

SECTION - II
CONCRETE WORK

1.0 GENERAL

1.1 Standard

Work shall be carried out to Indian Standards and Code of Practices. In absence International Standards shall be followed. These shall be latest issue. List given hereunder is not to be considered as conclusive and is for reference and guidance only. Any discrepancies / conflict noticed shall be directed to the PM for his direction/approval. However, as a general rule more stringent specification shall take precedence.

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| (1) | IS 269 | Specification for Ordinary and low heat, portland cement |
| (2) | IS 8112 | Specification for 43 grade ordinary portland cement |
| (3) | IS 12269 | Specification for 53 grade ordinary portland cement |
| (4) | IS 383 | Specification for Coarse and fine aggregates from natural sources for concrete |
| (5) | IS 456 | Code of practice for plain and reinforced concrete |
| (6) | IS 460 | Specification for test sieves (Part I, II & III) |
| | | i) Wire cloth test sieve |
| | | ii) Perforated plate test sieve |
| | | iii) Method of examination of test sieves |
| (7) | IS 515 | Specification for natural and manufactured aggregates from natural sources for concrete. |
| (8) | IS 516 | Method of test for strength of concrete |
| (9) | IS 875 | Design loads for building structure. |
| | | (Part I, II, III) |
| (10) | IS 1199 | Method of Sampling and analysis of concrete |
| (11) | IS 1791 | Batch type concrete mixers |
| (12) | IS 1893 | Earthquake resistant design. |
| (13) | IS 2386 | Method of test for aggregate for concrete (Part I, II & III) |
| | | i) Particle size and shape |
| | | ii) Estimation of deleterious materials and organic impurities |
| | | iii) Specific gravity, density, voids, absorption and bulking. |

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| (14) | IS 2505 | General requirements for concrete vibrators |
| (15) | IS 2645 | Specification for Integral cement waterproofing compound |
| (16) | IS 3025 | Methods of Sampling and test (Physical and Chemical for water) |
| (17) | IS 4326 | Code of practice for earthquake resistant design and construction of building. |
| (18) | IS 4926 | Specification for ready mixed concrete |
| (19) | IS 7861 | Code of practice for extreme weather concreting |
| | i) | Recommended practice for hot weather concreting |
| | ii) | Recommended practice for cold weather concreting |
| (20) | IS 9103 | Specifications for admixture for concrete |
| (21) | IS 12118 | (Part I)

Specification for two parts polysulphide based sealant : general requirements |
| (22) | SP 23 | Handbook on concrete mix |
| (23) | SP 24 | Explanatory handbook on Indian Standards code for plain and reinforced concrete (IS 456) |
| (24) | SP 27 | Handbook of method of measurement of building works |
| (25) | IS 1489 | Specification for Portland pozzolana cement |
| (26) | IS 2430 | Methods for sampling of aggregates for concrete |
| (27) | IS 3812 | Specification for fly ash use as Pozzolana and admixtures |

1.2 Quality Assurance

- 1.2.1 Concrete used on site shall comply to relevant parts of Standards, Codes of practices, technical specification given in particular or approved, designed mixes as prepared, approved and adopted for works to give designed strength, serviceability, long term durability etc.
- 1.2.2 Provide and monitor quality control over materials received from suppliers / manufacturers to ensure that materials comply with standard specified and are as approved.
- 1.2.3 Provide experienced full-time supervision on execution of work to ensure that workmanship is of specified quality and standard.
- 1.2.4 Work shall not be subjected to harmful, dangerous, damaging or deleterious exposures while it is in progress or on completion during contract period.
- 1.2.5 Contractor to undertake quality assurance and quality control rigorously by documenting. To create confidence and to ensure satisfactory working, a definite plan, tasked, responsibilities of all persons involved along with

adjust controls / checks shall be in place in force and shall be documented as under.

- ☐ Test report for material used in producing concrete.
- ☐ Mix design details with laboratory test report, actual site trial mix test and accepted modified design if any
- ☐ Pour cards with approval of the PM prior to placement
- ☐ Records of site inspection of workmanship, field test.
- ☐ Quality Control charts
- ☐ Statistical Analysis
- ☐ Non-conformance reports, changes, orders etc.

1.2.6 It is important that a closed supervision on following activities during progress of production / placing of Concrete are provided

- ☐ Manufacturing of concrete
- ☐ Transporting
- ☐ Pumping / placing through buckets etc.
- ☐ Placing at location including vibrating and leveling
- ☐ Curing

are utmost important & attended including documenting as noted above

1.3 Submittals

1.3.1 Submit samples of all materials such as cement, sand, aggregate, admixtures, water etc. to be incorporated into concrete along with test certificates from recognised laboratories for the PM approval.

1.3.2 Samples

During construction, the materials shall be sampled and tested as often as directed by the PM to the contractor. Samples shall be taken and tested in accordance with latest revisions of Indian standard specifications and the cost thereof shall be borne by the Contractor.

1.3.3 Shop Drawings

Contractor shall prepare and submit method made of casting of slabs, beams with details of construction and expansion joint for approval of the PM.

1.4.0 Examination of conditions

Contractor shall inspect and examine sub stratas and confirm prior to start that.

- ☐ Substrate is acceptable and approved by PM
- ☐ Conditions are satisfactory
- ☐ Setting out/Layout is verified
- ☐ Corrective measures needed if any are within reach and contractor proceeds with full responsibility for work.

2.0 MATERIALS

2.1 Cement

Cement shall be ordinary Portland cement conforming to IS and shall be of grade 53/43 for structural use or as specified in drawing.

Portland Pozzolana (fly ash or Blast furnace slag blended conforming to IS) shall be permitted.

The cement selected shall be appropriate for the intended use.

It shall be received in bags of 50 kg or loose in tankers and each batch shall be accompanied with a test certificate of the factory. Also it shall be tested before use to ascertain its strength, setting time, etc. In case cement has been stored for over 3 months or for any reasons the stored cement shows signs of deterioration or contamination, it shall be tested as per the direction of the PM prior to use in the works.

2.2 Coarse aggregate

2.2.1 Coarse aggregate shall be obtained from natural sources such as stone, gravel, etc. crushed or uncrushed or a combination thereof from approved quarries. Aggregate shall be hard, strong, dense, durable, clean and free from veins and adherent coatings. It shall be free from soft, feeble, thin, elongated or laminated pieces and shall be roughly cubical in shape. It shall consist of coarse material, 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.

2.2.2 Coarse aggregate shall not contain any harmful material such as iron, pyrites, coal, mica, shale or similar laminated material; neither shall it contain clay, alkali, soft fragments, sea shells, organic impurities, etc. in such quantities that adversely affects the strength and durability of the concrete. In addition to the above, in reinforced concrete the aggregate shall not contain any material which might attack the reinforcement. The maximum quantities of deleterious materials in the coarse aggregate, when determined in accordance with IS 2386 Part I and Part II "Method of test for aggregates for concrete" shall not exceed the limits laid down in IS 383.

2.2.3 Aggregate crushing value, impact value, abrasion value and soundness of aggregate shall respectively be in accordance with IS 383.

2.2.4 Grading of coarse aggregate shall be in conformity with the requirements laid down in IS 383.

The grading of coarse aggregate shall be such that not more than 5% shall be larger than the maximum size and not more than 10% shall be smaller than the smallest size. Between these sizes the coarse aggregates shall be well graded.

For heavily reinforced concrete the aggregate shall be subjected to tests in accordance with IS 2386 or as directed by the PM.

The maximum size of coarse aggregate should not be greater than one fourth of the minimum thickness of the member and it should be restricted to 5 mm

less than the minimum clear distance between the main bars or 5 mm less than the minimum cover to the reinforcement.

- 2.2.5 Source of aggregate shall be from an approved Government location. It shall be tested prior to the approval of the PM from an approved testing laboratory. In case available aggregates do not meet certain requirements of IS 383 or any other specification, required processing shall be carried out by the contractor at his cost. No extra cost towards these processes, treatment or combination of both shall be paid. It shall be the duty of the contractor to make sure that aggregate material received by him is from Government approved quarries and with fully paid royalties, taxes, duties, etc. as may be in force from time to time for respective locations.
- 2.2.6 Coarse aggregate shall have a minimum specific gravity of 2.6. (Saturated surface dry basis). Aggregate below this specific gravity shall not be used without the special permission of the PM.
- 2.2.7 Once a specific source of supply of coarse aggregate is approved, the source shall not be changed without the prior approval of the PM.
- 2.3 Fine aggregate
- 2.3.1 Natural sand deposited by stream or glacial agencies as a result of disintegration of rock shall be used as fine aggregate. Fine aggregate shall pass through 4.75 mm sieve in total. Crushed sand may be added to natural sand in approved proportions to achieve required grading. The fine aggregate shall conform to following standards.
- (i) For plain and reinforced concrete IS 383 Specification for coarse and fine aggregates from natural sources for concrete.
 - (ii) Mortar and grout IS 2116 Specification for sand for masonry mortars.
- 2.3.2 Sea sand shall not be used unless special approval by the PM in is given in writing. If approved, the required treatment shall be done at the contractor's cost.
- 2.3.3 Sand shall be hard, durable, chemically inert, clean and free from adherent coatings and organic matter and shall not contain any appreciable amount of clay and pellets. Sand shall not contain harmful impurities such as iron, pyrites, salts, coal particles, lignite, mica shale or similar laminated material, alkali, and organic impurities in such form or quantities as to affect the strength or durability of concrete or mortar. Also, it should not contain any material liable to attack the steel reinforcement.
- 2.3.4 When tested as per IS 2386 Part I and Part II, fine aggregate shall not exceed permissible quantities of deleterious materials as given in IS 383.
- 2.3.5 Fine aggregate shall be thoroughly washed at site with clean fresh water such that the percentage of all deleterious material is within the permissible limits laid down. Fine aggregate containing more than allowable percentage of silt shall be washed so as to bring the silt content within allowable limits for which nothing extra shall be paid.

- 2.3.6 Grading of fine aggregate shall conform to IS and shall fall within limits of one of the four zones given in IS 383.
- 2.3.7 Due allowance for bulking due to damp and moist sand shall be made while preparing the mixes based on volume measurements. It shall be determined as per IS 2386.
- 2.4 Water
- 2.4.1 Water used for mixing and curing shall be clean, reasonably clear and free from objectionable quantities of silt, oils, alkalies, acids, salts, sugar so as not to weaken mortar, or concrete or cause efflorescence or attack the steel in RCC while curing. It shall be free of elements, which significantly affects the hydration reaction or otherwise interferes with hardening of concrete during curing or those elements which produce objectionable stains or deposits. Potable water is generally satisfactory, but it shall be tested prior to use in the works.
- 2.4.2 Water tested shall be in accordance with IS 3025. Maximum permissible limits of solids in water as given in Table Cl. No. 4.4 of NBC.
- 2.4.3 Suitability of water shall be ascertained by the compressive strength and initial setting time test as specified under:
- a) Average 28 days compressive strength of atleast three 15 cm concrete cubes prepared with water proposed to be used shall not be less than 90% of the average strength of three similar concrete cubes prepared with distilled water. Preparation and testing to be in accordance with IS 516.
 - b) The initial setting time of test blocks made with proposed cement and water to be used shall not be less than 30 minutes and shall not differ by ± 30 minutes from the initial setting time of control test block prepared with the same cement and distilled water. Preparation and testing of block shall be in accordance with IS 4031.
- 2.4.4 The PH value of water shall not be less than 6 and more than 9.
- 2.4.5 Water shall be tested and approved in writing by the PM prior to use in the works.
- 2.4.6 Sea water
- Sea water in concrete shall not be permitted unless specifically approved in writing by the PM for purpose stated. The PM, under unavoidable circumstances, may allow mixing or curing by sea water in concrete construction which are permanently under sea water.
- 2.5 Admixture
- 2.5.1 Chemical Admixture
- 2.5.1.1 These are substances other than cement, aggregate and water shall be permitted to be used to modify workability ease while manufacturing and placing at site. It is important that these shall not impair durability of concrete, form harmful compound or risk of corrosion of reinforcement. These shall be used at the cost of the contractor.

- 2.5.1.2 The workability, compressive strength and the slump loss of concrete with or without the use of admixture shall be established during the trial mixes before of admixtures.
- 2.5.1.3 Where two or more admixtures are used in simultaneously in mix data shall be obtained to assess their compatibility prior to permission for use.
- 2.5.1.4 The relative density of liquid admixtures chloride content of each batch of drum received shall be tested prior for acceptance.
- 2.5.1.5 The amount of admixture added to a mix shall be recorded. Redosing of admixture in principle not permitted. If additional dose of admixture added at project site, it shall be mixed adequately in mixer itself to achieve workability. This shall be done with mutual consent of employer and contractor. In all cases a specific record of the same shall be maintained.
- 2.5.2 Mineral Admixtures
- a) Mineral admixtures are used to facilitate specific purpose to be achieved at execution site. It is advisable and recommended to use them with due care and preferably at batching plant location to ensure uniform blending of addition with cement is done. Following are approved are
- i) Fly ash (pulverised fuel ash)
 - ii) Silica fume
 - iii) Metakaolin
 - iv) Ground Granulated Blast Furnace Slag
- b) These shall be used as part replacement to ordinary Portland cement and shall conform accepted standard.
- Use of mineral admixture shall be done only after sufficient actual trial.
- Compability of Chemical admixture
 - mixing time
 - workability and setting time
 - Plastic shrinkage cracking
 - Rate of gain of strength
 - Finishibility
- c) Use of blended cement with mineral admixture shall be avoided, in case of must rigorous trials for suitability of concrete shall be made and specific approval of structural consultant obtained.
- d) Rice husk is not permitted and hence not included.
- 2.5.3 Admixtures generally in use are classified as under:
- a) Accelerators
 - b) Retarders
 - c) Workability agents

- d) Water repelling agents
- e) Air-entraining agents
- f) Gas-forming agents
- g) Corrosion inhibitor additive

These are manufactured and sold by various companies under brand names. The contractor proposing to use any one of them shall submit to the PM technical literature with its chemical composition, purpose of use and method recommended by the manufacturer and what he proposes to follow at site for strict control.

2.5.4 The contractor's proposal shall accompany the followings with his request to use admixture.

- a) The trade name of the admixture, its source and the manufacturer's recommended method of use.
- b) Typical dosage rates and the possible detrimental effects of under and over-dosage.
- c) Whether the admixture contains chloride in any free form or any other chemical present as an active ingredient which is a likely cause of corrosion of reinforcement or deterioration of concrete.
- d) The average expected air content of freshly mixed concrete containing an admixture which causes air to be entrained when used at the manufacturer's recommended rate of dosage.

2.5.5 The Polycarbonate based admixtures compatible with mineral admixtures, fine & coarse aggregates, cement, fly ash etc. shall be used for high performance concrete.

2.6 Miscellaneous

2.6.1 Integral cement water proofing compound specified for specific use shall conform to IS 2645.

2.6.2 Bituminous felts for water proofing and damp proofing course shall conform to IS 1322.

2.6.3 Bituminous compounds for water proofing purposes shall conform to IS 1580.

2.6.4 Expansion joint filler

Bituminous impregnated pre-moulded preformed expansion joint filler board conforming to IS 1838 part (I) specification for preformed filler boards shall be of approved quality and thickness at designated locations.

2.6.5 Polysulphide sealants

- 1 Expansion, construction or other joints shall be sealed with approved quality polysulphide sealants.
- 2 One-part gun grade polysulphide-based joint sealants shall conform to IS 11433 (Part I). It shall be used with the approval of the PM and

as per the manufacturer's instructions. Correct primer shall be used at the specified location.

- 3 Two-part polysulphide based sealant gun grade or pouring grade shall conform to IS 12118 (part I). Pouring grade shall be used in horizontal joints. Gun grade shall be used in vertical, inclined and horizontal joints. Specified primer shall be applied prior to the use of sealant. Use of sealant shall be as per instructions of the approved manufacturer.
- 4 Sealant shall be cured at ambient temperature and humidity when applied as per the approved manufacturer's instruction and received in suitable packs. Each package shall indicate
 - ☐ Manufacturer's name and trademark
 - ☐ Weight of the components
 - ☐ Instructions for storage
 - ☐ Type and grade of sealants
 - ☐ Date of manufacture and expiry
 - ☐ Instructions for use

2.6.6 Water bar

PVC or rubber or swellable water bar of type, quality and width shall be used as approved by the PM. Water bar shall be continuous and fixed at the indicated locations. Water bar should be welded or joined with the approved method. All angles and corners shall be purpose-made and shall be joined with the approved method.

2.7 Delivery and Storage

- 2.7.1 Cement shall be received at site in bags of 50 kg as packed confirming to IS bearing the manufacturer's name or his registered trademark, grade of cement, type of cement and each batch shall be accompanied with a test certificate of the factory. Reject damp or torn bags.

Cement shall be stored in dry and waterproof shed so as to prevent deterioration due to moisture, dampness. Bags shall be stacked on rigid water-proof platforms about 15 to 20 cm clear above the floors, bags shall be stacked at least 45 cm clear or away from the surrounding walls and in rows of two bags leaving in a space of at least 60 m between two consecutive rows. A maximum high stack of 10 bags permitted. Stacks shall be so arranged that the first batches are used first, (FIFO) and that they permit easy access for inspection and handling.

Different types of cement shall be stacked and stored separately.

Loose cement received shall be stored in Silo's. Silo's shall be equipped to receive cement by pump and manually. Silo's shall be watertight and damp proof to keep cement fresh.

2.7.2 Coarse Aggregates and Fine Aggregates

Aggregate shall be stored in such a way that it does not get mixed with mud, dust, grass, vegetables and other foreign matter. The best way is to have a hard surface platform made out of concrete, bricks or planks. It should be to the approval of the PM.

2.7.3 Water

Water storage tanks shall be such as to prevent any deleterious materials getting mixed with it.

2.7.4 Covered storages

Considering the atmospheric/ weather conditions at site storages, covering shall be arranged to take care of temperature controls at site.

2.8 FLY ASH

2.8.1 It is compulsory to use fly ash in concrete for RCC and PCC.

2.8.2 Fly ash used for cement concrete shall be conforming to IS 3812. Physical and Chemical requirements of fly ash shall be confirming to IS. Moisture content of fly ash shall be as specified by the Structural Consultant / PM. Testing of fly ash shall be carried out according to IS 1727.

2.8.3 Fly ash shall be stored in such a way to permit easy access for inspection and identification of each consignment. Manufacturer or supplier of fly ash has to furnish certificate for standard of fly ash. The consignment shall also mark with the Standard Mark

3.0 CONCRETE

Concrete is prepared by mixing graded aggregate of stone or brick aggregate of nominal size as specified along with cement, in a specified proportion with required quantity of water. Mixing shall be done by a mechanical mixer. Manual hand mixing shall be permitted in specific cases with the written permission of the PM on account of small quantity or location or any other reason acceptable to the PM.

3.1 Cement concrete

This shall be classified as plain cement concrete or reinforced cement concrete. Plain cement concrete shall be in leveling course under foundations, floors, copings, etc. and shall include form work as part of the work.

Reinforced cement concrete shall be at all locations and comprises form work, reinforcement and concrete. Payment of reinforced cement concrete may be composite or item wise as specified in the BOQ. In PCC, payment for form work shall not be made.

3.1.1 Concrete shall be classified by its compressive strength at the 28th day. The concrete grades shall be as designated in IS 456.

3.1.2 Design mix

Design mix concrete is that concrete in which the design of mix i.e. the determination of proportions of cement, aggregate and water is arrived as to have target mean strength for specified grade of concrete.

BOQ shall specify various types of concrete aimed to be used in works. It shall be the responsibility of the contractor to carry out design mixes and approval of the same shall be obtained from the PM at least 35 days in advance from the actual pouring of concrete at site in the permanent works.

1. Mix design of concrete shall be done as per IS 10262 & SP 23, 24. Following basic points shall be finalised.
 - ☐ Characteristic compressive strength of concrete at 28 days and targeted compressive strength required at design stage.
 - ☐ Standard deviation factor based on site actual execution conditions.
 - ☐ Minimum cement specified by the structural consultant or as per IS for strength and durability for location where concrete is to be used.
 - ☐ Water cement ratio permitted by IS.
 - ☐ Workability to be achieved for better workmanship and good quality concrete
 - ☐ Admixtures to be used if any
 - ☐ Aggregates being used are tested to IS383. Include for Alkali reactivity, chloride and sulphate contents independently and combination of cement and water.
 - ☐ Water being used is tested.

Further the contractor shall ensure that designed mix meet minimum cement contents as specified in BOQ/drawings and proposed revision to IS 456 along with maximum water cement ratio, to different exposure condition from durability point of view. In addition, contractor shall ensure

a) Alkali - reactivity

Aggregates containing material susceptible to attack by alkali's (Na_2O and K_2O) originating from cement or other sources and producing expansive reaction shall not be used.

The aggregates source shall be initially tested for alkali reactivity prior to being used in design mix.

b) Sulphate and chlorides in concrete

Harmful salts coming from the concrete materials such as cement, aggregate, water and admixture, as well as by diffusion from environments shall be limited to following weight of cement.

- ☐ Total chlorides (as Cl) - 0.15 %

□ Total soluble sulphate (as SO₃) - 4 %

3.1.3 Compressive strength

For expected strength of cubes tested on the 28th day, the design mix at preliminary test and work site shall be as per IS 456-2000.

3.1.4 Water cement ratio

The water-cement ratio shall be between 0.42 to 0.55. Additional water may be permitted only at the discretion of the Structural Engineer. The slump shall depend upon the location and type of work. Higher slump with use of plastisizers shall be permitted.

3.1.5 Trial mixes

3.1.5.1 The contractor shall submit, at least 5 weeks in advance, to the PM the mix design that he proposes to use at site. The mix design in addition to points in 3.1.2 shall also give basic details (when tested according to IS 1199 and IS 2386-Part III 1963), as per followings

- a) Slump/Workability
- b) Bleeding
- c) Compacting factor
- d) Vee-Bee time
- e) Cement required for one cubic meter of concrete
- f) Wet and dry density
- g) Air contents if applicable

3.1.5.2 On receipt of this, the PM may immediately order to carry out work site test before the final approval. This shall be done with mixer and materials actually being used at site.

This shall give the contractor additional chance to check for himself actual workability and make sure that the mix proposed by him will be fully satisfactory with regards to slump, segregation, bleeding, water-cement ratio and workability.

6 cubes shall be taken from each of the 3 batches to test the mix. Cubes shall be cast, stored, cured, transported and tested to IS 516. The test may be carried out at site or laboratory as approved by the PM.

Trial mixes shall be approved provided that average strength of 3 consecutive cubes is not less than that specified and that one out of three may give a value less than specified but limited to a maximum of 90% of the specified strength.

3.1.5.3 In case the trial mix falls below the above criterion, the PM shall order fresh trial mixes to be made as before, until the desired strength is arrived at.

3.1.5.4 This design mix and trial mix hold good so long as the materials continue to be of the same quality and from the same sources. For any change, the PM may order fresh design mix and trial mixes to be carried out before the same is used at site.

3.1.6 Mixing of concrete

3.1.6.1 Machinery and equipments.

a) Batching

Batching shall be done by weigh batchers conforming to IS 2722. A platform scale of capacity 300kg with fraction upto 100gms shall be at site.

For water supply to mixture through metering system shall be organised.

Design mix converted to volumetric may be permitted by PM. Accordingly suitable size of boxes equivalent to 1 bag of 50kg cement shall be prepared by the contractor.

b) Mixer

Mixers used shall conform to IS. Type Capacity shall be as per size, extent and nature of work.

c) Transportation

Wheel borrows, cranes, mini dumpers, truck, agitators, belt conveyors, pumps with piping etc. as per requirement depending upon location, size extent and nature of work shall be deployed by the contractor with prior approval of the PM.

d) Vibrators

Internal and external vibrators working on electricity, Pneumatic or petrol shall be approved by the PM. Vibrators shall conform to IS.

e) All machineries and equipments shall be maintained regularly. Periodic calibration of all machines shall be done and records maintained in a register. As and when requested by the PM same shall be forwarded for his inspection.

3.1.6.2 At the start of mixing mixer shall be rinsed /coated by loading with cement, sand, water of the same proportion of batch to be used. Loading the mixer/charging the mixer shall be done mechanically and care to be taken that all material is fully loaded.

The mixer shall be run for a minimum period of 2 minutes after all materials are loaded in full quantity. The concrete produced shall be uniform in colour and consistency. Unless agreed by PM the first batch of concrete from mixer shall contain two-third of normal quantity of coarse aggregate.

3.1.6.3 Transportation

Concrete shall be transported to place of pour as far as possible in most efficiently, conveniently and without loss of concrete characteristic. Method of transportation shall depend upon the location, size and nature of work. Concrete should be placed within ½ hour of production i.e. prior to initial set as designed at lab for extra retention time where needed.

Use of admixtures shall be adopted and incorporated into design mix stage based on purpose, location and properties expected.

Concrete shall be kept in agitating state when ambient temperatures are high. This shall increase placing time to 1 ½ hrs after water is added.

Points to be taken care are

- ◆ Method adopted do not permit segregation
- ◆ Containers used are leak proof
- ◆ Containers are well covered during rains, heavy winds
- ◆ Concrete does not get contaminated by oil, dirt etc.

3.1.6.4 Placing

The placing temperature of concrete shall not be more than 34° C. If it is more, the PM may order addition of ice or chilled water to the concrete. Also the contractor shall take the following precautions:

- a) Mixers and weigh batchers shall be painted with white colour
- b) Aggregate storing bins shall not be exposed to the Sun
- c) Water shall be sprinkled on aggregates well before concreting to keep the temperature low.
- d) Use chilled water for mixing or add flake ice as a proportion of the mixing water.
- e) Place concrete at night.

3.1.6.5 Ready mix concrete (RMC)

- a) Concrete

Ready mix concrete as approved only shall be used. It shall comply all requirements of concrete. Batching plant, mixture, truck mixture, pump etc. shall conform to relevant Indian standard. Daily returns shall be provided showing total volume of each class of concrete received.

- b) Pumping of concrete

Stationary or mobile pumps as per requirements shall be deployed. Concrete shall be continuous to avoid any blockage within pump. Concrete mix shall be with slump as desired by pump manufacturer and most desirable at site to pump operator / supervisor.

Required piping, bends, clamps, chutes etc. shall be well organised and placed in position prior to start so continuous concrete with minor changes will keep concrete flowing at predetermined location in approved manner.

Mix design adopted shall be approved by PM and shall conform all test as detailed in specification.

Pump concrete shall flow quite fast and is placed with larger impact on formwork. Hence special precautions at design stage of formwork shall be taken and staging/scaffolds should be well restrained in all directions to withstand thrust.

Pumping shall be done with due care and safety. Recommendation of pump suppliers shall be followed strictly.

c) Field control

Sampling at both truck discharge and point of final placement shall be employed to determine if any changes in the slump and other significant mix characteristics occur. However, for determining strength of concrete, cubes shall be taken from the placement end of line.

d) Planning

Proper planning of concrete supply, pump locations, line layout, placing sequence, and the entire pumping operation shall be made and got approved. The pump should be as near the placing area as practicable, and the entire surrounding area shall have adequate bearing strength to support concrete delivery pipes. Lines from pump to the placing area should be laid out with a minimum of bends. For large placing areas alternate lines should be installed for rapid connection when required. Standby power and pumping equipment should be provided to replace initial equipment, should breakdown occur.

The placing rate should be estimated so that concrete can be ordered at an appropriate delivery rate.

As a final check, the pump should be started and operated without concrete to be certain that all moving parts are operating properly. A grout mortar should be pumped into the lines to provide lubrication for the concrete, but this mortar shall not be used in the placement. When the form is nearly full, and there is enough concrete in the line to complete the placement, the pump shall be stopped, and a go-devil inserted and shall be forced through the line by water under pressure to clean it out. The go-devil should be stopped at a safe distance from the end of the line so that the water in the line will not spill into the placement area. At the end of placing operation, the line shall be cleaned in the reverse direction.

3.1.7 Shrinkage cracks

Concreting shall be avoided in very warm weather. If necessary, it shall be covered with damp hessian within 2 hours of placing of concrete.

To achieve good results the concrete shall be immediately covered with a plastic sheet and not allowed any direct wind contact. This shall eliminate shrinkage cracks.

3.1.8 Laying of concrete

- a) Concreting shall commence only after form work is approved, reinforcement is recorded and permission to proceed with concreting has been approved in writing from the PM.
- b) Form work should be clean, free from sawdust, pieces of wood or any other foreign material. It should have been treated by form releasing

agent prior to the laying of reinforcement and concrete. Prior to placing concrete against old concrete, masonry, rock all loose materials shall be removed, and surfaces washed down. Concrete shall be worked around ties and bond and in open joints.

- c) Concrete shall be as gently deposited as is practically possible, in its final position to avoid rehandling and shall be so deposited that segregation of aggregates does not occur. In case of deep trenches and footings, it may be done with the help of a chute. Columns and walls shall be so adjusted in form work so that maximum depth is 1.5 meter unless consented to by the PM. Concrete from wheelbarrows shall not be dumped away from the face of concrete already in place. It shall be dumped into the face of concrete already in place. In excavations prevent contamination of earth and concrete without disturbing unsupported sides of excavation. Concrete shall not be placed in water except where specified.
- d) Concrete onto a sloping surface shall be discharged by providing a chute with a baffle and a drop at its end so that the concrete remains on the slope.
- e) Column and walls shall be concreted in one operation to their full height to avoid any horizontal construction joint as far as possible.
- f) All slabs, beams, wooden planks, and catwalks shall be provided clear of reinforcement.
- g) Concrete shall be placed in position within 30 minutes from the time it is produced. Concrete shall be laid during normal working hours. No concrete shall be laid within half an hour of the closing time of the day, unless permitted by the PM. Concreting at night or on holidays shall be permitted only on the written approval of the PM.
- h) Placing in each section shall be a continuous between construction joints. The contractor shall make provision for standby equipment. In case of delay or break down stop ends are to be provided or concrete placed to be removed as per direction of the PM.
- i) Placing shall not take in open during storms or rains, strong winds. Contractor to organise and provide required protection.

3.1.9 Compaction of concrete

Concrete shall be thoroughly compacted as depositing shall proceed by means of suitable vibrators. The vibrators shall maintain the entire concrete under treatment in an adequate state of agitation and shall continue during the whole period occupied by placing of concrete. Care shall be taken not to over-vibrate the concrete. While withdrawing needles no holes should be visible in concreting. Compaction shall be completed before the initial setting time. Concrete already set shall not be disturbed by successive vibrations. 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.

It shall be ensured that the needle vibrators are not applied on reinforcement which may destroy the bond between concrete and reinforcement.

When electric vibrators are in use, the standby petrol vibrator must always be available at the concreting point.

3.1.9 Construction joints

In large pours, it is practically not possible to carry on concreting continuously. Hence construction joints shall be provided. Location of construction joint shall be submitted by the contractor for approval of the PM. Such joints shall be kept to a minimum. The joints shall be at places where shear force is nil or minimum and these shall be straight and at right angles to the direction of the main reinforcement. Preferred locations shall be accessible permitting cleaning out of laitance cement slurry and unsound concrete.

Stop ends provided shall be with necessary slots for reinforcement bars to pass freely without bending or any other obstruction. Also, a trapezoidal fillet nailed on stop board shall be provided to form a regular keyed joint. Joints shall be straight and truly vertical or horizontal. Inclined or feather joints shall not be permitted.

Before commencement of concrete, adjacent concrete stopper and surfaces shall be chipped and roughened to expose aggregate, then thoroughly cleaned with wire brush. The concrete surface shall be sprayed with water for 24 hours before casting and kept wet until casting.

True horizontal joints shall also be provided with a keyed joint by inserting plained greased timber.

Prepared joint shall be treated as above prior to the start of fresh concreting.

For vertical joints neat cement slurry shall be applied on the surface just before concreting. For horizontal joints, the surface shall be covered with a layer of mortar about 10 to 15 mm thick composed of cement and sand in the same ratio as the cement and sand in the concrete mix. This layer of cement slurry shall be freshly mixed and applied just before concreting, fresh concrete should be thoroughly vibrated near junction to develop proper bond.

3.1.10 Expansion joints

Expansion joints shall be formed and located as detailed in the drawing. Insert sealant to completely fill the joint and finish neat and smooth.

3.1.11 Curing

Curing of concrete is most important. There shall be no compromise on this activity and it is for the contractor to arrange for everything necessary to make sure that the concrete is cured to the complete satisfaction of the PM. As said above in clause 3.1.8, after concrete has begun to harden i.e. about 1 to 2 hours after laying, it shall be protected from quick drying with moist or damped hessian cloth, gunny bags, sand or any other material approved by the PM. After 24 hours of laying of the concrete, the surface shall be cured by flooding with water or covering with damp hessian cloth for a period of 7 days to keep it moist.

For the next 7 days the surface shall be kept wet all the time by sprinkling water continuously.

For membrane curing, details as listed in 12.5 of SP 24 shall be followed.

3.1.12 Finishing

Concrete shall be finished keeping in mind the next operation to be carried out over the surface. For guidance the following points shall be noted but the PM shall be consulted prior to start of concreting and his decision in this regard shall be final.

- a) Roof slab shall be troweled even and smooth with a wooden float.
- b) The surface that will receive plaster shall be roughened immediately.
- c) Surfaces that will be in contact with any masonry work shall be roughened immediately.
- d) The surface that will receive mosaic floor or IPS or any other type of tiled work shall be roughened while it is green. Every care shall be taken not to disturb the freshly laid concrete.
- e) For dust proof (or hardened) finish, clean the concrete surface of oil and contamination and apply approved dust proof hardener as per manufacturer's instructions.

3.1.13 Inspection and corrective measures

- 3.1.13.1** On placing of concrete next day or 1st opportunity it shall be physically inspected preferably jointly by Engineer and Contractor. Till such time, no remedial measures shall be carried out by the contractor. Concrete is duly leveled, free of cracks, bulging, honey combed. All patching, rectification or chipping shall be done only on the PM 's instructions. In case of any violation of this rule, the concrete poured stands rejected. The decision of the PM in this regard shall be final and binding on all parties.

Sagged, bulged, patched, honeycombed work shall stand to be rejected for surfaces that are exposed, or require fairface finish or decorative textured finish. The PM may permit any work found structurally safe and areas of unexposed faces, for repairing. As directed by the PM these works shall be retained and the cost of repair shall be at the contractor's account.

- 3.1.13.2** Cracks observed shall be brought to the notice of the PM who shall examine them. It shall be kept under observation and a record shall be maintained for a period of 45 days. It shall be shown to the Structural Engineer and the following procedure shall be followed:-

- a) Cracks not developing further and in the opinion of Structural Engineer not detrimental to the strength of the construction shall be grouted with non-shrinking cement slurry or as directed by the PM.
- b) Cracks developing further and, in the opinion of the Structural Engineer, detrimental to the strength of construction, shall be tested as per the relevant Indian standard.
- c) Based on results of the test, the PM in consultation with the Structural Engineer shall order remedial measures or order the

contractor to dismantle construction, cart away the debris, replace the construction and carry out all the consequential works thereto.

- d) Cost of the above shall be borne by the contractor if the failure was on his part. In case it is due to design faults, it shall be borne by the employer.
- e) The decision of the PM in this matter shall be final and binding on all parties. This decision shall not be open for arbitration.

3.1.14 Testing

3.1.14.1 Quantum of cubes and testing

The minimum frequency of cube casting shall be as follows. Each sample shall consist of 6 cubes.

Concrete quantity		Number of Samples.
Upto 5 cu m in a day	:	1
5 cu m to 15 cu m	:	2
15 cu m to 30 cu m	:	3
30 cu m to 50 cu m	:	4
More than 50 cu m	:	4 + one additional per each 50 cu m or part thereof

Three cubes shall be tested on the 7th day and other three cubes on the 28th day.

3.1.14.2 Field Tests

It is the responsibility of the contractor to prepare and get the cubes tested and to provide all the material, labour, moulds, equipment, casting and curing facility, charges for testing, etc.

Further, the contractor shall have to provide and maintain all the equipment and staff at the site throughout to carry out the following tests in a small laboratory or get these tests from approved laboratories without extra cost to the contract.

- a) Grading of coarse and fine aggregates
- b) Silt content of sand
- c) Moisture content of coarse and fine aggregates
- d) Slump test of concrete
- e) Concrete cube test

3.1.14.3 The contractor shall maintain and produce full records of all above tests in a register. The format of records shall be prepared in consultation with the PM and either he or his representative shall have full access to the contractor's laboratory.

The contractor shall include charges for the above work in his rates and no extra whatsoever shall be admissible on this account of designing, testing, maintaining laboratory, etc.

3.1.15 CURING AND PROTECTION

The contractor shall submit the curing media and methods to be used for review 30 days before concrete placement begins.

3.1.15.1 Curing Time

All concrete shall be cured by one of the following methods or combination of methods for the period of time given below corresponding to the cementing materials used in the concrete:

- 53 Grade Portland cement 7 days
- 53 Grade Portland cement in combination with silica fume. 7 days
- 53 Grade Portland cement blended with 25 percent or less fly-ash or GGBF slag 14 days
- 53 Grade Portland cement blended with more than 25 percent fly-ash or GGBF slag 21 days

Curing shall begin immediately after placing. Provide all equipment heeded for curing and protection of the concrete on hand and ready to install before actual concrete placement begins.

3.1.15.2 Moist Curing

Concrete containing silica fume shall be moist cured. Horizontal and nearly horizontal surfaces shall be moist cured by ponding, by covering with a minimum uniform thickness of 50 mm (2 inches) of continuously saturated sand, or by covering with saturated non-staining burlap or cotton mats. Burlap and cotton mats shall be rinsed to remove soluble substances before using. Other surfaces shall be moist cured when approved or directed. Concrete that is moist cured shall be maintained continuously, not periodically, wet for the duration of the entire curing period. If the water, sand, mats, etc. cause staining or discoloration of permanently exposed concrete surfaces, the surfaces shall be cleaned by a method approved. When wood forms are left in place during curing, the forms shall be kept continuously wet except for sealed insulation curing in cold weather. When steel forms are left in place on vertical surfaces during curing of concrete OR when concrete being cured has a water-cement ratio less than 0.40 the forms shall be carefully broken loose from the hardened concrete and curing water continuously introduced into the void. The temperature of the water should be tepid. Horizontal construction joints shall be allowed to dry sufficiently to remove free water immediately prior to placing the next lift.

3.1.15.3 Membrane Curing

Membrane curing may be used on surfaces that are not specified or directed to receive moist curing and that are not to receive a grout-cleaned finish. Membrane-forming curing compound shall not be used on surfaces that contain protruding steel reinforcing, that are heated by free steam, that will have additional concrete bonded to them, or that are to be grout-cleaned.

3.1.15.4 Pigmented Curing Compound

Only pigmented compound of the styrene acrylate or chlorinated rubber formulation conforming to ASTM C 309, Class B, requirements may be used on surfaces that are to be painted or to receive bituminous roofing or water proofing or floors that are to receive adhesive applications of resilient flooring. The curing compound selected by the Contractor for such use shall be compatible with any subsequent paint, roofing, coating, or flooring specified elsewhere in the contract.

3.1.15.5 Non-pigmented Curing Compound

Non-pigmented compound containing a fugitive dye may be used on surfaces that will be exposed to view when the project is completed. The reflective requirements of ASTM C 309 are waived. Surfaces cured with non-pigmented compound shall be shielded from direct rays of the sun for 3 days.

3.1.15.6 Application

The curing compound shall be applied to formed surfaces immediately after the forms are removed. The surfaces shall be thoroughly moistened with water, and the curing compound applied as soon as free water disappears. The curing compound shall be applied to unformed surfaces as soon as free water has disappeared provided steps have been taken when necessary to prevent premature loss of free water due to excessive evaporation as described in paragraph UNFORMED SURFACES above. The curing compound shall be applied in a two-coat continuous operation by motorized power-spraying equipment or pressure-tank equipment operating at a minimum pressure of 520 kPa 75 psi with provisions for continuous agitation. The application equipment shall be approved in advance. Hand-operated pressure applicators ("garden sprayers") shall not be used except in small, isolated areas as approved. The compound shall be applied at a uniform coverage of not more than 10 square meters/L 4 00 square feet/gallon for each coat. The second coat shall be applied perpendicular to the first coat. Concrete surfaces that have been subjected to rainfall within 3 hours after the curing compound has been applied shall be re-sprayed by the method and at the coverage specified. All concrete surfaces on which the curing compound has been applied shall be protected for the duration of the entire curing period from pedestrian and vehicular traffic and from any other influence that will disrupt the continuity of the curing membrane.

3.1.15.7 Protection

No fire or excessive heat shall be permitted near or in direct contact with concrete at any time. No vibratory earth compaction equipment or pile-driving equipment shall be operated within 30 m 100 feet horizontally of concrete less than 5 days old. Blasting shall not be permitted within 30 m 100 feet horizontally of concrete less than 90 days old. Blasting plans shall be

approved by the Contracting Officer. All galleries, conduits, and other openings through the concrete shall be kept closed or sealed during the entire construction period. The surface of the concrete shall be protected from rain or snow during placing.

3.2 Concreting under special conditions

3.2.1 Work in extreme weather conditions

During hot or cold weather the concreting should be done as per the procedure set out in IS 7861 Part I or IS 7861 Part II or as directed by the PM

3.2.2 Underwater concreting

The procedure set out under 14.2 of IS 456 shall be followed or as directed by the PM.

3.2.3 Concreting in sea water

The procedure set out under 8.2.8 of IS 456 shall be followed or as directed by the PM.

3.2.4 Concreting in aggressive soils and water

Guidelines laid down in 8.2.6 of IS 456 shall be followed together with the instructions of the PM.

3.3.0 Precast concrete

3.3.1 Precast concrete can be plain or reinforced. It shall meet all requirements and specifications of concrete as stated hereof. Precast concrete shall be done for cellular roof units, drainage or specially designed for specific use taking into consideration achievements in flexibility, speed and economy in construction.

3.3.2 Precast concrete units shall be cast in a suitable mould so as to make sure that they are,

- a) Easy to lift
- b) Easy to transport
- c) Excellently finished
- d) Handy to erect and join at site

Units shall be sound and free from cracks or any other defects that would interfere with the proper placing of units or the strength or performance of units or the structure.

3.3.3 Precast units shall be lifted and handled with proper tools from points designated to avoid any cracking or developing of any undue stresses. If required, necessary tools and tackles shall be fabricated by the contractor. Precast units shall be removed from mould within 24 hours or the time allowed by the designer or as approved by the PM.

The mould for casting shall preferably be of steel to ensure better surface finish of the precast unit. Provision shall be made in the mould to

accommodate fixing device etc. and suitable rebates to act as plaster grooves as specified.

All units that are, in the opinion of the PM, cracked and unsafe, shall be removed forthwith and no arbitration on this account shall be applicable.

Units shall be stored and stacked in the casting yard in a proper manner. The date of casting shall be noted therein, and wet curing for 15 days shall be done without fail unless special curing methods are adopted which shall confirm to IS 6523. The yard shall have a duly dressed ground and sufficient supports at the required intervals to receive precast units.

Units shall be erected only after 28 days of casting and after the cubes of those days have given the strength specified.

Tolerances in units shall not be more than ± 3 mm as approved by the PM taking into consideration the purpose and location of use.

3.4.0 Plum Concrete

Stone plums shall be used only when specified. Size of stone plums may be from 150 to 300mm. The maximum dimension of these stones or plums shall not exceed $1/3^{\text{rd}}$ the least dimension of the members.

Plums shall be hard, double clean and free from soft or loose pieces or deleterious material and should not have sharp corners.

Generally, first layer of concrete of specified mix shall be of thickness 2.5-time thickness of maximum size of plums to be used. Plums shall be laid when concrete becomes stiff but top portion is still green. No plums shall be used for concrete laid under water. The thickness of next and successive layers shall be 2 times that of largest plums.

While placing the plums, care shall be taken to see that the clear distance between any two plums is not less than either the width or thickness of either of the plums. The distance from plums to the outer surface or from any steel reinforcement shall be equal to greatest width of the plum.

If plums of stratified stones are used, they shall be laid on their natural bed. Stones with concave faces shall be laid with the concave upwards.

The thickness of the next and successive layers of concrete shall be at least twice that of the largest plums.

The total volume of plums shall not exceed 15 percent of the volume of the finished concrete

3.5.0 Measurements

1. All works shall be measured in the decimal system.
 - a) Dimensions shall be measured to the nearest 0.01 metre except for thickness of slab which shall be measured to the nearest 0.005 metre.
 - b) Areas shall be worked out to the nearest 0.01 sq m
 - c) Cubic contents shall be worked out to the nearest 0.01 cu m

2. All measurements of cutting shall, unless otherwise stated, be held to include the consequent waste.
3. Cement concrete work shall be classified as under:
 - a) Concrete cast in-situ : Plain and reinforced
 - b) Precast concrete : Plain and reinforced
 - c) Prestressed concrete : Cast in-situ or pre-cast
4. All concrete, except as hereinafter provided, shall be measured in cubic meters.
5. The price of concrete shall include ingredient material, mixing, transporting, hoisting to any height and lowering to any depth, pouring or laying, consolidating, leaving pockets, holes, and protecting them till the next operation or completion of work, hacking the surface to provide key for further work including cleaning, curing and wetting surface, etc. and preparing construction joints as described in clause 3.1.9. of this section.
6. Concrete processed in a special manner for any specific purpose, such as cooled, heated, water-proofed, acid-proofed, heat-resistant shall be measured separately and as per provision in BOQ.
7. Admixtures shall be used, if necessary, at the request of the contractor for workability and the price for that shall be deemed to be included in the contractor's quoted price of concrete.
8. No deductions shall be made for :
 - (a) Ends of dissimilar materials (for example beams, posts, girders, purlins, corbels and steps) upto 500 sq cm in section.
 - (b) Opening upto 0.1 sq m.
 - (c) Volume occupied by reinforcement.
 - (d) Volume occupied by drainage, water pipes, conduits, etc. not exceeding 25 sq cm, each in cross sectional area.
 - (e) Small voids each not exceeding 40 sq cm in section.
 - (f) Small moulds, drip moulds, chamfers, splays, rounded or covered angles, beads, grooves and rebates upto 10 cm in depth and width.
9. Expansion joints shall be measured in running metre or sq m as the case may be. Price shall include required shuttering, special treatment if any, filler and finishing material as detailed in drawing or the BOQ.
10. Waterproofing of concrete shall be measured separately as an extra over ordinary concrete stating the quantity of water proofing material in liters or kilograms.
11. Surface treatment shall be measured in square metres stating number of coats and proportioning of water proofing liquid to water.

12. Grouting of holding-down bolts and providing temporary boxing or wedges to form holes shall be enumerated. The mix shall be specified. The price shall include required shuttering, grouting, etc.
13. To keep surface dry while concreting, dewatering due to rains and seepage shall be included in the price of concrete.

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