

A. TECHNICAL SPECIFICATIONS & SPECIAL CONDITIONS FOR SUPPLY OF CEMENT FOR CONSTRUCTION WORKS

1. SUPPLY OF CEMENT

- i. Supply of cement to various specifications as required for various items under different schedules will be paid under Schedule for supply of cement.
- ii. The cement required for various items of work under different schedule shall be supplied by the Contractor at the site of work in accordance with the requirements and specifications. The payment for the cement supplied and used by Contractor for USSOR items and Non USSOR items shall be based on the norms for use as prescribed in the Technical Specifications/Special Conditions/Cement Schedule etc., and shall be made as per relevant items under Schedule for supply of cement. However, Railway reserves the right to supply departmental cement to the extent available which shall be transported by the Contractor from depot to the work spot. Payment towards such transportation will be made under relevant item of Standard Schedule of Rates of the Railway. For supply and use of cement in various works, relevant IRS codes, specifications, IS Specifications and Railway's specifications will be applicable. Wherever, relevant specifications are not available, decision of the Engineer-in-charge is final and binding on the contractor.

I) Specifications for Cement

The cement used shall conform to any of the following standards.

- a. Ordinary Portland Cement conforming to IS:269
- b. Rapid Hardening Ordinary Cement conforming to IS:8041
- c. High Strength Portland Cement conforming to IRS:T:40
- d. Portland Slag cement conforming to IS:455(See note 1&4 below)
- e. Portland Pozzolana Cement conforming to IS:1489(See Note 2&4 below)
- f. Sulphate Resistance Cement conforming to IS:12330(see Note 3 below)

Note: (1) Use of any cement other than OPC Grade 43/53 shall have the pre- approval of the Sr.DEN in charge. Mixing of blast furnace slag with OP cement at site shall not be permitted.

2. Portland Pozzolana cement/Portland slag cement shall not be used for PSC works. When Portland Pozzolana cement is approved for use in plain and reinforced concrete by the Engineer-in-charge, proper damp curing of concrete at least for 14 days and supporting form work till concrete attains at least 75% of the design strength shall be ensured.

3. The sulphate resisting cement conforming to IS:12330 shall be used only in such conditions where the concrete is exposed to the risk of excessive sulphate attack e.g., concrete in contact with soil or ground water containing excessive amount of sulphate shall not be used under such conditions where concrete is exposed to risk of excessive chlorides and sulphate attack both.

4. The rate of development of strength is slow in case of blended cement i.e., Portland Pozzolana cement and Portland slag cement, as compared to ordinary Portland cement. This aspect should be taken care while planning to use blended cement. Accordingly period of removal of form work and period of curing etc., should be suitably increased.

5. Compatibility of chemical admixtures and super plasticizers with Portland Pozzolana cement and Portland blast furnace slag cement shall be ensured by trials before use and with pre approval.

6. Unified Standard Specification for Works and materials shall prevail and referred for detailed specifications.

II) SOURCE AND PACKAGING:

- i. Cement to be used on the works shall be procured from the main / reputed cement plants or from their authorized dealers. Decision of Engineer-in- charge regarding reputed firms shall be final and binding on the contractor.
- ii. Cement bags preferably in paper bags and packings should bear the following information in legible markings:

- a) Manufacturer's name _____
- b) Registered Trade Mark of manufacturer, if any
- c) Type of cement
- d) Weight of each bag in Kg. or No. of bags/Tone
- e) Date of manufacture, generally marked as week of the year/year of manufacture, eg. 30/13
which means 30th week of 2013.
- f) IS Code to which cement conforms.

- iii. All cement bags shall have company stitched intact and if any sign of tampering with company stitches is noticed it will be rejected without any test.

III) *Test certificate regarding quality of cement:*

- i) Necessary test certificates will have to be produced by the tenderer regarding the quality of the cement conforming to the specification indicated above in addition to the manufacturer's certificates.
- ii) The Railway reserves the right to take samples during the course of the work and get the cement tested in reputed laboratories to ascertain the conformity to the specification. Cost of such testing shall be borne by the contractor with out any extra payment.
- iii) Tests on cement are to be done as per relevant IS Codes. Some of the tests which may be carried out are:
 - 1. Compressive Strength
 - 2. Initial & final setting time
 - 3. Consistency
 - 4. Soundness
 - 6. Fineness
- iv) The contractor shall arrange to carry out above tests for every 100 T of cement and for every change in lot/ batch and the same shall be submitted and take approval of Engineer in charge before using in work. No extra payment will be made for conducting tests and the quoted rate is inclusive of testing charges.

IV) *Storage*

- i) Any temporary structure required for storage of cement, steel etc., has to be provided by the tenderer at his cost. The Railway will only provide suitable land/shed for construction of the above temporary shed free of cost wherever land/shed is available and is free for use. Double lock arrangement (Contractor and Railway) for the temporary stores shed should be provided by contractor. On completion of the work or as directed by the Engineer-in-charge, the shed if put up by the Contractor, should be removed by the contractor and site cleared at his cost.
- ii) Stacking and storing of cement can be done as per Unified Standard Specification for Works and materials.

V) *Consumption of cement:*

- i) The cement consumption for the works shall be as per the Unified Standard Specification for Works and materials along with the "Cement Schedule" of the Railway or as per the approved design mix and as per the Minimum and Maximum content specified for various grades. Excess cement used will not be paid for and the decision of the Engineer-in-charge is final and binding on the Contractor.
- ii) In case of design mix (M20, M30, M40 mix etc., or similar mix design), the quantity of cement will be decided based on the approved design mix and the decision of the Engineer-in-charge is final and binding on the contractor. The Contractor should submit design mix details at his cost from the approved laboratory to the Engineer-in-charge before getting the trial mix approval / use in construction.
- iii) The following minimum quantity of cement shall be used for various grade of concrete as per relevant IS specifications.

| Environment | Grade of Concrete & Cement content | | | | | |
|-------------|------------------------------------|-----|-----|-----|-----|-----|
| | PCC | | RCC | | PSC | |
| MILD | M20 | 300 | M25 | 350 | M35 | 400 |
| MODERATE | M25 | 350 | M30 | 400 | M45 | 400 |
| SEVERE | M25 | 380 | M35 | 400 | M45 | 430 |
| VERY SEVERE | M30 | 400 | M40 | 430 | M50 | 440 |
| EXTREME | M30 | 400 | M45 | 430 | M50 | 440 |

Depending upon the environment to which the structure is likely to be exposed during its service life, minimum cementations material content in concrete shall be as given in above table. Maximum cementations material content shall be limited to 500 kg/cum.

- iv) The minimum grade concrete in bridges shall be: Plain Cement concrete - M20; Reinforcement Cement concrete - M25; Pre-stressed Cement concrete –M40. Only the approved design mix shall be used for the concrete works. The quantity of cement used shall be based on the design-mix in such cases subject to the limitations of minimum and maximum laid down in relevant specifications. No wastage of cement shall be payable by the Railway.

VI) *Payment for supply of cement*

- i) Cement supplied for the work and measured under the Schedule for supply of cement will be paid only after its use in various works under the Schedules of the contract as per conditions and no advance payment for supply will be admissible.

VII) *General*

1. No wastage of any of the materials supplied and used in the work by the contractor including cement is payable by the Railway, contractor will make his own arrangements for storing cement for use in work.
2. Contractor should take proper precautionary measures to store the cement in good condition against rains, cyclones. Railway is not responsible for any loss of cement due to clodding on account of defective storage or delay and Railway will not permit usage of such cement in the works.
3. 53 Grade/43 Grade/any other types of cement should be stacked separately in countable manner.
4. Admixture / Plasticizers of approved specifications will be permitted to be used in concrete wherever required and into the approval by the Engineer-in-charge. However, no extra payment for the admixtures used shall be payable unless otherwise specified in the Schedule.
5. Cement for temporary and enabling works shall be arranged by the contractor at his own cost and no extra payment will be paid on this account.
6. Empty cement bags on release from the work is the property of the contractor and shall be disposed off by the contractor himself.

B. TECHNICAL SPECIFICATIONS & SPECIAL CONDITIONS FOR SUPPLY OF STEEL FOR CONSTRUCTION WORKS.

I. SUPPLY OF STEEL FOR VARIOUS WORKS

- i) Supply of steel to various specifications as required under various schedules in the contract is governed by the Technical specifications and Special Conditions specified hereunder.
- ii) All steel shall be supplied by the Contractor at the site of work and stacked, stored, protected and maintained by him at his cost till they are put into use. However, Railway reserves the right to supply departmental steel to the extent available which shall be transported by the Contractor from depot to the work spot. Payment towards such transportation will be made under relevant item of the USSOR 2021. Payment for cutting, fabrication etc., done on the Railways steel will also be made as per the USSOR or as per relevant items available in schedules. Any temporary structure required for storage

of steel etc., has to be provided by the Contractor at his cost and should be removed after completion of the work. The Railway will only provide suitable land for construction of the above temporary shed free of cost wherever available.

- iii) For supply and use of steel in various works, relevant IRS Codes Specifications, IS Specifications and Railways specifications will be applicable and wherever, relevant specifications are not available, decision of the Engineer-in-charge is final and binding on the Contractor.

II. SPECIFICATIONS FOR STEEL

- a. The steel supplied by the contractor must satisfy any of the following material specifications as required for the work along with other concerned specifications.
- i) The reinforcement steel shall be High Yield Strength Deformed steel conforming to IS 1786 (up to date) and in case of mild steel rods it shall conform to IS 432 (Part-I Up to date) as specified. The steel to latest code and of latest manufacturing technique, as approved, shall be made available by the contractor and the agreement rate applies to the same.
- ii) The structural steel shall be conforming to IS 2062 (up to date) as specified.
- iii) HTS wires/strands shall be conforming to IS 14268 (Up to date) as specified.
- iv) Relevant other IS and IRS Specifications with regard to properties, testing and use of the above steel items also shall govern.
- v) Only steel of grades Fe500/Fe550 shall be used in bridge construction and Fe415, if used, shall have pre- approval of Sr. DEN-in-charge. For special cases and in seismic zones III,IV and V, only Fe500D/Fe550D shall be used. For other concrete, IS 432/Fe415/Fe 500/Fe550 may be used as specified.
- vi) The contractor shall produce the manufacturers test certificate for each lot of supply satisfying the requirements of relevant IS specifications and at the specific frequency as laid down.
- vii) The Contractor shall arrange to carryout additional tests on physical properties of steel for every 50 metric tonne (t) of steel and for every change in lot/batch for reinforcement steel and structural steel at his cost. For HTS wires and strands, Contractor shall arrange to test the steel at a rate of one test per 3 metric tonne (t). The same shall be submitted to the Railways and approval taken of the Engineer-in- charge before using in work. No extra payment will be made for conducting such tests and the agreemental rate is inclusive of above testing charges.
- viii) Further, specimen of the material shall be tested before it is put to use in recognized laboratory and the cost of testing shall be borne by the Contractor, whenever directed by the Engineer-in-charge. The Engineer- in-charge reserves the right of testing of specimen at his own discretion and the cost of testing will be borne by the Contractor.

III. Payment for supply of steel

- i) Payment for supply of all types of steel will be made for the quantity required / used as per the USSOR of Southern Railway and as per drawings issued from time to time and as per approved designs for the completed and measured quantity of Prestressed concrete/Reinforced concrete works. No payment will be admissible for quantity supplied in excess of the required quantity as per designs/drawings. However, contractor will be permitted to take the excess quantity back by his own means, but no claim for payment for transportation so involved will be admissible. No payment will be made for more supply of steel at the site/excess used in Construction. No

payment will be made for steel used in temporary or enabling works unless explicitly provided for in the Schedules. Steel for enabling/temporary works shall be arranged by the Contractor at his own cost.

- ii) Payment for reinforcement steel will be as per reinforcement actually utilized in the work based on approved designs/bar bending schedule. Payment for HTS will be made for the length between the bearing plates in the pre-stressed structures as used only. Structural steel will be paid for the weights of steel work calculated from final working drawings based on nominal weights given in the producer's hand books and using minimum square over all dimensions, no deductions being made for skew cuts, holes or notches. The drawing office dispatch lists (D.O.D.Ls) when prepared according to above procedure shall be the basis and shall be submitted by the contractor to the Engineer-in-charge for approval. Each gusset shall be measured as equivalent to the dimension of the smallest enclosing rectangle. The wastage of steel in the form of skew cuts etc., shall be the property of the contractor. An addition of 1.5% shall be made to the member quantities as arrive above, to account for the weight of rivets and welds. Nothing extra will be paid for wastage or for cut rods/wires/steel sections which will be the property of the contractor. The weight of the steel will be calculated from the nominal weight as per relevant IS Specifications or the actual unit weight whichever is less based on linear measurements. GI wire or other binding material used in Construction shall not be covered under this supply schedule.
- iii) Any steel work the weight of which differs by more than 2.5% from the calculated weight determined from the nominal weight of the sections shall be liable for rejection. Should the actual weight fall short of the calculated weight by more than 2.5%, the material if accepted, will be paid for the actual weight only. Should the actual weight exceed the actual calculated weight, payment will be made for calculated weight only. In the event of a dispute arising as to the weight of a portion of steel work, a weighment shall be made in the presence of the inspecting officer/Engineer.
- iv) The cutting, bending and placing of reinforcement or other types of steel shall conform to relevant IS/IRS codes and instructions on detailing of reinforcement or other types of steel as directed by Engineer-in-charge. However, payment for the same will not be made under this schedule.
- v) Payment for steel overlap will be limited to a maximum limit of 5% of the total consumption of steel irrespective of whatever over lap provided actually even with approval. Unauthorized overlaps will not be paid for. Over laps in critical locations shall not be permitted.

IV. Others

- i) Steel, reinforcement and other types, shall be stored in such a way so as to avoid distortion and to prevent deterioration by corrosion. All steel used should be free from loose Mill scale, loose rust, paints and oil covering / coating etc.
- ii) The contractor shall make his own arrangements for the binding wire as per the relevant specifications at his own cost for all concreting works including works under the USSOR items in any schedules, even if mentioned otherwise in any other documents.
- iii) Cutting, bending, welding, placement of reinforcement steel shall conform to relevant IRS/IS Codes including requirements for laps, dowelling, other detailing etc. Rates for concrete items include the cost of the above activities in complete. Rates quoted includes that of GI binding wire of appropriate specifications.
- iv) The contractor shall be bound to store the materials at site of work earmarked for the purpose by engineer in charge and shall not remove from the site nor use for any other purposes than exclusively for execution of the work for which the materials intended for.
- v) Welding of reinforcement will not be generally permitted except in special circumstances under the written approval of the Engineer in charge.
- vi) Contractor shall remove from site any steel materials rejected by the Engineer-in-charge within reasonable time as specified by him. In case of failure to remove the rejected material within reasonable time as specified, penalty @ Rs 100/-per ton per day will be imposed and recovered from subsequent running bills.
- vii) A register shall be maintained by the contractor with full details of reinforcement for accountal and payment of steel. The contractor should sign a similar such register maintained by Railway before undertaking concreting works as a token of acceptance of the details of the reinforcement in works, failing which the details as recorded by Railway are binding on the contractor for the purpose of payment and no dispute will be entertained by Railway on this account.
- viii) If MS bars are supplied in coils, then the contractor will have to straighten them before cutting and bending etc. within quoted rate and no extra payment will be made on this account.
- ix) Prestressing Steel: The prestressing steel shall be used not later than 6 months from the date of manufacture or 3 months from the date of arrival at site and shall be Uncoated stress relieved low relaxation

strand conforming to IS 14268-1995 or as specified.

- x) Steel for temporary and enabling works shall be arranged by the contractor at his own cost and no extra payment will be paid on this account.
- xi) Stockpiling of Prestressing steel in the open at the work site will not be allowed under any circumstances. Special care shall be taken by the contractor to store the H.T. steel under suitable covered shed as approved by the Engineer. The Engineer/his representative shall always have an easy access to store yard for inspecting the H.T. Steel for satisfying themselves regarding the condition

thereof. Any modification/protection suggested by them shall be scrupulously followed by the Contractor.

- xii) In addition to manufacturer's certificate, the acceptance of H.T steel shall be subjected to the independent testing of steel for the following characteristics by the Contractor at his cost, and nothing extra shall be paid on this account.
 - o Mechanical properties like diameter, mass of strand
 - o Ultimate tensile strength and load extension curves, yield point, proof stress and modulus of elasticity.
 - o Elongation after fracture
 - o Relaxation after 1000 hour test.
- xiii) Before the test pieces are selected, the Contractor shall furnish copies of the mill records of the H.T steel giving number of coils in each cast with sizes and identity marks to enable identification of the material with the bill produced.
- xiv) Wires/strands shall be supplied/brought to site in reels or in reel-less packs having a minimum core diameter of 600mm. The coil shall be securely strapped to prevent distortion in transit and handling.
- xv) The wires/strands shall be quoted with water soluble oils to prevent corrosion
- xvi) However, for aggressive (severe, very severe and extreme) environment conditions, special anti corrosion treatment of reinforcement steel used in bridges may be necessary. The steel shall be treated by one of the following methods as indicated in table below and only with specific approval of the Sr.DEN in charge. Extra payments for the same are admissible unless otherwise included in the relevant schedules.
- xvii) Protective Coatings: - In order to offer adequate resistance against corrosion reinforcement bars shall be provided with suitable protective coatings depending upon the environmental conditions.
The recommended coatings are as under

| Aggressive environment | | Non Aggressive environment |
|--|--|---|
| Important & Major Bridges | Minor bridges & structures | All structures |
| Cement polymer composite coating or Fusion Bonded Epoxy coating | Cement polymer composite coating or Inhibited Cement Slurry coating | Truncated Inhibited Cement Slurry coating |

- xviii) The steel consumption shall be as per the designs/drawings issued/ adopted by the Railways. Quantity of steel reinforcement consumption shall be as per reinforcement actually utilized in the work based on approved bar bending schedule. Nothing extra will be paid for wastage or for cut rods, if any, which will be property of the contractor. The weight of the steel will be calculated from the nominal weight as per relevant IS Code or the actual unit weight whichever is less based on linear measurements.

C. TECHNICAL SPECIFICATIONS & SPECIAL CONDITIONS FOR CONCRETE

I) Specifications

- i) Concrete for PCC, RCC and PSC shall be as per Unified Standard Specification for Works and materials, relevant IRS and IS specifications / Rules/ guidelines. Some important ones are listed below. Along with these, all other relevant IRS, IRC and IS specifications with their update versions shall also govern. These govern all concrete works in bridges, buildings etc as applicable.
 - IRS Bridge rules
 - IRS concrete bridge code
 - IRS Substructure and foundation code
 - IS 456 – Code of practice for Plain and Reinforced Concrete.
 - IS 1343 – Code of practice for pre stressed concrete.
 - UIC 772R – Neoprene/ Elastomeric Bearings etc.
- ii) Specification for cement, steel, binding wire, HTS wires/ strands used in concrete construction shall be as per specifications indicated under the supply schedules or as per relevant IRS/ IS specifications. Aggregates shall comply IS 383. Water used in concrete shall comply IS 3025. Admixtures, if permitted, shall comply IS 9103 or equivalent. Mix design shall be as per IS 10262. Ready-Mix concrete shall be as per IS 4926. IS 2911 and IS 3955 govern pile & well foundations. The above are not exhaustive, but indicative only and their latest or updated versions shall govern the construction of works. Any other specifications/rules/guidelines issued from time to time by Railway Board/RDSO shall also govern the works.
- iii) In all matter of execution, including testing of various components, where the above codes/ specifications/ guidelines are not clear or explicit, the direction given by the Engineer in charge is final and binding on the contractor.

II) *Coarse & Fine Aggregate*

- i. Aggregates shall comply with the requirements of IS:383 and shall be subjected to the tests in accordance with IS: 2386. Coarse aggregates shall be from crushed stone from approved quarries. Sand shall be from good river sources of approved quarries only.
- ii. The nominal maximum size of the aggregate should be as specified but in no case greater than one-fourth of the minimum thickness of the member, provided that the concrete can be placed without difficulty so as to surround all reinforcement and pre-stressing tendons thoroughly and fill all corners of the formwork.
- iii. For heavily reinforced concrete members as in case of ribs of main beams, the nominal maximum size of the aggregates may be restricted to 5mm less than minimum clear distance between main bars, cables, strands or sheathing or 5mm less than minimum cover to the reinforcement, whichever is smaller. However, lightly reinforced concrete members such as solid slabs with widely spaced reinforcement limitation of the size of the aggregate may not be so important and nominal maximum size may sometimes be as great as or even greater than the minimum cover.
- iv. For Reinforced Concrete and Prestressed Concrete works, aggregate of nominal maximum size of 20 mm or as specified shall be used. In special cases larger size aggregate may be specifically permitted by the Engineer-in-charge but in no case the maximum size shall be more than 40 mm.
- v. Coarse aggregate shall be jaw crushed and cubical in shape. Fine aggregate shall be naturally produced. Creek/ Marine sand shall not be used in permanent works.
- vi. Sand if found too coarse, shall be suitably blend with finer sand obtained from approved sources to obtain desired grading. The provision of two types of sand , their stacking separately and their mixing in specified proportion shall be at contractor's cost. The sand shall not contain silt, shale, clay and other weak particles as specified in relevant specifications.
- vii. The grading of sand shall conform to IS 2386. The sand shall be screened on a 4.75mm size screen to eliminate over size particles. The sand shall be washed in screw type mechanical washers in potable water to remove excess silt, clay and chlorides wherever required. It should be done one day before concreting. The washed sand can be stored on a sloping platform and in such manner as to avoid

contamination.

- viii. Aggregate shall be stored in such a way as to prevent segregation of sizes and avoid contamination with fines and other undesirable material.

III) Water

- i. Water used for washing of aggregates and for mixing and curing concrete shall be clean, potable and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic matters or other substances that may be deleterious to concrete or steel shall conform IS 3025.
- ii. In case of doubt regarding development of strength, the suitability of water for making concrete shall be ascertained by the compressive strength and initial setting time tests specified as per IS 516/ IS 4031.
- iii. Water found satisfactory for mixing is also suitable for curing also. However, water used for curing should not produce any objectionable stain or unsightly deposit on the concrete surface. The presence of tannic acid or iron compounds is objectionable.

IV) Concrete Admixtures

- i. Engineer-in-charge may permit the use of admixtures, with approval of competent authority, for imparting special characteristics to the concrete or mortar on satisfactory evidence that the use of such admixtures does not adversely affect the properties of concrete or mortar particularly with respect to strength, volume change, durability and has no deleterious effect on reinforcement. In rail bridges, use of admixtures is governed by clause 4.5 of IRS Concrete Bridge Code.
- ii. The admixtures, when permitted, shall conform to IS:9103. They shall be non-air entraining type. Calcium chloride or admixtures containing calcium chloride shall not be used in structural concrete containing reinforcement, prestressing tendon or other embedded metal. The admixture containing Cl & SO₃ ions shall not be used. Admixtures containing nitrates shall also not be used. Admixtures based on thiocyanate may promote corrosion and therefore shall be prohibited. Naphthalene or melamine based admixtures may be used selectively.
- iii. It should be obtained from established manufactures with proven track record or as per approved list wherever available.
- iv. The contractor shall provide the following information after obtaining from manufacturer before the same is put to use.
 - 1. The chemical names of the main ingredients in the admixture
 - 2. Chlorine content if any, expressed as a percentage by the weight of the admixtures
 - 3. Values of dry material content, ash content and relative density of the admixtures which can be used for uniformity tests.
 - 4. Whether or not the admixture leads to the entrainment of air when used as per the manufacturer's recommended dosage, and if so to what extent.
 - 5. Where 2 or more admixtures are proposed to be used in any one mix, confirmation as to their compatibility.
 - 6. There would be no increase in risk of corrosion of the reinforcement or other embodiments as a result of using the admixture.
 - 7. Retardation achieved in initial setting time.
 - 8. Normal dosage and detrimental effects, if any, of under or over dosage.
 - 9. Recommended dosage and expected results, including proof for the same wherever required. Independent test result shall be produced by the contractor on demands/ as specified.

V) Storage of materials

- i. Storage of materials shall be as per IS: 4082. All materials may be stored at proper places so as to prevent their deterioration or intrusion by foreign matter and to ensure their satisfactory quality and

fitness for the work. The storage space must also permit easy inspection, removal and restoring of the materials. All such materials even though stored in approved godowns / places, must be subjected to acceptance test prior to their immediate use.

- ii. Aggregate stockpiles may be made of ground that is denuded of vegetation, is hard and well drained. If necessary the ground shall be covered with 50mm plank. Coarse aggregate, unless otherwise agreed by the engineer in charge in writing, shall be delivered to the site in separate sizes. Aggregate placed directly on the ground shall be removed from the stockpile within 30cm of the ground until the final cleaning up of the work, and then only the clean aggregate will be permitted to be used. In case of fine aggregate these shall be deposited at mixing site not less than 8 hours before use and shall have been tested and approved by the engineer in charge before use.
- iii. Cement shall be transported, handled and stored at the site in such a manner as to avoid deterioration or contamination. Cement shall be stored above ground level in perfectly dry and water-tight sheds and shall be stacked not more than eight bags high. Wherever bulk storage containers are used their capacity should be sufficient to cater to the requirement at site and should be cleaned at least once every 3 months. Cement older than 3 months from the date of manufacture shall not be used. Each consignment shall be stored separately so that it may be readily identified and inspected and cement shall be used in the sequence in which it is delivered at site. Any consignment or part of a consignment of cement which had deteriorated in any way, during storage, shall not be used in the works and shall be removed from the site by the Contractor without charge to Railways.
- iv. Supply of Reinforcement steel shall be taken from approved supplier as per the list only and no rerolled steel shall be incorporated in the work. The reinforcement bars, when delivered on the job, shall be stored above the surface of the ground upon platforms, skids or other supports, and shall be protected from mechanical injury and from deterioration by exposure. Every bar shall be inspected before assembling on the works and any defective, brittle, excessively rusted or burnt bars shall be removed. Cracked ends of bars shall be cutout.

VI) *Testing of steel and cement & others:*

- i. Prestressing steel, reinforcement steel, cement and other items shall be tested and results produced by the contractor as specified under the supply items. However, the contractor shall also arrange for additional tests at his own cost as required by the Engineer-in-charge as and when required. The decision of the Engineer-in-charge is final in this regard.

VII) *Concreting*

- i. The contractor shall make his own arrangements for supply of water and electricity for all his works at his own cost. He shall arrange potable quality water for use in all concrete works and samples of water shall be got tested from approved laboratory/approved by the Engineer-in-charge before being used in concreting. Apart from water, fine & coarse aggregates and all other materials shall be tested from time to time by the contractor at his cost to ensure proper quality works.
- ii. Maximum/minimum size of aggregates, standards of quality of materials, minimum cover for concrete, use of admixtures/chemicals, treatment to reinforcement/finished surfaces, etc., shall be as per relevant Codes, IS/IRS specifications and conditions of contract as specified.
- iii. All exposed concrete surfaces shall be finished smooth by the contractor at his own cost. Shuttering materials for RCC and PSC in superstructure shall be strictly of steel only to permit vigorous vibration and to ensure no deviation of finished dimensions by more than +5/-0 mm and wooden shutters are not permitted. For other works also, proper quality of shuttering materials which will permit vibrating and will not require additional finishing shall only be used. If there is any variation in the surface, alignment or lines in the products beyond permissible rejection limits indicated in these conditions, the Railway reserves the right to reject the same and the contractor shall not have any claim in this regard and cost of railway materials involved will be recovered from the contractor including penalties, if any imposed.

Weigh batching, vibrating, curing & testing:

- iv. All concrete, i.e. Plain, RCC & PSC, shall be machine mixed and vibration compacted by using appropriate vibrators. Weigh batching plant, mixers, vibrators, etc., of appropriate capacity, as specified/directed by the Engineer-in-charge, shall be arranged by the contractor at his cost. Weigh batching plants, for major works, shall have computerized control for weighing, loading, mixing and delivery. Major works for this purpose are those where the quantity of concrete in all types of concrete produced in a single site is more than 2500 cum or in multiple sites more than 4000 cum in one work.
- v. For major works, batching plants, transit mixers, concrete pumps, etc., shall be installed by the contractor necessarily at site. In case of failure of any of the above, standby arrangements for ensuing continuous concreting has to be provided by the contractor at his cost. For piling works & PSC works, concreting shall be done continuously as per the volumes designed without break and accordingly standby arrangements shall be ensured by the contractor. Wherever concreting by means other than weigh batching is done, even with the approval of the Sr. DEN in charge in case of special situations, the quantities & other details shall be recorded and maintained by the contractor and Railway reserves the right to reduce payment by 10% of the agreement rates for such concreting done and the decision of the Engineer-in-charge is final in this regard.
- vi. Curing & vibrating shall be arranged by the contractor at all locations/heights at his own cost and no extra payment on this account will be admissible. Curing of concrete shall be done as per relevant IS Codes/Specifications. If curing is not done by the contractor properly, Railway may get it done through any other means at the Contractor's cost without any notice to him and recover from his bills the same including penalty if any at the discretion of the Engineer-in-charge. The concrete shall be kept wet constantly by bonding or covered with a layer of sacking canvas etc. Steam curing or bonding is mandatory for special PSC works as specified and as per approved designs.
- vii. Test cubes shall be cast at regular intervals and tested to ascertain the strength of concrete. The contractor shall establish a cube testing facility along with operator at the site or nearby area to facilitate prompt testing of concrete. Test cube moulds as required as per IS Codes shall be made available by the contractor at his cost.

VIII) Design Mix

- i. For all items of concrete only design mix shall be used. Prior to the start of construction, the Contractor shall design the mix and submit to the Engineer-in-charge for approval, the proportions of materials, including admixtures to be used. Admixtures (including plasticizers or super- plasticizers) may be used as specified in the conditions of the contract. Atleast 8 weeks before commencing any concreting, the contractor shall make trial mixes using samples of coarse aggregates, sand, water etc., typical of those to be used in the works.
- ii. The mixes are designed to yield to mean strengths (fcm) greater than the correspondence specified characteristic strengths (fck) as indicated in table below. Mix design shall be as per IS10262.

The grades of concrete and the required average strength at 28 days for a few mixes are specified below for guidance:

| Grade of concrete | Max size of aggregate (mm) | Characteristic strength (fck) at 28 days (kg/sqmm) | Target Mean Strength (fcm) 28 days (kg/sqmm) |
|-------------------|----------------------------|--|--|
| M20 | 10 | 20 | 29 |
| M20 | 20 | 20 | 29 |
| M35 | 20 | 35 | 44 |
| M35 | 40 | 35 | 44 |
| M45 | 20 | 45 | 54 |
| M45 | 40 | 45 | 54 |

- iii. Trial mixes including making of cubes, curing, testing shall be in accordance with IS516. Wherever there is a significant change in materials used, fresh trial mix shall be arranged by the contractor as required by the Engineer-in-charge. When the proportions of the mix are approved, the contractor shall not vary any of the design parameters or the source of the materials without the approval of the Engineer-in-charge.

- iv. Requirements of Consistency: The mix shall have the consistency which will allow proper placement and consolidation in the required position. The slump of concrete shall be checked as per IS:516 as directed by the Engineer-in-charge. For guidance, recommended slump are as under:

| Sl.no. | Type of structure | Slump in mm |
|--------|--|-------------|
| 1 | RCC structures with widely spaced reinforcement, eg. Solid column, pier, abutments, well footing etc | 40-50 |
| 2 | RCC structures with fair degree of congestion of reinforcement, eg. pier, abutment cap, well cap, beam etc | 50-75 |

IX) Durability

- i. The durability of concrete depends on its resistance to deterioration and the environment in which it is placed. The resistance of concrete to weathering, chemical attack, abrasion, frost and fire depends largely upon its quality and constituents materials. Susceptibility to corrosion of the steel is governed by the cover provided and the permeability of concrete. The cube crushing strength alone is not a reliable guide to the quality and durability of concrete; it must also have an adequate cement content and water-cement ratio. The general environment to which the concrete will be exposed during its working life is classified in five levels of severity that is mild, moderate, severe, very severe and extreme, as described below

| Environment | Exposure Conditions |
|-------------|---|
| Mild | Concrete surfaces protected against weather or aggressive conditions, except those situated in coastal area. |
| Moderate | Concrete surface sheltered from severe rain or freezing whilst wet; Concrete exposed to condensation and rain; Concrete continuously Under water. Concrete in contact or buried under non-aggressive soil/ groundwater. Concrete surfaces sheltered from saturated salt air in coastal area. |
| Severe | Concrete surfaces exposed to severe rain, alternate wetting and drying or occasional freezing whilst wet or severe condensation; Concrete completely immersed in sea water; Concrete exposed to coastal environment. |
| Very severe | Concrete surfaces exposed to sea water spray, corrosive fumes or severe freezing conditions whilst wet. Concrete in contact with or buried under aggressive sub-soil/ ground water. |
| Extreme | Concrete surface exposed to abrasive action/ Surface of members in tidal zone. Members in direct contact with liquid / solid aggressive chemicals. |

X) Maximum Water Cement Ratio

- i. Maximum water-cement ratio, grade of concrete and cementitious material content for various environment conditions for achieving durability are indicated below for guidance:
- ii. The limits for maximum water cement ratio for design mix shall be based on environmental

conditions and durability.

The limits for maximum water cement ratio for different environmental conditions shall be as given below

| Environment | Plain Concrete (PCC) | Reinforced Concrete (RCC) | Pre-stressed Concrete (PSC) |
|-------------|----------------------|---------------------------|-----------------------------|
| Mild | 0.55 | 0.50 | 0.45 |
| Moderate | 0.50 | 0.50 | 0.40 |
| Severe | 0.50 | 0.45 | 0.40 |
| Very severe | 0.50 | 0.45 | 0.35 |
| Extreme | 0.45 | 0.40 | 0.35 |

XI) Grade of concrete

From durability consideration, depending upon the environment to which the structure is likely to be exposed during its service life, minimum grade of concrete shall be as given in table below.

| Environment | Plain Concrete (PCC) | Reinforced Concrete (RCC) | Pre-stressed Concrete (PSC) |
|-------------|----------------------|---------------------------|-----------------------------|
| Mild | M20 | M25 | M35 |
| Moderate | M25 | M30 | M35 |
| Severe | M25 | M35 | M45 |
| Very severe | M30 | M40 | M50 |
| Extreme | M30 | M45 | M50 |

XII) Cementitious Material Content

Maximum Cementitious Material Content shall be limited to 500kg/m³. Depending upon the environment to which the structure is likely to be exposed during its service life, minimum cementitious material content in concrete shall be as given in table below.

| Environment | Plain Concrete (PCC) | Reinforced Concrete (RCC) | Pre-stressed Concrete (PSC) |
|-------------|----------------------|---------------------------|-----------------------------|
| Mild | 210 | 300 | 350 |
| Moderate | 250 | 300 | 400 |
| Severe | 250 | 350 | 430 |
| Very severe | 300 | 400 | 440 |
| Extreme | 300 | 400 | 440 |

XIII) Permeability of concrete

Permeability test shall be mandatory for all RCC/PSC bridges under severe, very severe, and extreme environment. Under mild and moderate environment, permeability test shall be mandatory for all major bridges, and for other bridges and structures permeability test is desirable. Depth of penetration of moisture shall not exceed 25mm or as specified.

XIV) Mixing of concrete

- Concrete shall be mixed either in a mini mobile batching plant or in a batching and mixing plant as per the specification. Hand mixing shall not be permitted. Mixer or the plant shall be at an approved location considering the properties of the mixes and the transportation arrangements available with the contractor. The mixer or the plant shall be approved by the engineer in charge.
- Mixing shall be continued till materials are uniformly distributed and a uniform color of the entire mass is obtained, and each individual particle of the coarse aggregate shows complete coating of mortar containing its proportionate amount of cement.
- Mixers which have been out of use for more than 30 minutes shall be thoroughly cleaned before putting a new batch. The first batch of concrete from the mixer shall contain only two thirds of the normal quantity of coarse aggregate. Mixing plant shall be thoroughly cleaned before changing from one type of mix to another.

XV) *Transporting, placing and compaction of concrete*

- i. The method of transporting and placing concrete shall be approved by the engineer in charge. Concrete shall be transported and placed as near as practicable to its final position, so that no contamination, segregation or loss of its constituent materials takes place. Concrete shall not be freely dropped into place from a height exceeding 1.5m.
- ii. When concrete is conveyed by chute, the plant shall be of such size and design as to ensure practically continuous flow. Slope of the chute shall be so adjusted that the concrete flows without the use of excessive quantity of water and without any segregation. The delivery end of the chute shall be as close as possible to the point of the deposit. The chute shall be thoroughly flushed with water before and after each working period and the water used for this purpose shall be discharged outside the formwork.
- iii. All formwork and reinforcement contained in it shall be cleaned and made free from standing water, dump, immediately before placing of concrete.
- iv. No concrete shall be placed in any part of the structure until approval of the Engineer in charge has been obtained.
- v. If concreting is not started within 24 hours of the approval given, it shall have to be obtained again from the engineer in charge. concreting shall then proceed continuously over the area between the construction joints. Fresh concrete shall not be placed against concrete which has been in position for more than 30 minutes unless a proper construction joint is formed.
- vi. Except where otherwise specified by the engineer in charge, concrete shall be deposited in horizontal layers to a compacted depth of not more than 450mm.
- vii. Concrete when deposited shall have a temperature of not more than 40°C. it shall be compacted in its final position within 30 minutes of its discharge from the mixer, unless carried in properly designed agitators, operating continuously when this time shall be within 1 hour of the addition of cement to the mix and within 30 minutes of its discharge from the agitator. In all such matters, the engineer – in charge's decision shall be final.
- viii. Concrete shall be thoroughly compacted by vibration or other means during placing and worked around the reinforcement, embedded fixtures and into corners of the formwork to produce a dense homogenous void-free mass having the required surface finish. When vibrators are used, vibration shall be done continuously during the placing of each batch of concrete until the expulsion of air has practically ceased and in a manner that does not promote segregation. Over vibration shall be avoided to minimize the risk of forming a weak surface layer. When external vibrators are used, the design of formwork and disposition of vibrator shall be such as to ensure efficient compaction and to avoid surface blemishes. Vibrations shall not be applied through reinforcement and where vibrators of immersion type are used, contact with reinforcement and all inserts like ducts etc., shall be avoided. The internal vibrators shall be inserted in an orderly manner and the distance between insertions should be about one and half times the radius of the area visibly affected by vibration. Additional vibrators in serviceable condition shall be kept at site so that they can be used in the event of breakdowns.
- ix. Mechanical vibrators used shall be of appropriate specifications, type and capacity and as directed by the Engineer-in-charge.

XVI) *Equipment & machinery for concreting*

- i. For major concrete works, the following equipments in numbers indicated are considered necessary for efficient and speedier concreting. However, the actual numbers may be arranged as required by the Engineer-in-charge, taking into account the site conditions.

| | | |
|---|---|------|
| 1 | Concrete batching plant (10-20cum capacity) | 1no. |
| 2 | Transit mixers (4-7 cum capacity) | 2no. |
| 3 | Concrete vibrators (2HP) | 4no. |
| 4 | Vibrators of needles (60mm & 40mm) | 4no. |
| 5 | Screed vibrator (for ROB) | 2no. |
| 6 | Form vibrator (500Watt capacity) | 2no. |
| 7 | Generator (35KV capacity) | 1no. |
| 8 | Welding set (3- 5KV capacity) | 1no. |

| | | |
|----|---|---------------|
| 9 | Reinforcement steel cutting maxchine | 1 no. |
| 10 | Reinforcement steel bending maxchine | 1no. |
| 11 | Conrete pumps (10-20HP capacity with 40m pipe length) | 1no. |
| 12 | Hydra 12.0 capacity crane | 1 no. |
| 13 | Concrete funnel bucket | 1no. |
| 14 | Air compressor (100-150cum capacity) | 1no. |
| 15 | Concrete Dumpers | 2no. |
| 16 | Any other including power lifts etc, as required to suit site | Adeq uate no. |

- i. For smaller works, equipments as required by the Engineer in charge shall be arranged by the contractor. The contractor may make his own arrangements such as the above or with better machinery with the approval of the Engineer in charge; however the plants shall be able to produce at least 20cum of the concrete per hour continuously in major works site to enable speedier completion of the works.
- ii. All the above machineries are required to be arranged by the contractor at his own cost and the agreement rates for concreting include the same. No extra payment is admissible for any machines arranged by the contractor.

XVII) Construction joints

- i. Construction joints shall be avoided as far as possible and in no case case the locations of such joints shall be changed or increased from those shown on the drawings, except with express approval of the engineer in charge. The joints shall be provided in a direction perpendicular to the member axis. Sequencing of concrete placement should be organized in such a way that cold joints are totally eliminated. The sequence of concreting shall be submitted for the approval of engineer prior to concreting of the structural element. Concreting shall be carried out continuously up to the construction joints, the position and arrangement of which shall be pre-determined by the designer.
- ii. The use of Construction joints in prestressed concrete should preferably be avoided. If it is found necessary, they shall be restricted to bare minimum duly adopting proper construction techniques.
- iii. Construction joints should be positioned to minimize the effect of the discontinuity on the durability, structural integrity and appearance of the structure. Joints should be located away from regions of maximum stress caused by loading particularly where shear and bond stresses are high. Construction joints between slabs and ribs in composite beam should be avoided. As a general rule joints in column are made as near as possible to the beam hunching. Joints in beams and slabs should normally be made at the centre or within the middle third of the span. As far as possible, joints for fair faced concrete should be located where they conform with the architectural features of the construction. Unless they are masked in this way, the position of the joints is always obvious, even when the concrete is given a textured finish. If substantial changes in the cross-section of a member are necessary, the joints should be formed where they minimize stresses caused by temperature gradients and shrinkage.
- iv. Laitance, both on the horizontal and vertical surfaces of the concrete, should be removed before fresh concrete is cast. The surface should be roughened to promote good adhesion. Various methods for removal can be used but they should not dislodge the coarse aggregate particles. Concrete may be brushed with a stiff brush soon after casting while the concrete is still fresh and while it has only slightly stiffened. If the concrete has partially hardened, it may be treated by wire brushing or with a high pressure water jet, followed by drying with an air jet, immediately before the new concrete is placed. Fully hardened concrete should be treated with mechanical hand tools or grit blasting, taking care not to split or crack aggregate particles.
- v. Where there is likely to be a delay before placing the next concrete lift, protruding reinforcement should be protected. Before the next lift is placed, rust loose mortar or other contamination should be removed from the bars and where conditions are particularly aggressive and there has been a substantial delay between lifts, the concrete should be cut back to expose the bars for a length of about 50mm to ensure that contaminated concrete is removed.

- vi. In all cases, when construction joints are made, it should be ensured that the joint surface is not contaminated with release agents, dust or curing membrane and that the reinforcement is fixed firmly in position at the correct cover.
- vii. When the form work is fixed for the next lift, it should be inspected to ensure that no leakage can occur from fresh concrete. It is a good practice to fix a 6mm thick sponge which seals the gap completely. The practice of first placing a layer of mortar or grout is not recommended. The old surface should be soaked with water without leaving puddles, immediately before starting concrete, then the new concrete should be thoroughly compacted against it. When the fresh concrete is cast against existing matured concrete or masonry, the older surfaces should be thoroughly cleaned and soaked to prevent the absorption of water from the new concrete. The standing water should be thoroughly vibrated in the region of the joint.

XVIII) Concreting under water

- i. The permanent structure shall not be allowed to come in contact with sea water/sewage for at least 72 hours after the green concrete is laid. When it is necessary to deposit concrete under water, the methods, equipment, materials and proportions of mix to be used shall be got approved from Engineer-in-charge before any work is started. Concrete shall contain 10% more cement than that is required for the same mix placed in dry conditions.
- ii. In case cofferdams are required, the same shall be provided. Nothing extra shall be paid on this account unless specified in the schedules otherwise. Cofferdams shall be sufficiently tight to ensure free of water conditions, in any case to achieve still water conditions. Cofferdams shall be sufficiently tight to prevent loss of mortar through the joints in the walls. Pumping of water shall not be done while concrete is being placed or until 24 hours thereafter. To minimize the formation of laitance, great care shall be exercised not to disturb the concrete as far as possible while it is being deposited.
- iii. All under-water concreting shall be carried out by tremie method only as per relevant IS specifications, using tremie of appropriate diameter. The number and spacing of the tremies should be worked out to ensure proper concreting. The tremie concreting when started should continue without interruption for the full height of the member being concreted. The concrete production and placement equipment should be sufficient to enable the underwater concrete to be completed uninterrupted within the stipulated time. Necessary stand-by equipment should be available for emergency situations.

XIX) Finishing of concrete

- i. The finished surface of concrete after removal of form work shall be such that no touching up is required. All fins / holes caused by form joints, supports, rods etc shall be ground / filled up effectively using appropriate machinery. Shuttering, formwork etc used in construction shall be specified in the conditions and the labour used shall be as skilled to suit the quality requirements of the work. Any surface, finished poorly in the opinion of engineer in charge's decision requires repair / remedial measures at the cost of the contractor and the engineer in charge's decision in this regard is final. Any structure which has deficiencies in finishing including product parameters beyond the rejection limits, as specified in these conditions, are liable to be rejected and the decision of Sr.DEN/ DEN is final in this regard.

XX) Coatings of concrete

- i. Normally finished concrete structures do not require any surface protective coatings in mild, moderate and severe aggressive environments. A cement coat is considered adequate. For very severe and extreme conditions, however, phenolic IPN coating or CECRI Integrated four coat system can be used.

XXI) Use of RMC

- i. Ready Mix Concrete (RMC) shall be used only as provided for in the contract and with the approval of the Chief Engineer / Sr.DEN as specified.
- ii. Use of RMC:- RMC shall conform to the specifications of concrete, as laid down in Indian Railways

Concrete Bridge Code. For other aspects which are not covered in this code, IS:4926 (Specification for Ready Mixed Concrete) shall apply. The mix design proposed to be adopted and RMC shall be approved by the Engineer-in-charge. Minimum Cement content, maximum cement content, maximum water cement ratio, initial setting time, etc., shall be as specified by Railways.

- iii. Preparation of RMC:- RMC shall be produced by completely mixing cement, aggregates, admixtures, if any, and water at a Central Batching and Mixing Plant of reputed producers and delivered in fresh condition at site of construction. The producer of RMC shall be approved by the Railway and contractor shall have no claim in this regard.
- iv. Effect of transit (Transportation) time on RMC:- As RMC is available for placement after lapse of transit time, reduction in workability occurs, which may lead to difficulty in placement of concrete. In addition, in case of longer transit time, initial setting of concrete may also take place, which may render it unusable. Thus, while planning for using of RMC, these aspects should be kept in view and got approved.

Checking suitability of Admixtures:

- v. Generally admixtures, like water reducing agent, retarder etc., are used in Ready Mixed Concrete for retention of desired workability and to avoid setting of concrete. In such cases, admixtures should be tested for their suitability as per IS: 9103 at the time of finalizing mix design. Records of all test carried out to judge the suitability of admixture, shall be furnished by the RMC producer to Railways. Regarding specification of admixtures, clause 4.4 of Concrete Bridge Code may be referred.

Quality control

- vi. The producer of RMC shall adopt quality assurance programme duly approved by Railways. He shall have necessary tests to ensure quality control at each stage during production of concrete.

Access to Railway Officers to RMC plant

- vii. RMC producer shall allow railway officials to supervise the operations involved in concrete production, materials proposed to be used and take samples of materials used.

Accessibility to technical records maintained by RMC producer.

- viii. RMC producer shall allow railway officials to peruse the past and present records of concrete produced for the work.
- ix. Deputation of Railway supervisor:- RMC Producer shall allow Railway supervisor at RMC plant on the date of concrete supply and even prior date to see arrangements.
- x. Transportation of RMC:- The RMC shall be transported in concrete transit agitators conforming to IS:5892 (Specification for concrete transit mixers and agitators). Agitating speed of the agitators during transit shall not be less than two revolutions per minute and not more than six revolutions per minute.

Time period for delivery of concrete :

- xi. The concrete shall be delivered completely to the site of work within 1½ hours (when the atmospheric temperature is above 20°C) and within 2 hours (when the atmospheric temperature is at or below 20°C) of adding the mixing water to the dry mix of cement and aggregate or adding the cement to the aggregate, whichever is earlier. In case, location of site of construction is such that this time period is considered inadequate, increased time period may be specified provided that properties of concrete have been tested after lapse of the proposed delivery period at the time of finalizing mix design. Concrete received after the transit time limit as specified above shall not be accepted. Concrete shall be placed in position within the designed initial time. At the end of initial setting time, the left over portion of the concrete if any shall be rejected.

Re-tempering with Concrete :

- xii. Under any circumstances, re-tempering i.e. addition of water after initial mixing shall not be allowed, as it may affect the strength and other properties of concrete.

Testing of workability and strength of concrete at the time of placing

- xiii. The concrete shall be tested for the required workability and strength at the time of placement. Concrete shall be deemed to satisfy the strength requirement when it fulfils the criteria laid down IRS concrete bridge code clause no. 8.7

Dosing of Admixtures at site of concreting

- xiv. After arrival of RMC at site, additional dose of admixture shall not be added unless pre approved with proper designs / testing by the Sr.DEN.

XXII) SHUTTERING:

- i. Shuttering, Formwork & False work shall be designed to meet the requirements of the permanent structure, taking into account the actual conditions of materials, environment and site conditions. Careful attention shall be paid to the detailing of connections and functions. All the materials used for shuttering, formwork & false work shall conform to the specified quality consistent with the intended purpose and actual site condition as applicable. All shuttering, formation, false work, etc., shall be got approved by the Engineer-in-charge before it is put into use.
- ii. Forms shall not be struck until the concrete has reached strength at least twice the stress to which the concrete may be subjected at the time of removal of formwork or as approved by the Engineer-in-charge. In normal circumstances and where Ordinary Portland Cement is used, forms may generally be removed after the expiry of the following periods:-

| Type of Formwork | Minimum Period before striking Form work |
|---|--|
| (a) Vertical formwork to columns, walls, beams | 16 – 24 hours |
| (b) Soffit formwork to slabs (Props to be refixed immediately after removal of formwork) | 3 days |
| (c) Soffit formwork to - beams (Props to be refixed immediately after removal of formwork) | 7 days |
| (d) Props to slabs (1) Spanning up to 4.5m (2) Spanning over 4.5 m | 7 days 14 days |
| (e) Props to beams and arches: (1) Spanning up to 6m (2) Spanning over 6m | 14 days 21 days |

- iii. Where the shape of the element is such that the form work has re entrant angles, the form work shall be removed as soon as possible after the concrete has set, to avoid shrinkage crack occurring due to the restraint imposed.
- iv. Shutters for PSC / Box/ other type of girder be such that it permits pouring of concrete in one pour without requiring any dismantling / striking of any part / full of the shutters at any stage.
- v. Specialized formwork may be required in the case of slip formwork, underwater concreting etc. Such specialized formwork shall be designed and detailed by competent agencies and a set of complete working drawings and installation instructions shall be supplied to the Engineer-in-charge before commencement of work. The site personnel shall be trained in the erection and dismantling as well as operation of such specialized formwork. In case proprietary equipment is used, the supplier shall supply drawings, details, installation instructions, etc. in the form of manuals along with the formwork. Where specialized formwork is used close coordination with the design of permanent structure is necessary. For slip form the rate of slipping the formwork shall be designed for each individual case taking into account various parameters including the grade of concrete, concrete strength, concrete temperature, ambient temperature, concrete admixtures, etc. In order to verify the time and sequence of striking/removal of specialized formwork, routine field tests for the consistency of concrete and strength development are mandatory and shall be carried out before adoption.

XXIII) Defective Concrete and measurement of concrete

- i. Should any concrete be found honey combed or in any way defective which may be, at the discretion of Engineer in charge suspected to affect the performance of the structure, shall be rejected out right. Contractor shall have no claim in this regard and the decision of Sr.DEN is final. The member, structurally independent, in which the concrete is found to be defective, shall be replaced by the contractor at his cost fully. The damages arising on account of such defective concreting shall also be recoverable from the dues of the contractor, including penalties if any. Railway reserves the right to get the member replaced by any means at the cost of the contractor at any cost if the contractor delays reproduction.
- ii. However, some surface defects, not affecting structural properties shall o the instruction of the engineer in charge, be repaired as per the approved procedures. The complete cost of such repairs shall be borne b the contractor and no compensation shall be payable. Records of such repairs done shall be maintained by the contractor.
- iii. The tolerances for finished concrete bridge structures shall be governed by IRS Concrete Bridge Code and shall be as follows; deviations beyond the permissible limits shown are liable to be rejected. These tolerances apply to other structures also appropriately.

| S No | Description of defects in any part or full member or thestructure at the decision of the Engineer-in-charge | Permissible limits (specified designs/drawings)unless otherwise |
|------------|---|---|
| 1 Shift | from alignment | 1) ± 5 mm in member. 2) ± 10 mm in reinforcement |
| 2 | Deviation from specified batter. plumb i pie o variation mb rs r from | 1 in 250 |
| 3 | Deviation from plumb in abutments or variation fromspecified batter | 1 in 125 |
| 4 | Cross sectional dimensions of piers, abutments and girders | +20mm/-5mm |
| 5 | Thickness of deck slab of bridges | + 6 mm / - 3 mm |
| 6 | Size and location of openings | ± 12 mm |
| 7 | Plan dimensions of footings (formed excavation) | + 50 mm / - 25 mm |
| 8 | Plan dimensions of footings (unformed excavation) | + 75 mm / - 25 mm |
| 9 | Thickness of footings | $\pm 5\%$, not exceeding 25mm |
| 10 | Footing eccentricity | 0.02 times the width of the footing inthe direction of deviation, but not more than 50 mm |
| 11 | Reduced level of top of footing / pier / bed block | ± 5 mm |
| 12 | Centre to centre distance of pier and abutments at piertop | 30 mm |
| 13 | Centre to centre distance of bearings along span | ± 5 mm |
| 14 | Centre to centre distance of pier bearings across span | ± 5 mm |
| 15 | Honey combing in any part of any member | Not more than 100mm in surface dimensions and not more than 20mm in depth. |

In prestressed concrete construction, permissible tolerances are 75% of the above permissible limits only.

XXIV) Tests & Standards of Acceptance

- i. Testing and acceptance of concrete shall be as per IRS Concrete Bridge Code read along with relevant

IS specifications.

- ii. Samples from fresh concrete shall be taken as per IS1199 and testing shall be as per IS516.
- iii. Random sampling and lot by lot of acceptance inspection shall be made for the 28 days cube strength of concrete. Concrete under acceptance shall be divided into lots for the purpose of sampling, before commencement of work. The delimitations of lots shall be determined by the following:
 - No individual lot shall be more than 30cum in volume.
 - At least one cube forming an item of sample representing the lot shall be taken from concrete of the same grade and mix proportions cast on any day.
 - Different grades of mixes of concrete shall be divided into separate lots.
 - Concrete of a lot shall be used in the same identifiable component of the structure.

XXV) Sampling and testing

- i. Concrete for making 3 test cubes shall be taken from a batch of concrete at point of delivery into construction. A random sampling procedure to ensure that each of the concrete batches forming the lot under acceptance inspection has equal chance of being chosen for taking cubes shall be adopted. 150mm cubes shall be made, cured and tested at the age of 28 days for compressive strength.
- ii. 3 test specimens shall be made from each sample for testing at 28 day. Additional cubes may be required for various purposes such as to determine the strength of the concrete at 7 days or any other purpose. The test strength of the sample shall be the average of strength of the 3 cubes. The individual variation should not be more than + 15% of average. When the individual variation exceeds this limit, the procedure for the fabrication of specimen and calibration of the testing machine should be checked and tested.
- iii. Frequency
The minimum frequency of sampling of concrete of each grade shall be in accordance with table below. At least one sample shall be taken from each shift of work.

| Quantity of concrete (m3) | No. of samples |
|---------------------------|---|
| 1-5 | 1 |
| 6-15 | 2 |
| 16-30 | 3 |
| 31-50 | 4 |
| 51 and above | 4 plus one additional samples for each additional 50m3 or part thereof. |

XXVI) Acceptance criteria

- i. It will be as per clause no. 8.7.6 of IRS Concrete bridge code and the following instructions shall be strictly followed.
- ii. Whenever a mix is re designed due to change in the quality of aggregate or cement or any other reason, it shall be considered a new mix and initially subject to the acceptance criteria above.
- iii. If the concrete produced in the site does not satisfy the above strength requirement the engineer in charge will reserve the right to require the contractor to improve the method of batching, the quality of the ingredients and design the mix with increased cement content, if necessary. The contractor shall not be entitled to claim any extra cost for the extra cement used for the modifications stipulated by the Engineer in charge for fulfilling the strength requirement specified.
- iv. It is the complete responsibility of the contractor to redesign the concrete mixes by approved standard methods and to produce the reinforced concrete conforming to the specification and the strength requirements approved by the engineer in charge. It is expected that the contractor will have competent staff to carry out this work.
- v. As frequently as the engineer in charge may require, testing shall be carried out in the field for:
 - test for silt content in sand
 - grading of fine aggregate
 - test for particle size

- Slump test
- Moisture content and absorption and density of sand and aggregate
- Concrete cube test
- Permeability test for concrete as per DIN 1048
- Density and Ph value of plasticizer

XXVII) Setting of field laboratory by the contractor

- i. For all the major works, the Contractor shall set up a field laboratory of his own for testing of cement/steel/water/concrete at work site, which should be open for use and inspection by the Railway officials at any time and carryout the tests with his own equipments, gauges, machinery, consumables and operators, at his own cost. The laboratory shall be equipped with necessary equipment to carry out various tests such as property tests, sieve analysis, setting time of cement, compression tests on cubes, slump test, workability test etc., on aggregate, cement, water and concrete required for ensuring the required quality. For steel and cement however, test reports of reputed institutes/laboratories are acceptable.
- ii. The cost of setting up the laboratory, equipping the same, maintaining, conducting all tests on materials and cubes shall be borne by the contractor, within his quoted rates for works and no extra payment is eligible for the same.
- iii. All gauges, machines, equipments and other measuring and testing equipment of the laboratory shall be got checked / calibrated regularly and the necessary certificate furnished to Engineer in charge by the contractor.
- iv. All the equipments, machinery etc., shall be kept in good working condition. Contractor shall also maintain therequired qualified/experienced staff at the laboratory.
- v. The following is the minimum laboratory facilities at the site which are to be provided and operated by the contractor at his cost.
 - Testing of aggregates – IS 383 & 2386
 - Testing of cement concrete - IS 8142 & 516
 - Testing of water – IS 456 & 3025
 - Compressive strength testing of cubes of M55 Concrete
- vi. Certain non-routine testing such as (a) Testing of admixtures, (b) Chemical testing of fine and coarse aggregates (c) Permeability of concrete (permeability test on concrete shall be got done when the mix design is approved/changed of the reputed laboratories as approved by Engineer-in-charge). The frequency and need for these tests shall be decided by the Engineer-in-charge, based on stipulations contained in conditions of contract or on the basis of accepted Engineering practice (e.g. whenever source of admixture is changed, tests stipulated in the codes will have to be carried out afresh, etc).