

Structural Concrete

1700

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1701. DESCRIPTION

The work shall consist of furnishing and placing structural concrete and incidental construction in accordance with these specifications and in conformity with the lines, grades and dimensions, as shown on the drawings or as directed by the Engineer.

1702. MATERIALS

All materials shall conform to Section 1000 of these Specifications.

1703. GRADES OF CONCRETE

1703.1. The grades of concrete shall be designated by the characteristic strength as given in Table 1700-1, where the characteristic strength is defined as the strength of concrete below which not more than 5 per cent of the test results are expected to fall.

TABLE 1700-1.

Grade Designation	Specified characteristic Compressive strength of 150 mm cubes at 28 days, in MPa
M 15	15
M 20	20
M 25	25
M 30	30
M 35	35
M 40	40
M 45	45
M 50	50
M 55	55

1703.2. The lowest grades of concrete in bridges and corresponding minimum cement contents and water-cement ratios shall be maintained as indicated in Tables 1700-2 and 1700-3.

TABLE 1700-2 FOR BRIDGES WITH PRESTRESSED CONCRETE OR THOSE WITH INDIVIDUAL SPAN LENGTHS MORE THAN 30 M OR THOSE THAT ARE BUILT WITH INNOVATIVE DESIGN/CONSTRUCTION

(A) MINIMUM CEMENT CONTENT AND MAXIMUM WATER CEMENT RATIO

Structural Member	Min. cement content for all exposure conditions (kg/cu.m)	Max. water cement ratio	
		Normal	Severe
a) PCC members	360	0.45	0.45
b) RCC members	400	0.45	0.40
c) PSC members	400	0.40	0.40

(B) MINIMUM STRENGTH OF CONCRETE

Member	Conditions of Exposure	
	Moderate	Severe
a) PCC members	M 25	M 30
b) RCC members	M 35	M 40
c) PSC members	M 35	M 40

TABLE 1700-3. FOR BRIDGES OTHER THAN THOSE MENTIONED IN TABLE 1700-2 AND FOR CULVERTS AND OTHER INCIDENTAL CONSTRUCTION

(A) MINIMUM CEMENT CONTENT AND MAXIMUM WATER CEMENT RATIO

Structural Member	Min. cement content (kg/cu.m)		Max. water cement ratio	
	Exposure conditions		Exposure conditions	
	Normal	Severe	Normal	Severe
a) PCC members	250	310	0.50	0.45
b) RCC members	310	400	0.45	0.40

(B) MINIMUM STRENGTH OF CONCRETE

Member	Conditions of Exposure	
	Moderate	Severe
a) PCC members	M 15	M 20
b) RCC members	M 20	M 25

Notes Applicable to Tables 1700-2 and 1700-3

- (i) The minimum cement content is based on 20 mm aggregate (nominal max. size). For 40 mm and larger size aggregates, it may be reduced suitably but the reduction shall not be more than 10 per cent.
- (ii) For underwater concreting, the cement content shall be increased by 10 per cent.
- (iii) Severe conditions of exposure shall mean alternate wetting and drying due to sea spray, alternate wetting and drying combined with freezing and buried in soil having corrosive effect.
- (iv) Moderate conditions of exposure shall mean other than those mentioned in (iii) above.

The cement content shall be as low as possible but not less than the quantities specified above. In no case shall it exceed 540 kg/cu.m. of concrete.

1703.3. Concrete used in any component or structure shall be specified by designation along with prescribed method of design of mix i.e. "Design Mix" or "Nominal Mix". For all items of concrete, only "Design Mix" shall be used, except where "Nominal Mix" concrete is permitted as per drawing or by the Engineer. "Nominal Mix" may be

permitted only for minor bridges and culverts or other incidental construction where strength requirements are upto M 20 only. "Nominal Mix" may also be permitted for non-structural concrete or for screed below open foundations.

1703.4. If the Contractor so elects, the Engineer may permit the use of higher grade concrete than that specified on the drawing, in which event the higher grade concrete shall meet the specifications applicable thereto without additional compensation.

1704. PROPORTIONING OF CONCRETE

Prior to the start of construction, the Contractor shall design the mix in case of "Design Mix Concrete" or propose nominal mix in case of "Nominal Mix Concrete", and submit to the Engineer for approval, the proportions of materials, including admixtures to be used. Water-reducing admixtures (including plasticisers or super-plasticisers) may be used at the Contractor's option, subject to the approval of the Engineer. Other types of admixtures shall be prohibited, unless specifically permitted by the Engineer.

1704.1. Requirements of Consistency

The mix shall have the consistency which will allow proper placement and consolidation in the required position. Every attempt shall be made to obtain uniform consistency.

The optimum consistency for various types of structures shall be as indicated in Table 1700-4, or as directed by the Engineer. The slump of concrete shall be checked as per IS:516.

TABLE 1700-4.

	TYPE	SLUMP (mm)
1	(a) Structures with exposed inclined surface requiring low slump concrete to allow proper compaction	25
	(b) plain cement concrete	25
2.	RCC structures with widely spaced reinforcements; e.g. solid columns, piers, abutments, footings, well steining	40 - 50
3.	RCC structures with fair degree of congestion of reinforcement; e.g. pier and abutment caps, box culverts well curb, well cap, walls with thickness greater than 300 mm	50 - 75
4.	RCC and PSC structures with highly congested reinforcements e.g. deck slab girders, box girders, walls with thickness less than 300 mm	75 - 125
5.	Underwater concreting through tremie e.g. bottom plug, cast-in-situ piling	100 - 200

1704.2. Requirements for Designed Mixes

1704.2.1. Target mean strength

The target mean strength of specimen shall exceed the specified characteristic compressive strength by at least the "current margin".

- (i) The current margin for a concrete mix shall be determined by the Contractor and shall be taken as 1.64 times the standard deviation of sample test results taken from at least 40 separate batches of concrete of nominally similar proportions produced at site by the same plant under similar supervision, over a period exceeding 5 days, but not exceeding 6 months.
- (ii) Where there is insufficient data to satisfy the above, the current margin for the initial design mix shall be taken as given in Table 1700-5 :

TABLE 1700-5.

Concrete Grade	Current Margin (MPa)	Target Mean Strength (MPa)
M 15	10	25
M 20	10	30
M 25	11	36
M 30	12	42
M 35	12	47
M 40	12	52
M 45	13	58
M 50	13	63
M 55	14	69

The initial current margin given in the Table 1700-5 shall be used till sufficient data is available to determine the current margin as per sub-clause (i) above.

1704.2.2. Trial mixes

The Contractor shall give notice to enable the Engineer to be present at the making of trial mixes and preliminary testing of the cubes. The Contractor shall prepare trial mixes, using samples of approved materials typical of those he proposes to use in the works, for all grades to the Engineer's satisfaction prior to commencement of concreting. The initial trial mixes shall generally be carried out in an established laboratory approved by the Engineer. In exceptional cases, the Engineer may permit the initial trial mixes to be prepared at the site laboratory of the Contractor, if a full fledged concrete laboratory has been established well before the start of construction, to his entire satisfaction. In all cases, complete testing of materials forming the constituents of proposed Design Mix shall have been carried out prior to making trial mixes.

Sampling and testing procedures shall be in accordance with these specifications.

When the site laboratory is utilised for preparing initial mix design, the concreting plant and means of transport employed to make the trial mixes shall be similar to that proposed to be used in the works.

Test cubes shall be taken from trial mixes as follows. For each mix, set of six cubes shall be made from each of three consecutive batches. Three cubes from each set of six shall be tested at an age of 28 days and three at an earlier age approved by the Engineer. The cubes shall be made, cured, stored, transported and tested in accordance with these specifications. The average strength of the nine cubes at 28 days shall exceed the specified characteristic strength by the current margin minus 3.5 MPa.

1704.2.3. Control of strength of design mixes

a) Adjustment to Mix Proportions

Adjustments to mix proportions arrived at in the trial mixes shall be made subject to the Engineer's approval, in order to minimise the variability of strength and to maintain the target mean strength. Such adjustments shall not be taken to imply any change in the current margin.

b) Change of Current Margin

When required by the Engineer, the Contractor shall recalculate the current margin in accordance with Clause 1704.2.1. The recalculated value shall be adopted as directed by the Engineer, and it shall become the current margin for concrete produced subsequently.

c) Additional Trial Mixes

During production, the Contractor shall carry out trial mixes and tests, if required by the Engineer, before substantial changes are made in the material or in the proportions of the materials to be used, except when adjustments to the mix proportions are carried out in accordance with sub-clause (a) above.

1704.3. Requirements of Nominal Mix Concrete

Requirements for nominal mix concrete unless otherwise specified, shall be as detailed in Table 1700-6.

TABLE 1700-6. PROPORTIONS FOR NOMINAL MIX CONCRETE

Concrete Grade	Total Quantity of dry aggregate by mass per 50 kg of cement to be taken as the sum of individual masses of fine and coarse aggregates (kg)	Proportion of fine to Coarse aggregate (by mass)
M15	350	Generally 1:2, subject to upper limit 1:1.5 and lower limit of 1:2.5
M20	250	—do—

1704.4. Additional Requirements

Concrete shall meet with any other requirements as specified on the drawing or as directed by the Engineer. Additional requirements shall also consist of the following overall limits of deleterious substances in concrete :

- a) The total chloride content of all constituents of concrete as a percentage of mass of cement in mix shall be limited to values given below:

- Prestressed Concrete	:	0.1 per cent
- Reinforced concrete exposed to chlorides in service (e.g. structures located near sea coast)	:	0.2 per cent
- Other reinforced concrete construction	:	0.3 per cent
- b) The total sulphuric anhydride (SO₃) content of all the constituents of concrete as a percentage of mass of cement in the mix shall be limited to 4 per cent

1704.5. Suitability of Proposed Mix Proportions

The Contractor shall submit the following information for the Engineer's approval :

- a) Nature and source of each material
- b) Quantities of each material per cubic metre of fully compacted concrete
- c) Either of the following :
 - (i) appropriate existing data as evidence of satisfactory previous performance for the target mean strength, current margin, consistency and water/cement ratio and any other additional requirement(s) as specified.
 - (ii) full details of tests on trial mixes.
- d) Statement giving the proposed mix proportions for nominal mix concrete.

Any change in the source of material or in the mix proportions shall be subject to the Engineer's prior approval.

1705. ADMIXTURES

Use of admixtures such as superplasticisers for concrete may be made with the approval of the Engineer.

As the selection of an appropriate concrete admixture is an integral part of the mix design, the manufacturers shall recommend the use of any one of his products only after obtaining complete knowledge of all the actual constituents of concrete as well as methodologies of manufacture, transportation and compaction of concrete proposed to be used in the project.

1706. SIZE OF COARSE AGGREGATE

The size (maximum nominal) of coarse aggregates for concrete to

be used in various components shall be given as Table 1700-7.

TABLE 1700-7.

Components	Maximum Nominal Size of Coarse Aggregate (mm)
i) RCC well curb	20
ii) RCC/PCC well steining	40
iii) Well cap or Pile Cap Solid type piers and abutments	40
iv) RCC work in girders, slabs, wearing coat, kerb, approach slab, hollow piers and abutments, pier/abutment caps, piles	20
v) PSC work	20
vi) Any other item	As specified by Engineer

Maximum nominal size of aggregates shall also be restricted to the smaller of the following values :

- a) 10 mm less than the minimum lateral clear distance between main reinforcements
- b) 10 mm less than the minimum clear cover to the reinforcements

The proportions of the various individual size of aggregates shall be so adjusted that the grading produces densest mix and the grading curve corresponds to the maximum nominal size adopted for the concrete mix.

1707. EQUIPMENT

Unless specified otherwise, equipment for production, transportation and compaction of concrete shall be as under :

- a) For Production of Concrete :
 - i) For overall bridge length of less than 200 metres - batch type concrete mixer diesel or electric operated, with a minimum size of 200 litres, automatic water measuring system and integral weigher (hydraulic/pneumatic type)
 - ii) For overall bridge length of 200 metres or more - concrete batching and mixing plant fully automatic with minimum capacity of 15 cu.m. per hour.

All measuring devices of the equipment shall be maintained in a clean and serviceable condition. Its accuracy shall be checked over the range in use, when set up at each site and thereafter periodically as directed by the Engineer.

The accuracy of the measuring devices shall fall within the following limits:

- | | |
|--------------------------|---|
| Measurement of Cement | ± 3 per cent of the quantity of cement in each batch |
| Measurement of Water | ± 3 per cent of the quantity of water in each batch |
| Measurement of Aggregate | ± 3 per cent of the quantity of aggregate in each batch |
| Measurement of Admixture | ± 5 per cent of the quantity of admixture in each batch |
- b) For Concrete Transportation :
- | | |
|---------------------------------|--|
| i) Concrete dumpers | depending upon actual requirement
minimum 2 tonnes capacity |
| ii) Powered hoists | minimum 0.5 tonne capacity |
| iii) Chutes | |
| iv) Buckets handled by cranes | |
| v) Transit truck mixer | |
| vi) Concrete pump | |
| vii) Concrete distributor booms | |
| viii) Belt conveyor | |
| ix) Cranes with skips | |
| x) Tremies | |
- c) For Compaction of Concrete :
- | | |
|-----------------------|---|
| i) Internal vibrators | size 25 mm to 70 mm |
| ii) Form vibrators | minimum 500 watts |
| iii) Screed vibrators | full width of carriageway
(upto two lanes) |

1708. MIXING CONCRETE

Concrete shall be mixed either in a concrete mixer or in a batching and mixing plant, as per these specifications. Hand mixing shall not be permitted. The 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.

Mixing shall be continued till materials are uniformly distributed and a uniform colour 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. In no case shall mixing be done for less than 2 minutes.

Mixers which have been out of use for more than 30 minutes shall be thoroughly cleaned before putting in a new batch. Unless otherwise agreed to by the Engineer, 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 cement to another.

1709. TRANSPORTING, PLACING AND COMPACTION OF CONCRETE

The method of transporting and placing concrete shall be approved by the Engineer. 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 1.5 metres.

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 of its ingredients. The delivery end of the chute shall be as close as possible to the point of 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.

All formwork and reinforcement contained in it shall be cleaned and made free from standing water, dust, snow or ice immediately before placing of concrete.

No concrete shall be placed in any part of the structure until the approval of the Engineer has been obtained.

If concreting is not started within 24 hours of the approval being given, it shall have to be obtained again from the Engineer. Concreting then shall 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.

Except where otherwise agreed to by the Engineer, concrete shall be deposited in horizontal layers to a compacted depth of not more than 450 mm when internal vibrators are used and not exceeding 300 mm in all other cases.

Concrete when deposited shall have a temperature of not less than 5 degrees Celsius, and not more than 40 degrees Celsius. 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. It may be necessary to add retarding admixtures to concrete if trials show

that the periods indicated above are unacceptable. In all such matters, the Engineer's decision shall be final.

Concrete shall be thoroughly compacted by vibration or other means during placing and worked around the reinforcement, tendons or duct formers, embedded fixtures and into corners of the formwork to produce a dense homogeneous 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 minimise 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 a 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.

Mechanical vibrators used shall comply with IS:2502, IS:2506, IS:2514 and IS:4656.

1710. CONSTRUCTION JOINTS

Construction joints shall be avoided as far as possible and in no case the locations of such joints shall be changed or increased from those shown on the drawings, except with express approval of the Engineer. The joints shall be provided in a direction perpendicular to the member axis.

Location, preparation of surface and concreting of construction joints shall conform to the additional specifications given in *Appendix 1700II*.

1711. CONCRETING UNDER WATER

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 the Engineer before any work is started. Concrete shall contain 10 per cent more cement than that required for the same mix placed in the dry.

Concrete shall not be placed in water having a temperature below

5 degrees Celsius. The temperature of the concrete, when deposited, shall not be less than 16 degrees Celsius, nor more than 40 degrees Celsius.

Coffer dams or forms shall be sufficiently tight to ensure still water conditions, if practicable, and in any case to reduce the flow of water to less than 3 metres per minute through the space into which concrete is to be deposited. Coffer dams or forms in still water shall be sufficiently tight to prevent loss of mortar through the joints in the walls. Pumping shall not be done while concrete is being placed, or until 24 hours thereafter. To minimise the formation of laitance, great care shall be exercised not to disturb the concrete as far as possible while it is being deposited.

All under water concreting shall be carried out by tremie method only, 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 situation.

The top section of the tremie shall have a hopper large enough to hold one full batch of the mix or the entire contents of the transporting bucket as the case may be. The tremie pipe shall not be less than 200 mm in diameter and shall be large enough to allow a free flow of concrete and strong enough to withstand the external pressure of the water in which it is suspended, even if a partial vacuum develops inside the pipe. Preferably, flanged steel pipe of adequate strength for the job shall be used. A separate lifting device shall be provided for each tremie pipe with its hopper at the upper end. Unless the lower end of the pipe is equipped with an approved automatic check valve, the upper end of the pipe shall be plugged with a wadding of gunny sacking or other approved material before delivering the concrete to the tremie pipe through the hopper; so that when the concrete is forced down from the hopper to the pipe, it will force the plug (and along with it any water in the pipe) down the pipe and out of the bottom end, thus establishing a continuous stream of concrete. It will be necessary to raise slowly the tremie in order to allow a uniform flow of concrete, but it shall not be emptied so that water is not allowed to enter above the concrete in the pipe. At all times after placing of concrete is started and until all the required

quantity has been placed, the lower end of the tremie pipe shall be kept below the surface of the plastic concrete. This will cause the concrete to build up from below instead of flowing out over the surface and thus avoid formation of layers of laitance. If the charge in the tremie is lost while depositing, the tremie shall be raised above the concrete surface and unless sealed by a check valve, it shall be replugged at the top end, as at the beginning, before refilling for depositing further concrete.

1712. ADVERSE WEATHER CONDITIONS

1712.1. Cold Weather Concreting

Where concrete is to be deposited at or near freezing temperature, precautions shall be taken to ensure that at the time of placing, it has a temperature of not less than 5 degrees Celsius and that the temperature of the concrete shall be maintained above 4 degrees Celsius until it has thoroughly hardened. When necessary, concrete ingredients shall be heated before mixing but cement shall not be heated artificially other than by the heat transmitted to it from other ingredients of the concrete. Stock-piled aggregate may be heated by the use of dry heat or steam. Aggregates shall not be heated directly by gas or on sheet metal over fire. In general, the temperature of aggregates or water shall not exceed 65 degrees Celsius. Salt or other chemicals shall not be used for the prevention of freezing. No frozen material or materials containing ice shall be used. All concrete damaged by frost shall be removed. It is recommended that concrete exposed to freezing weather shall have entrained air and the water content of the mix shall not exceed 30 litres per 50 kg of cement.

1712.2. Hot Weather Conditions

When depositing concrete in very hot weather, precautions shall be taken so that the temperature of wet concrete does not exceed 40 degrees Celsius while placing. This shall be achieved by stacking aggregate under the shade and keeping them moist, using cold water, reducing the time between mixing and placing to the minimum, cooling formwork by sprinkling water, starting curing before concrete dries out and restricting concreting as far as possible to early mornings and late evenings. When ice is used to cool mixing water, it will be considered a part of the water in design mix. Under no circumstances shall the mixing operation be considered complete until all ice in the mixing drum has melted.

The Contractor will be required to state his methodology for the Engineer's approval when temperatures of concrete are likely to exceed 40 degrees Celsius during the work.

1713. PROTECTION AND CURING

Concreting operations shall not commence until adequate arrangements for concrete curing have been made by the Contractor.

Curing and protection of concrete shall start immediately after compaction of the concrete to protect it from :

- a) Premature drying out particularly by solar radiation and wind
- b) High internal thermal gradients
- c) Leaching out by rain and flowing water
- d) Rapid cooling during the first few days after placing
- e) Low temperature or frost
- f) Vibration and impact which may disrupt the concrete and interfere with its bond to the reinforcement

Where members are of considerable size and length, with high cement content, accelerated curing methods may be applied, as approved by the Engineer.

1713.1. Water Curing

Water for curing shall be as specified in Section 1000.

Sea water shall not be used for curing. Sea water shall not come into contact with concrete members unless it has attained adequate strength.

Exposed surfaces of concrete shall be kept continuously in a damp or wet condition by ponding or by covering with a layer of sacks, canvas, Hessian or similar materials and shall be kept constantly wet for a period of not less than 14 days from the date of placing of concrete.

1713.2. Steam Curing

Where steam curing is adopted, it shall be ensured that it is done in a suitable enclosure to contain the live steam in order to minimise moisture and heat losses. The initial application of the steam shall be after about four hours of placement of concrete to allow the initial set of the concrete to take place.

Where retarders are used, the waiting period before application of the steam shall be increased to about six hours.

The steam shall be at 100 per cent relative humidity to prevent loss of moisture and to provide excess moisture for proper hydration of the cement. The application of steam shall not be directly on the concrete and the ambient air temperature shall increase at a rate not exceeding

5 degrees Celsius per hour until a maximum temperature of 60 degrees Celsius to 70 degrees Celsius is reached. The maximum temperature shall be maintained until the concrete has reached the desired strength.

When steam curing is discontinued, the ambient air temperature shall not drop at a rate exceeding 5 degrees Celsius per hour until a temperature of about 10 degrees Celsius above the temperature of the air to which the concrete will be exposed, has been reached.

The concrete shall not be exposed to temperatures below freezing for at least six days after curing.

1713.3. Curing Compounds

Curing compounds shall only be permitted in special circumstances and will require specific approval of the Engineer. Curing compounds shall not be used on any surface which requires further finishing to be applied. All construction joints shall be moist, cured and no curing compound will be permitted in locations where concrete surfaces are required to be bonded together.

Curing compounds shall be continuously agitated during use. All concrete cured by this method shall receive two applications of the curing compound. The first coat shall be applied immediately after acceptance of concrete finish. If the surface is dry, the concrete shall be saturated with water and curing compound applied as soon as the surface film of water disappears. The second application shall be made after the first application has set. Placement in more than two coats may be required to prevent streaking.

1714. FINISHING

Immediately after the removal of forms, exposed bars or bolts, if any, shall be cut inside the concrete member to a depth of at least 50 mm below the surface of the concrete and the resulting holes filled with cement mortar. All fins caused by form joints, all cavities produced by the removal of form ties and all other holes and depressions, honeycomb spots, broken edges or corners, and other defects, shall be thoroughly cleaned, saturated with water, and carefully pointed and rendered true with mortar of cement and fine aggregate mixed in the proportions used in the grade of concrete that is being finished and of as dry a consistency as is possible to use. Considerable pressure shall be applied in filling and pointing to ensure thorough filling in all voids. Surfaces which have been pointed shall be kept moist for a period of

twenty four hours. Special pre-packaged proprietary mortars shall be used where appropriate or where specified in the drawing.

All construction and expansion joints in the completed work shall be left carefully tooled and free from any mortar and concrete. Expansion joint filler shall be left exposed for its full length with clean and true edges.

Immediately on removal of forms, the concrete work shall be examined by the Engineer before any defects are made good.

- a) The work that has sagged or contains honeycombing to an extent detrimental to structural safety or architectural appearance shall be rejected.
- b) Surface defect of a minor nature may be accepted. On acceptance of such work by the Engineer, the same shall be rectified as directed by the Engineer.

1715. TOLERANCES

Tolerances for dimensions/shape of various components shall be as indicated in these specifications or shown on the drawings or as directed by the Engineer.

1716. TESTS AND STANDARDS OF ACCEPTANCE

1716.1. Concrete shall conform to the surface finish and tolerance as prescribed in these specifications for respective components.

1716.2. Random sampling and lot by lot of acceptance inspection shall be made for the 28 days cube strength of concrete.

1716.2.1. Concrete under acceptance shall be notionally divided into lots for the purpose of sampling, before commencement of work. The delimitation of lots shall be determined by the following :

- (i) No individual lot shall be more than 30 cu.m. in volume
- (ii) At least one cube forming an item of the sample representing the lot shall be taken from concrete of the same grade and mix proportions cast on any day.
- (iii) Different grades of mixes of concrete shall be divided into separate lots
- (iv) Concrete of a lot shall be used in the same identifiable component of the bridge

1716.2.2. Sampling and testing

1. Concrete for making 3 test cubes shall be taken from a batch of concrete at point of delivery into construction, according to procedure laid down in IS:1199.
2. 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.
3. 150 mm cubes shall be made, cured and tested at the age of 28 days for compressive strength in accordance with IS:516. The 28-day test strength result for each cube shall form an item of the sample.

1716.2.3. Test specimen and sample strength : Three test specimens shall be made from each sample for testing at 28 days. Additional cubes may be required for various purposes such as to determine the strength of concrete at 7 days or for any other purpose.

The test strength of the sample shall be the average of the strength of 3 cubes. The individual variation should not be more than ± 15 per cent of the average.

1716.2.4. Frequency : The minimum frequency of sampling of concrete of each grade shall be in accordance with Table 1700-8

TABLE 1700-8

Quantity of Concrete in work, m ³	No. of samples
1 - 5	1
6 - 15	2
16 - 30	3
31 - 50	4
51 and above.	4 plus one additional sample for each additional 50 m ³ or part thereof

At least one sample shall be taken from each shift of work.

1716.2.5. Acceptance criteria

Compressive Strength

When both the following conditions are met, the concrete complies with the specified compressive strength :

- a) The mean strength determined from any group of four consecutive samples should exceed the specified characteristic compressive strength.
- b) Strength of any sample is not less than the specified characteristic compressive strength minus 3 MPa.

The quantity of concrete represented by the test results include the batches from which the first and last samples were taken, together with all intervening batches.

Chloride and Sulphate Content

The total chloride and sulphuric anhydride (SO₃) content of all the constituents of concrete as a percentage of mass of cement in the mix shall not exceed the values given in this section of the specifications.

1716.3. Density of Fresh Concrete

Where minimum density of fresh concrete is specified, the mean of any four consecutive samples shall not be less than the specified value and any individual sample result shall not be less than 97.5 per cent of the specified value.

1716.4. Density of Hardened Concrete

Where minimum density of hardened concrete is specified, the mean of any four consecutive samples shall not be less than the specified value and any individual sample result shall not be less than 97.5 per cent of the specified value.

1716.5. Permeability Test

The concrete should pass the following test if it is properly compacted and is not considered permeable.

- (i) Prepare a cylindrical test specimen 150 mm dia and 160 mm high
- (ii) After 28 days of curing, the test specimen is fitted in a machine such that the specimen can be placed in water under pressure upto 7 bars. A typical machine is shown in *Appendix 1700/III*.
- (iii) At first a pressure of one bar is applied for 48 hours, followed by 3 bars for 24 hours and 7 bars for next 24 hours.
- (iv) After the passage of the above period, the specimen is taken out and split in the middle by compression applied on two round bars on opposite sides above and below.
- (v) The water penetration in the broken core is to be measured with a scale and the depth of penetration assessed in mm (max. permissible limit 25 mm).

1716.6. If the concrete is not able to meet any of the standards of acceptance as prescribed, the effect of such deficiency on the structure shall be investigated by the Contractor as directed by the Engineer. The Engineer may accept the concrete as sub-standard work. Any additional work required by the Engineer for such acceptance shall be carried out by the Contractor at his cost. In case the concrete is not found to be acceptable after investigation, the Contractor shall remove the rejected concrete forthwith.

1717. MEASUREMENTS FOR PAYMENT

Structural concrete shall be measured in cubic metres. In reinforced or prestressed concrete, the volume occupied by reinforcement or prestressing cables and sheathing shall not be deducted. The slab shall be measured as running continuously through and the beam as the portion below the slab.

1718. RATE

The contract unit rate for structural concrete shall cover costs of all materials, labour, tools, plant and equipment required for mixing, transporting and placing in position, vibrating and compacting, finishing and curing as per this Section or as directed by the Engineer, including all

incidental expenses, sampling and testing, quality assurance and supervision. Unless mentioned separately as an item in the Contract, the contract unit rate for concrete shall also include the cost of providing, fixing and removing formwork required for concrete work as per Section 1500.

Where concrete is found to be acceptable as sub-standard work, the Contractor shall pay a discount over the contract unit rate, as decided by the Engineer. For deficiency in compressive strength of concrete when accepted by the Engineer, the reduction in rate may be applied as under :

$$\text{Per cent reduction} = \frac{\text{Design Strength} - \text{Observed Strength}}{\text{Design Strength}} \times 100$$
