrete:**

The contractor shall keep the Engineer advised as to when placing of concrete will be performed. Unless inspection is waived in each specified case by direction from the Engineer, placing of concrete shall be performed only in the presence of an authorized representative of the Engineer. The surface of all rock and concrete against which concrete is to be placed shall be thoroughly cleaned and damped. After the surfaces are prepared satisfactorily, all approximately horizontal surfaces of rock and construction joints shall be covered with a layer of mortar approximately three eighth of an inch (10mm) thick. The mortar shall have the same proportions of water, cement, and sand as the regular concrete of mixture, unless otherwise directed. The water cement ratio of the mortar in place shall not exceed that of the concrete to be placed upon it, and consistency of the mortar shall be suitable for placing and working in the manner hereinafter specified. The mortar shall be spread and shall be worked thoroughly into all irregularities of the surface. Concrete shall be placed immediately upon the fresh mortar.

In placing concrete against formed construction, joints, the surface of the joints where accessible, shall be coated thoroughly with brooms dipped in the fresh mortar. Where it is

impracticable to apply such mortar coating, special precautions shall be taken to ensure that the new concrete is brought into intimate contact with the surface of the joint by careful puddling and spading with the end of suitable tools.

Retempering of concrete will not be permitted. Any concrete which has become so stiff that proper placing cannot be assured shall be wasted. Concrete shall be deposited in all cases as nearly as practicable, directly in its final position and shall not be caused to flow such that the lateral movement will permit or cause segregation of the coarse aggregate from the concrete mass. Methods and equipment employed in depositing concrete in forms shall be such as will not result in clusters or groups of coarse aggregate particles being separated from the concrete mass, but if clusters do occur, they shall be scattered before the concrete is vibrated. A few scattered individual pieces of coarse aggregate that can be restored into the mass by vibration will not be objectionable.

Except as intercepted by joints, all formed concrete shall be placed in continuous approximately horizontal layers, the depths of which generally shall not exceed 50cms (20 inches). the engineer reserves the right to require lesser depths of layers, where concrete in 50cms (20 inches) layers cannot be placed in accordance with the requirements of these specifications. All intersections of construction joints with concrete surfaces which will be exposed to view shall be made straight and level or plumb. Construction joints shall be allowed only at places as directed by the engineer.

In reinforced concrete work, the thickness of the layer shall be reduced to 150 mm to 300 mm (6" to 12") or as directed. In congested parts, care shall be taken to see that all the bars are properly embedded and that no voids are left. On flat horizontal surfaces, whether the congestion of steel near the forms makes placing difficult, a mortar of the same cement, sand ratio as is used in the concrete shall be first deposited to cover the forms.

In placing uniformed concrete on slopes so steep as to make internal vibrating of the concrete impracticable without form work, the concrete shall be placed ahead of non-vibrated slip-form screed extending approximately 2 and ½ feet (75cm) back from its loading edge. Concrete ahead of the slip- form screed shall be compacted by internal vibrators so as to assure complete filling under the slip form.

If concrete is placed monolithically around openings having vertical dimensions greater than 2 feet (0.6m), or if concrete is for decks, floor slabs, beams, girders, or other similar parts of structure is placed monolithically with supporting concrete, the following instructions shall be strictly observed:

- i. placing of concrete may be delayed from 1 to 3 hours at the top of openings and at the bottoms of bevels under docks, floor slabs, beams, girders, or other similar parts of structures when bevels are specified and at the bottom of such structural members when bevels are not specified but in no case shall the placing be delayed so long that the vibrating unit will not readily penetrate of its own weight, the concrete placed before the delay. When compacting, concrete placed after the delay, the vibrating unit shall penetrate and revibrated the concrete placed before the delay.
- ii. The last 2 ft (0.6 mt) or more of concrete placed immediately before the delay shall be placed with as low as slump as practicable and special care shall be exercised to affect thorough compaction of the concrete.



- iii. The surface of concrete where delays are made shall be clean and free from loose and foreign material when concrete placing is started after the delay.
- iv. Concrete placed over openings and in decks, floors, beams girders, and other similar parts of structures shall be placed with as low a slump as practicable and compaction of the concrete. The contractor shall not be entitled to additional payment over the unit price bid in the schedule for concrete by reason of any limitations in the placing of concrete required under the provisions of this paragraph.

### **Compaction:**

Concrete shall be compacted to the maximum practicable density so that it is free from pockets of coarse aggregate and entrapped air, and closes snugly against all surface of form embedded materials. Compaction of concrete in structure shall be by petrol /diesel driven or electric or pneumatic drive, immersion type vibrators. Concrete vibrators shall be operated at least 7,000 rpm when immersed in the concrete. Forms vibrators where used shall be rigidly attached to the forms and shall operate at speeds of at least 8000 rpm when vibrating concrete.

In compacting each layer of concrete, the vibrator shall be operated in a nearly vertical position and vibrating head shall be allowed to penetrate and re-vibrate the concrete in the upper portion of the underlying layer. Layers of concrete shall not place until the layers previously placed have been worked thoroughly as specified. Care shall be exercised to avoid contact of the vibrating head with surface of the forms or displacing reinforcement or embedded metal. Large void or air pockets which may be left in the permanently exposed faces of the structure by vibration shall be eliminated by systematically speeding the face with an appropriate flat tool.

Excessive vibration causing segregation or tending to bring an excessive amount of water to the surface shall be avoided. Cobbles and coarse aggregate protruding from the surface of the life shall be embedded into the mass during the initial compacting and vibrating operations. Surface vibrators or peddlers shall not be used except for wearing coat for the roadway.

Disturbance of the surface concrete at a construction joint during the early stages of hardening shall be avoided. Necessary traffic on new concrete shall be on timber walkways constructed so as not to cause injury to the concrete. For formed concrete surface which are to be exposed to high velocities of water, special precautions shall be taken to prevent or to minimize surface pitting without resorting to over-manipulation of the concrete next to the form.

Inadvertent or intended re-vibration of some concrete is beneficial provided the concrete become momentarily plastic again during re-vibration. Re-vibration shall be resorted to only after specific instructions are given by the Engineer.

### **Formwork:**

#### **General**

- a) The forms for concrete work shall have sufficient strength and rigidity to hold and withstand the pressure of fresh concrete during compaction including live load and shaped to the required line within the tolerance specified. The tolerances specified are for finished concrete and not for the forms. Where the character of the natural material cut into to

receive a concrete structure, is such that it can be trimmed to the prescribed lines, the use of forms shall not be required. All exposed concrete surfaces having slopes of two horizontal to one vertical or steeper shall be formed.

- b) Forms shall be used wherever necessary to confine the concrete and shape it to the required lines or to ensure against contamination of the concrete by material caving in or sloughing from adjacent surface left by excavation or other features of the work. All exposed concrete surface having slope steeper than two horizontals to one vertical shall be formed.
- c) Formwork may be of plywood, timber, steel or precast concrete panels or of such other suitable materials or combination of such materials. Formwork shall be substantially and rigidly constructed to the shapes, lines and dimensions required, efficiently propped and braced to prevent deformation due to placing, vibrating and compacting, other incidental loads or the effect of weather. If settlement or deflection of forms under the load of fresh concrete is to be expected, allowance should be made in the original construction of the forms so that the finished lines and dimensions of the structures are in accordance with those specified on the drawings. The bamboos for formwork shall be straight and in one piece. The form work for concrete shall be designed, treating concrete as a fluid, weighing 150lbs/cuft. (2400 kg/cu.mt) addition a live load of 50 Lbs/sq. ft (245 kg/cu.mt) on horizontal projection of the surface shall be used. The supports shall be so arranged as to keep the maximum deflection within 1/360 of the span. Forms shall be designed and constructed to permit early removal without injury to the concrete. Suitable devices shall be used to hold corners, adjacent ends of panels of other forms together in accurate alignment during compaction of concrete by vibration or other means. The forms and their joints shall be tight enough to prevent, while vibrating, the loss of mortar from concrete. The ties and bracings as may be necessary shall be attended to. Forms to be used more than once shall be maintained in serviceable condition and shall be clean, smooth and free from adhering grout before being reused. Curved and special forms shall be of a character that will result in smooth concrete surfaces. They shall be designed and constructed so that they will not warp or swell during erection or placing of concrete.
- d) The surface of form work shall be made such as to produce surface finishes as specified and form work joints space be tight enough to prevent loss of liquid or bleeding from concrete. Joints between the form work and existing concrete structures shall also be grout tight. Formwork shall be arranged to facilitate easing and removing of the various parts in correct sequence, without jarring or damaging the concrete. Fixing blocks, or bolts similar devices may be embedded in the concrete, provided they do not reduce the strength or effective cover of any part of the structure below the required standard. But the use of through bolt shall be avoided as far as possible. Temporary opening shall be provided at all points necessary in the forms to facilitate cleaning and inspection immediately before placing of the concrete.
- e) Form shall overlap the hardened concrete in the lift previously placed by not less than 75 mm and shall be tightened snugly against the hardened concrete. Particular attention shall be paid in setting and tightening the forms for construction joints so as to get a smooth joint free from sharp deviations or projections.
- f) Molding strips shall be placed in the corners of forms so as to produce chamfered edges as required on permanently exposed concrete surface.
- g) The formwork for various types of vertical R.C.C. members i.e. retaining walls, counter forts,

bridge piers side walls, abutment walls or any vertical wall shall be carried out as per drawing or any equivalent arrangement approved by Engineer-in-Charge shall be used. Formwork shall not allow any exposure of corrosive material after removal of formwork. The shuttering arrangement for that consisting of through bolts (either replaceable or non-replaceable) or reinforcing bolts, washer which shall be confirming to IS: 1786-1985. It will come in direct contact with water, soil or any aggressive atmosphere which will ingress on corrosion of reinforcement and ultimately lead to the deterioration of concrete which is not permitted. It shall be consisting of projecting cores H.D.P.E (High Density Polyethylene Extrusion) which shall be confirming to IS: 7328-1974 and P.V.C. IS: 10515-1982 or any latest published code. After concreting work is completed the bolt shall be removed and the hole left in concrete shall be filled in accordance with the provision of repair of concrete as per Para 5.15.

**Material to be used:**

- a) Material used for form sheathing and lining shall conform to the following requirements.

Required Finish	Timber Sheathing or lining	Steel Sheathing or lining
F1	Any type of grade timber meeting the dimensional requirement of surface finish except that metal forms shall be used on surface of internal transverse and longitudinal joints in mass concrete gravity walls.	Steel sheathing permitted steel lining permitted exact on surface of internal transverse and longitudinal joints in the structure component where steel sheathing is required.
F2	Common grade timber or plywood or plywood sheathing or lining.	Steel sheathing permitted steel lining permitted if strongly supported.
F3	For plain surface common grade timber or better timber sheathing or plywood.	Steel sheathing permitted steel lining not permitted
F4	For warped surface timber which is free from knots and other imperfections and which can be cut and bent accurately to the required shape without splintering or splitting.	Steel sheathing permitted Steel lining not permitted

**Note:**

- Steel sheathing denotes steel sheets not supported by a backing of timber boards; steel lining denotes steel sheets supported by a back of timber boards.
- Timber sheathing or lining shall be of such kind and quality or shall be so treated or coated that there will be no chemical deterioration or discoloration of the formed concrete surfaces. The type and condition of form sheathing and lining and the ability of forms to withstand distortion caused by placement and vibration of the concrete, and the workmanship used in the form construction shall be such that the formed surface will conform to applicable requirements of this specification pertaining to finish off formed surfaces.
- Forms for concrete surface required to receive F2 and F3 finishes shall be constructed so as to produce uniform and consistent texture and pattern on the concrete faces. Metal patches

on forms for these faces shall not be permitted. The form sheathing or lining shall be so placed that all horizontal form marks are continuous across the entire surface. Where finish F2 is specified the sheathing or lining shall be placed so that the joint marks on the concrete surface shall be in general alignment both horizontally and vertically and the form sheathing material used for such surfaces shall be restricted to one type in any one major feature of the work.

- d) Forms for surfaces required to receive F4 finish shall be constructed so as to confirm accurately to the required curvature of the section. Where necessary to meet requirements for curvature, the form sheathing shall be built up of laminated splices cut to make right, smooth form surface. The forms shall be so constructed that the joints marks on the concrete surface shall in general, follow the line of water flow. After the forms have been constructed, all surfaces imperfections shall be corrected, all the nails shall be hidden and any roughness and all angles on the surface of the forms caused by matching the forms materials shall be dressed to curvature.
- e) If temperate hard wood is used as form lining, it shall be continuously supported with timber or plywood.
- f) Embedded ties for holding forms shall remain embedded and except where F1 finish is permitted they shall terminate not less than two diameters or twice the minimum dimension of the tie or ten millimeters whichever is greater, from the formed faces of the concrete. Where F1 finish is permitted, ties may be cut off flush with formed surface.
- g) The ties shall be constructed so that removal of the ends or end of fasteners can be accomplished without causing appreciable spelling at the faces of the concrete. Recesses resulting from removal of the ends of the form ties shall be filled in accordance with the provision for repair of concrete as per relevant para.

#### **Form, Centering and Temporary works.**

- a) The basic requirements of good formwork are strength, rigidity and conformity to design and geometrical shapes. The formwork shall be properly designed to withstand the loads coming over it. The formwork shall also be firm and rigid. It shall be so strong that at the time of vibration of concrete it does not get out of alignment and does not allow any mortar or water to leak from the gaps. It should be so designed that it can be finely adjusted in lines and levels and can be removed gradually by wedging action. Form oil shall be applied to facilitate easy removal of formwork without damaging the concrete surface. In short, formwork shall be given due importance in the concrete work. As far as possible only steel formwork shall be used.
- b) Timber formwork can be used where special shapes are to be formed and where repetitive use is not feasible. Plywood of good quality should be used or wood should be lined with G.I sheeting. Green or wet timber shall not be used. If, the formwork has been in use for some time, its surfaces shall be checked for geometrical shape. Defect if any, shall be corrected before use.
- c) All centering, formwork and temporary works shall be constructed according to the approved drawings and specifications. The IS:883-1970"Code of practice for design of structural timber in building" shall be applicable for this work.As soon as practicable, after the acceptance of his tender, the Contractor shall submit a scheme showing the order of precedence and method by which he proposes to carry out work, together with such details as are necessary to demonstrate the adequacy, stability and safety of the methods.
- d) The approval to the general scheme of centering as well as design criteria and loading shall be obtained in good time to facilitate all preparatory works. Any delay on this account shall

be the responsibility of the Contractor.

- e) After approval of the general scheme, the Contractor shall prepare detailed design and drawings for execution of the formwork, centering and temporary work. These shall be forwarded to the Engineer- in-Charge for approval. No work shall be carried without prior approval of the Engineer-in-Charge.
- f) Notwithstanding to the approval given to the design criteria and loading and the general scheme for the centering, the entire responsibility for the satisfactory execution of centering and all temporary works shall rest with the Contractor and he shall be liable to pay all claims and compensation arising from any loss or damage to life and property due to deficiency, failure or malfunctioning of the centering or the temporary works.
- g) Forms required to be used more than once shall be maintained in serviceable condition and shall be thoroughly cleaned and repaired before reuse. Where metal sheets are used for lining forms, the sheets shall be placed and maintained in the forms without lumps or other imperfections. All forms shall be checked for shape and strength before reuse.
- h) The Contractor shall procure minimum two sets of the formwork for walls and slabs.

**Scaffolding:**

The scaffolding, hoisting arrangements and ladders etc. required for the facility of concreting shall be provided and removed on completion of work by the contractor at his own expenses. The scaffolding hoisting arrangement and ladders etc. shall be strong enough to withstand all live, dead and impact loads expected to act and shall be subject to the approval of the Engineer-in-charge. However, contractor shall be solely responsible for the safety of the scaffolding, hoisting arrangement, ladders work and workman etc. and a certificate from the supervisory Engineer of the contractor for its safety shall be furnished by the contractor before approval of scaffolding by the Engineer-in-charge. The scaffolding, hoisting arrangement and ladders shall allow easy approach to the work spot and offer easy inspection.

**Cleaning and Treatment of Forms**

At the time the concrete is placed in the forms, the surfaces of the forms shall be free from encrustations of mortar, grout or other foreign materials. Before concrete is placed, the surfaces of the forms designated to produce F1, F2, F3, and F4, finishes shall be oiled with commercial form oil that will effectively prevent sticking and will not stain the concrete surface. For timber forms, form oil shall consist of pure refined pale paraffin mineral oil or other approved form oil. For steel forms, form oil shall consist of refined mineral oil suitably compounded with one or more ingredients which are appropriate for the purpose. Care shall be taken to keep form oil out of contact with reinforcement.

**Removal of Forms**

- a) Except or otherwise, provided in this sub clause forms shall be removed as soon as the concrete has hardened sufficiently, thus facilitating satisfactory specified curing and earliest practicable repair of surface imperfections. Forms on upper sloping surface of concrete, such as forms on the water sides of warped transition, shall be removed as soon as the concrete has attained sufficient stiffness to prevent sagging. Any needed repair or treatment required on such sloping surface shall be performed at once and be followed immediately by the specified curing.

- b) In order to avoid excessive stresses in the concrete that might result from swelling of the forms, timber forms for wall openings shall be loosened as soon as this can be accomplished without damage to the concrete.
- c) Subject to approval, forms on concrete surface close to excavated rock surface may be left in place provided that the distance between the concrete surface and the rock is less than 400mm and that the forms are not exposed to view after completion of the works.
- d) Forms shall be removed with care so as to avoid damage to the concrete. Concrete damaged if any in form removal shall be repaired in accordance with the provisions for repair of concrete as per
- e) Minimum strength to be attained by concrete for safe removal of forms
- f) Concrete not subjected to appreciable bending or direct stress nor reliant on forms for vertical support nor liable to injury from removal or other construction activities, vertical or approximately vertical surface of thick section-500 psi (35 kg/sq.cm.)

Concrete subjected to appreciable bending and for direct stress and partially reliant on forms for vertical support.

- (i) Subject to dead load only, surfaces of unloaded Columns, walls, beams, and other than sections (750 PSI at three day)
- (ii) Subject to dead and live loads, galleries, loaded columns and walls. (1500 PSI at three day)
- (iii) Roof or floor slabs, walkways, platforms etc., press and not on boards (2000 PSI at 20 days).
- (iv) Heavily reinforced beams, bridges, lock and girders and other heavily reinforced thick section wholly reliant on forms for vertical support (2500 PSI at 20 days).
- (v) In normal circumstances and where ordinary cement is used, form may be struck off after expiry of following period.
  - 1. Side walls of Beams : 28 to 48 hrs
  - 2. Removal of beam soffits(Props left under) : 7 days
  - 3. Removal of props slab
    - Spanning up to 4.5 mt :7 days
    - Spanning over 4.5 mt :14 days
  - 4. Removal of props of beams and arches
    - Spanning up to 6 mt :14 days
    - Spanning over 6 mt : 21 days
- g) The period given above in brackets are approximate and for rough guidance. The removal of forms should entirely be based on the minimum strength specified varies widely under different job conditions of temperature, materials and curing etc.
- h) Procedure when removing the form work:All form work shall be removed without such hook or vibrations as would damage the reinforcement concrete surface. Before the soffits and struts are removed, the concrete surface shall be exposed where necessary in order to ascertain that the concrete has sufficiently hardened.
- i) Re-Use:
 

Before use all form shall be inspected by the Engineer-in-charge and their suitability ascertained. The forms shall be scarred. Cleaned and joints, repaired where required. Inside surface shall be retreated to prevent adhesion of concrete.

## **SPECIALIZED FORM WORK:**

Specialized form work may be required in the case of slip form work under water concreting, segmental construction etc. Such specialized form work shall be designed and detailed by competent agencies and design shall be certified by qualified Structural Engineer under his Signature and Seal and a set of complete work drawing and installation instruction shall be supplied to the Engineer. The site personnel shall be trained in the erection and dismantling as well as operation of such specialized form work. In case proprietary equipment is used the supplier shall supply drawing details, installation instructions, etc. in the form of manuals along with the form work. Where specialized form work is used close co-ordination with the design of permanent structure is necessary.

For slip form the rate of slipping the form work shall be designed for each individual case considering various parameters including in the grade of concrete, concrete strength, concrete temperature, ambient temperature, concrete admixtures etc. In the case of segmental construction, the concrete mix shall be normally designed for developing high early strength so that the form work is released as early as possible.

In order to verify the time and sequence of striking/removal specialized form work, routine field tests for the consistency of concrete and strength development are mandatory and shall be carried out before adoption.

For specialized formwork, the form lining material may be either plywood or steel sheet of appropriate thickness. Plywood is preferably where superior quality of surface is desired, whereas steel sheeting normally used where large number of repetitions are involved.

## **Finishing:**

- a) General: The concrete surface shall be termed as formed or unformed. Both types of surface shall be finished by skilled workmen. The concrete surface shall be tested as detailed below and compared with the tolerance fixed. The surface irregularities shall be classified as either 'abrupt' or 'gradual' Offsets and fins caused by displaced or misplaced form sheathing, lining or form section by loose knots in forms or by otherwise defective form number shall be classified as 'abrupt' and tested by direct measurement. Others shall be template as 'gradual' irregularities and measured with a template as 'gradual' irregularities and measured with a template consisting of a straight edge for plain surface or its equivalent for curved surface. The length of the template will be 5 ft. (1.5m) for formed surface and 10 ft. (3.0m) for unformed surface. All exposed surface shall be cleaned of all unsightly encrustations or stain.
- b) Formed Surfaces: Surface having slopes steeper than two horizontals to one vertical shall be formed. The classes of finish for formed concrete surface are designated by the use of symbols F1, F2, F3 and F4. Unless otherwise specified or indicated on the drawings, the classes of finish shall apply as follows:

F1 – Finish: F1 applies to formed surface upon or against which backfill or concrete is to be placed or which will otherwise be permanently concealed. The surface requires no treatment after form removal, except removal and repair of defective concrete and the specified curing. Correction of surface irregularities will be required only for depressor greater than 1 inch. Form sheathing may be anything that will not leak mortar when concrete

is vibrated. Form may be built with minimum of refinement.

F2 – Finish: F2 applies to all formed surface not permanently concealed by backfill or concrete except surface for which finish F3 or F4 is specified. This would apply to all galleries, structures and to other permanently exposed surface for which other finish are not specified. Surface for which finish F2 is specified will need no filling of pits or sack rubbing and no grinding other than that needed for repair of surface imperfection. Surface irregularities, shall not exceed ¼ inch (6mm) for abrupt irregularities and ½ inch (12mm) for gradual irregularities.

F3 – Finish: F3 applies to all formed surface. This shall be applicable for surfaces or structures permanently exposed to public view when appearance is of special importance such as parapets, spillway piers, interior and exterior walls of hoist elevator towers and other decorative features. No general stoning or grinding will be required on surfaces for which Finish F3 is specified, although in some cases conspicuous air holes shall be filled by sack rubbing. Surface irregularities shall not exceed 1/8 inch (3 mm) for abrupt irregularities and ¼ inch (6 mm) for gradual irregularities. Irregularities exceeding these limits shall be reduced by grinding with no.60 carborundum stone or sand grinder to a level of 1 to 20 ratio of height to length. Immediately after removal of form work from surfaces for which F3 as required, sack rubbed mortar finish, as described below, shall be given to fill up the air holes and to remove difference in colour, if any, due to use of excess oil on forms and rust stains after completing all patching, cleaning operations and correction of major imperfections.

F4– Finish: F4 applies to formed surfaces where accurate alignment and evenness of surfaces are essential for prevention of destructive effect of running water e.g. it applies to hydraulic surfaces. Such surfaces include spillway crest, spillway face, spray wall, part of divide wall exposed to running water, intake for canals, outlet for canals, energy dissipation for outlet works, in late structures, spillway face, except where special finish is required. In addition to any necessary repairs, surface treatment will consist of the grinding of offsets and bulges on a level of 1 to 20. Gradual surface irregularities shall not exceed ¼ inch (6mm).

Special Finish: This finish shall be applied to star risers, and other important places where especially smooth and even surface is required. Forms from the vertical surfaces where the special finish is required, shall be removed between 12 to 24 hours after completion of concreting and all required patching and repair of major imperfections shall be done. Then the entire surface shall be wetted with a brush and rubbed with a hard-wood float, dipped in water containing two pounds of Portland cement per gallon of water (0.2 kg of cement per liter). Rubbing shall be continued, until all form marks and projections are removed. Wood float rubbing shall be timed in such a way, that the aggregate grains should not be dislodged nor so late, that the surface is too hard to be readily dressed. Curing of the surface shall be continued till the completion of the curing period of concrete. The grindings from the rubbing operations shall be uniformly spread over the entire surface with a brush in such a manner as to fill all pits and small holes. The brushed surface shall be allowed to harden and shall then be kept moist for at least 3 days. The final finish shall then be obtained by rubbing with a carborundum stone of no.50 grit until the entire surface has a smooth texture and is uniform in colour.

Unformed Surfaces: The classes of finish specified for unformed surfaces are designated as U1, U2 and U3. Unformed surfaces exposed to weather and those which would normally be horizontal shall be sloped for drainage. Unless otherwise indicated, on drawings or ordered, narrow surfaces such as the top of walls and curbs shall be sloped 3/8" per foot (30.0 mm per meter) of width and broader surface such as roadways, platforms and decks shall be sloped ¼" per foot, (20 mm per meter). Concrete having unformed, exposed surface shall



contain just enough mortar to avoid the necessity for excessive floating. Collection of excess mortar at the surface after thorough compaction should be avoided and any fine materials or excess mortar worked up to the top should be removed. No dry cement nor a mixture of dry cement and sand shall be sprinkled directly on the surface to stiffen the mix. Use of finishing tools in areas where water has accumulated should be prohibited. Operations on such areas should be delayed for nearly 30 to 40 minutes until the water is absorbed, has nearly 30 to 40 minutes until the water is absorbed, has evaporated, or is removed by draining or other means. The finish shall be brought to a smooth surface free from defects and blemishes. Working of the surface of the various finishing operations should be the minimum necessary to obtain the desired finish.

**Finish U1:** Finish U1 shall apply to unformed surface finished by screening. This finish shall be done for all concealed surface such as floor which will be covered concrete floor topping and for surface requiring roughness such as road surface. This is also used as the first stage for finish U2 and U3. The finishing operations shall consist of leveling and screening the concrete to produce an even uniform surface and surface irregularities of more than 3/8" (10.0 mm) shall not be permitted.

**Screed Finish:** Wherever feasible, electrically operated vibrances shall be used. After the concrete is thoroughly vibrated, finishing pass of the vibrating screed should follow with the vibrator running at low frequency. The finishing pass shall be made with the screed sliding along the forms and shall be performed by skilled workmen.

Wherever wooden or metal screed is used, it should be removed back and forth across the concrete with a skewing motion and advanced forward a short distance with each movement with some excess concrete against the front face of the screed. This will facilitate filling of low portions of concrete to the desired surface as the template passes over. Metal edged screed should be used where minimum tearing of surface is desired.

**Finish U2:** This is a floated finish and shall be used for spillway bucket, exposed face of Spillway Bridge, floors of galleries, surface of gutters and similar another outdoor unformed surface. Floating shall be done either by vibrancies or metal edged screed. The concrete surface shall be left undisturbed for 30 to 45 minutes until all surface water has disappeared and there is no visible seen. Minimum floating necessary to produce surface uniform in texture and free from screed marks, should be done. Wherever finish U3 is to be applied the floating should leave, small amount of mortar without excess water at the surface to permit effective troweling. Any necessary cutting or filling should be done during the floating operations. Joints and edges shall be finished with steel edging tools. Surface irregularities shall not exceed 1/4 inch (6 mm).

**Finish U3:** This is troweled finish and shall be applicable to unformed surface permanently exposed to view such as top of parapets, stair treads and gallery floors. When the floated surface has stiffened sufficiently to prevent excess of fine material or free water being drawn to the surface, steel troweling shall be started and too long a delay in troweling should be avoided as the surface will become too hard for finishing. Steel troweling shall be performed with a firm pressure that will flatten and smoothen the sandy texture left by floating and the troweling should produce, dense, uniform surface, free of blemishes, surface irregularities more than 1/4" (6 mm) and trowel marks. For this regular U3 finish shall be troweled again after the surface is nearly hardened, using glossy appearance. When the concrete surface has hardened sufficiently, initial curing shall be done by gentle spraying of water, taking care to protect the finished surface.

**Preventing hair cracks:**

Hair cracks are usually the result of concentration of water and fines at the surface caused by over- manipulation during and by too rapid drying or cooling. When the humidity is so low as to cause cracking of the finished surface before it can be covered without damage, the surface should be moistened and kept moist temporarily with a very fine spray of water supplied so as not to wash the surface nor form pools on it. Since chilling of the green concrete increases its tendency to crack, it is desirable that the water used for preliminary moistening not be cooler than and should preferably be warmer than concrete.

**Curing protection:**

All concrete shall be protected against injury until final acceptance. Unhardened concrete shall be protected from heavy rains and flowing water. No fire or excessive heat shall be permitted near or in direct contact with concrete at any time. Exposed finished surface of concrete shall be protected from the direct rays of the sun for at least the first three days after placement. Such protection shall be made effective as soon as practicable after placing of unformed concrete or after the removal of forms from formed concrete. Exposed finished surface of concrete shall be protected from the direct rays of sun for at least 72 hours after placement. Concrete shall be kept continuously moist for not less than 21 days. Construction joints shall be cured in the ways as other concrete and shall also be kept moist for at least 72 hours prior to the placing of additional concrete upon the joints. Approximately horizontal surface shall be cured by sprinkling or by covering by damp sand, or may cured by covering with mats. If damp sand is used for curing, it shall be removed completely later. Water curing shall be used on all concrete works. It shall be applied by means of sprays or sprinklers.

Forms shall be kept sprinkled until removal. The contractor shall protect all concrete against injury until final acceptance by the engineer.

**Repairs of concrete:**

Repair of concrete shall be performed by skilled workers. All imperfection of the concrete shall be corrected as necessary to produce smooth surface. Repairs of imperfections in formed concrete shall be completed as soon as practicable, within 24 hours after the removal of forms. Concrete that is damaged from any cause, concrete that is honey-combed, fractured or otherwise defective and concrete, which because of excessive surface depressions must be removed and replaced by dry pack mortar or as hereinafter specified.

Dry filling shall be used for holes that have surface dimensions smaller than the depth of hole, such as for holes left by the remover of fasteners from the ends of form, tie rod for grout, insert holes and for narrow slots, out for repair of cracks. Filling of holes left by removal of fasteners from the ends of the tie rods in the surface, for which finish F1 is specified, will not be required. Dry pack shall not be used for filling behind reinforcement or for filling holes that external completely through a concrete section.

Mortar filling, placed under impact by use of mortar gun, shall be used for holes too wide dry pack filling and too shallow for concrete filling and no deeper than the far side of the reinforcement that is nearest concrete surface.

Concrete filling shall be used for holes extending through concrete sections, for holes which are greater in area than one square foot (0.1 Sqmt) and deeper than 4 inches (0.1 m), and for holes, in reinforced concrete, which are greater in area than one half square foot (0.05 Sq. mt) and which extend beyond reinforcement. All materials, procedures and operations

used in the repair of concrete shall be subject to direct by the Engineer. All filling shall be bounded tightly to the surface of the hole and shall be sound and free from shrinkage, cracks and drumly areas after the filling has been cured and dried. All filling in surface for which finish F3 specified shall contain sufficient white Portland cement to produce the same colour as that of the adjoining concrete.

All patching shall be with extreme care, so that patches will not be noticeable from a distance of 75 ft (25mt). Colored cement as an ingredient of the patching mortar may be used if necessary, to produce patch of same colour as the adjoining concrete.

**Signature of Contractor**