


**FABRICATION, INSTALLATION OF NEW PONTOON AND
REPAIR AND MAINTENANCE OF EXISTING PONTOON FOR
RORO/ROPAX FACILITY AT GHOGHA- GUJARAT**

(DPA/RORO/2024, Dated:25/07/2024)

PART 3 – TECHNICAL DOCUMENTS

	<p>FABRICATION, INSTALLATION OF NEW PONTOON AND REPAIR AND MAINTENANCE OF EXISTING PONTOON FOR RORO/ROPAX FACILITY AT GHOGHA- GUJARAT. SPECIFICATION FOR CIVIL AND MARINE WORKS</p>	<p>PAGE: 2/ 69 01 Feb 2024</p>
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TENDER DOCUMENT

FOR

**FABRICATION, INSTALLATION OF NEW
PONTOON AND REPAIR AND
MAINTENANCE OF EXISTING PONTOON
FOR RORO/ROPAX FACILITY AT
GHOGHA- GUJARAT.**

VOLUME II

SPECIFICATION FOR CIVIL AND MARINE WORKS



DEENDAYAL PORT AUTHORITY

ADMINISTRATIVE OFFICE BUILDING

POST BOX NO. 50

GANDHIDHAM (KUTCH)

GUJARAT – 370201

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1. CONCRETE

1.1. General Specifications

1.1.1. National Specifications

Unless otherwise stated in these Specifications, the materials and construction of the Works shall comply in all respects with the latest edition of I.S. 456 and I.S. 13920, other relevant IS codes together with the latest editions of all relevant Indian Standard Specifications and Codes of Practice.

1.1.2. Concrete for the Works

Concrete for the Works shall be produced on Site using floating batching plant for piling and all in situ works. For precast concrete work concrete produced at site or ready-mixed concrete plants located in the vicinity of the Site can be used.

For Site produced concrete, the Contractor shall provide details of his quality control procedures to the Engineer for approval prior to the preparation of the trial mixes. Once design mix is approved, the Engineer will monitor the operation of these procedures during the course of the Works and any deviations from those procedures will be corrected by the Contractor at his own expense.

The Contractor shall provide a field material testing laboratory including such assistance as may be necessary. The laboratory shall be equipped to carry out all routine tests on concrete making materials and concrete as per relevant Indian Standards and any other standards referred to in this Specification. The material testing laboratory shall be maintained in a clean and efficient manner throughout the currency of the Contract by the Contractor at their own cost. The rates quoted by Contractor shall be inclusive of all the costs related to sampling, testing and maintaining the testing laboratory at site with requisite qualified personnel.

1.1.3. Definitions

Cement	Hydraulic binder that sets and hardens by chemical interaction with water and is capable of doing so under water.
Characteristic Strength	That value of strength below which not more than 5% of the test results of all possible strength measurements of the specified concrete are expected to fall.
	Cement Content Mass of cement contained in a cubic metre of fresh, fully compacted concrete, expressed in kg/m^3 .
Free Water/Cement Ratio	Ratio of the mass of free water (that is, excluding the

water absorbed by the aggregate to reach a saturated surface dry condition) to the mass of cement in a concrete mix.

Certified Average Alkali Content The average of 25 consecutive determinations of equivalent alkali content, expressed as the sodium oxide equivalent, carried out on samples each of which is representative of a day's production.

Declared Mean Alkali Content

The mean alkali content, expressed as the sodium oxide equivalent, which will not be exceeded without prior notice from the manufacturer. This is the certified alkali content plus a margin that reflects the manufacturer's variability of production.

Guaranteed Alkali Limit

The alkali limit, expressed as the sodium oxide equivalent, which the manufacturer guarantees will not be exceeded by any test result, on any spot sample.

1.2. Site Specific Requirements

1.2.1. Permitted Types of Cement

Type	Standard Specification
Portland Slag Cement (PSC) with compressive strength satisfying the requirement of OPC grade 53	I.S. – 455 (1989)

1.2.2. Cement Properties

Property	Maximum Permissible Value	Test
Alkali Limit (as Na ₂ O equivalent)	0.6 per cent	I.S.- 4032

1.2.3. Permitted Aggregates

Type	Standard Specification
Natural River Sand	I.S. – 383

M-sand/Crushed sand satisfying the requirements of IS 456, IS 383 and other codal requirements and grading, strength, fineness modulus etc. is acceptable subjected to approval by Engineers / Engineer's Representative.

1.2.4. Aggregate Properties

Property	Maximum Permissible Value	Test
Flakiness Index	15% (in case of Pumped Concrete, use of flaky)	I.S. 2386 Part I

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Property	Maximum Permissible Value	Test
	aggregate shall be avoided)	
Elongation Index	25%	I.S. - 2386 Part I
Water Absorption	2% by weight	I.S. - 2386 Part III
Aggregate Abrasion Value	30%	I.S. - 2386 Part IV
Aggregate Crushing Value	45%	I.S. - 2386 Part IV
Magnesium Sulphate Soundness loss over 5 cycles	18% for coarse aggregate 15% for fine aggregate	I.S. - 2386 Part V
Sodium Sulphate Soundness loss over 5 cycles	12% for coarse aggregate 10% for fine aggregate	I.S. - 2386 Part V
Limits of deleterious materials in coarse and fine aggregate	As per I.S. - 383, Clause 3.2.1 Table I	I.S. - 2386 Part II
Chloride Content (expressed as chlorine)	0.02% by weight of aggregate dried at 105°C	I.S. - 2386 Part VII/ DIN 4226 Part 3, Clause 3.6.5
Sulphate Content (SO ₃)	0.5% by weight of aggregates dried at 105°C	I.S. - 2386 Part VII/ DIN 4226 Part 3 Clause 3.6.4

1.2.5. Concrete Mix Schedule

Concrete Grade	M 20	M 40	M 40	M 20	M40	M30
Usage	Mass Concrete (above water)	Reinforced Concrete (above water)	Reinforced Concrete (Precast)	Mass Concrete (under water)	Reinforced Concrete (under water)	Reinforced Concrete (above water)
Type of Mix	Design Mix	Design Mix	Design Mix	Design Mix	Design Mix	Design Mix
Cement Type	As specified above					

Nominal max aggregate size	20 mm	20 mm	20 mm	20 mm	20mm	20 mm
Concrete characteristic strength N/mm ²	20	40	40	20	40	30
Min. Cement content kg/m ³	280	400	400	350	450	350

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Sample rate m ³ /sample		As specified below.					
Workability	Slump (mm)	75-100	75-100	75-100	150-200	150-200	75-100
Max. free water/cement ratio		0.45	0.45	0.45	0.45	0.45	0.45
Max. cement content kg/m ³		500	500	500	500	500	500
Total Drying Shrinkage strain		0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
Admixtures	Specified	No	No	No	No	No	No
	Permitted	See Note 1	See Note 1	See Note 1	See Note 1	See Note 1	See Note 1
	Amount	As per manufacturer's recommendations and approved by the Engineer					
Air content		Zero	Zero	Zero	Zero	Zero	Zero
Air Temperature on Placement °C	Maximum	38	38	38	38	38	38
	Minimum	5	5	5	5	5	5
Density of Concrete kg/m ³	Minimum	2400	2400	2400	2400	2400	2400
Fibres	Kg/m ³	Permitted	Permitted	Permitted	Permitted	Permitted	Permitted
Max. Temperature of Concrete at time of placing		40°C	40°C	40°C	40°C	40°C	40°C

Notes

- Water reducing admixtures, retarders, plasticizers all of approved make, will be permitted.
- Bi-polar Concrete Penetrating Corrosion inhibiting admixture shall be provided for all RCC works

1.2.6. Concrete Mix Properties

Property	Value
Total water-soluble sulphate content, expressed as SO ₃	4.0% max by mass of cement in the mix in accordance with IS 456
Total acid-soluble chloride content of the mix expressed as chloride ions	0.6% max by wt of cement for unreinforced concrete 0.3% max by wt of cement for reinforced concrete 0.1% max by wt of cement for prestressed concrete or in accordance with IS 456

1.2.7. Information to be submitted to the Engineer

Certificates of Conformity
Personnel, Foreman, Mixer Operators, Vibrator Operators.
Approval of Cement Supply
Manufacturer's Cement Test Certificates

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Sources of Aggregates
Aggregate Test Certificates
Site Processing of Aggregates
Source of Water
Approval of Admixtures
Approval of Corrosion Inhibitor
Prior Approval of Mix Proportions
Proposals for Minimising the Risk of Damaging Alkali-Silica Reaction
Approval of Batching Methods
Mixing Plant
Position & Form of Construction Joints

1.2.8. Personnel, Foremen, Mixer Operators, Vibrator Operators.

Personnel: A fully qualified and experienced concrete quality control Engineer shall be employed by the Contractor and shall be available on Site at all times when concreting is taking place. Prior to commencement of the Works, the Contractor shall submit for the approval of the Engineer, details of qualifications and experience of the personnel to be engaged in the work of concrete and quality control.

Foremen: Fully experienced foremen shall be in charge of all concrete placing gangs. **Plant/Mixer Operators:** Only approved experienced mixer operators shall be employed.

The operators shall be trained in the operation of the plant and shall be subject to checking and approval by the Engineer.

Vibrator operators: Mechanical vibrators shall be operated only by trained and experienced workmen who shall be named to the Engineer and tested and approved by him.

1.3. Cement

Cement to be used for civil, marine and structural works shall be Portland Slag Cement only as per IS:455 with compressive strength not less than grade 53 Ordinary Portland Cement. **Fly ash mixing with cement is NOT permitted.**

1.3.1. Permitted Types of Cement

Changing of types and brands of cement within the same structure or part thereof will not be permitted. Change of brand will be permitted with prior approval of Engineer subject to re-design of concrete mix design.

1.3.2. Approval of Cement Supply



Supply of cement for the Works shall be arranged by the Contractor.

So far as is possible cement of a required type shall be supplied from only one source throughout the execution of the Works, and no variations in source of supply shall be made without the approval of the Engineer.

The approval of the Engineer to any type of cement shall not relieve the Contractor his responsibility and at any time the Engineer may give notice for removal of any consignment of cement from the Site if such consignment does not in every way comply with the requirements of this Specification.

Before any cement is ordered or brought on to Site, the Contractor shall submit to the Engineer for his approval a detailed list of the sources / manufacturers and manufacturer's brand names of all types of cement which he proposes to use in the Works, as per the Cement records contained in Appendix A (At the end of this section) to this document.

This shall be accompanied by full details of the composition and properties of cement, as set out in the Cement Properties Table. This shall be completed for each type of cement and for each proposed source / manufacturer, as per the Cement Properties Table contained in Appendix A to this document (Performa given at the end of this section).

1.3.3. Manufacturer's Cement Test Certificates


Manufacturer's Works test certificates shall be furnished to the Engineer for all consignments of cement and no cement shall be used in the Works until the Engineer has been satisfied that it has been tested and complies with the relevant standard specifications.

1.3.4. Sampling and Testing of Cement

Notwithstanding the submission by the Contractor of the information detailed above, the Engineer may at any time order any further tests which he considers necessary for the purpose of establishing the true quality of the cement proposed and the concrete produced there from, under actual Site conditions and with the aggregates proposed by the Contractor, before giving his approval to any cement.

Any consignment of cement delivered to the Site may be subject to testing, if directed by the Engineer. Cement in storage may also be subject to testing to check that it has not deteriorated. Cement which is not used within 90 days from its date of manufacture shall be tested. The Engineer shall take samples from different containers and he will despatch them to a laboratory approved by him for testing.



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The cement from the consignment from which the samples have been extracted for testing shall not be used in the Works before completion of testing and analysis and until it has been accepted as satisfactory by the Engineer.

Should the results of any of the tests provided for in this Clause show that any sample fails to meet the minimum requirements of this Specification, the whole consignment to which the sample belongs shall be rejected and be removed from the Site.

No cement from any consignment shall be used in the Works without the approval of the Engineer.

1.3.5. Failure to Supply Certificates or Carry out Tests

Failure to comply with either of the two requirements mention above, will render liable to rejection by the Engineer all work containing unapproved cement.

1.3.6. Delivery of Cement

The cement shall be delivered to the Site in such consignments to ensure satisfactory progress of the Works.

Except where bulk delivery is approved, cement shall be packaged by the manufacturer in bags or containers that are so designed as to prevent any contamination and to minimise loss of Contents and the adverse effects of moisture and high humidity during transportation and storage.


All bags and containers shall be delivered sealed to the satisfaction of the Engineer. Each shall be adequately and permanently marked with the manufacturer's name, the name of the producing works, the cement type, the standard specification to which it was made, the date of manufacture or date code and batch number, so as to enable correlation to be made of every part of each consignment with the relevant test certificates and delivery notes.

Cement, when being conveyed to the Site in lorries, vessels or other vehicles, shall be properly protected from the weather and from contamination of any kind. Any cement which proves to have been damaged or contaminated in transit will be rejected upon delivery.

Cement delivered in split bags or containers will be rejected.

Where bulk cement deliveries are proposed the Contractor shall obtain the prior consent of the Engineer to the method of delivery and shall provide all information required by the Engineer concerning off-site storage and loading arrangements. He shall also provide reasonable



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facilities for the Engineer to inspect these arrangements for approval and routine inspection purposes. The temperature of cement delivered in bulk shall not exceed 65°C.

1.3.7. Storage of Cement

From the time that a consignment of cement is brought on the Site and tested and approved by the Engineer and until such time as cement is used in the Works, the Contractor shall be responsible for keeping the same in sound and acceptable condition.

If cement is to be stored in bulk containers these shall be subject to the prior approval of the Engineer and shall be large enough to contain such quantities as may be required with sufficient reserve to allow for the likely frequency of supply.

Cement stored in bulk containers shall be, in the opinion of the Engineer, adequately protected against rain, humidity, dewfall and dust, and all charging and discharging points shall be properly sealed. Aeration equipment for the bulk containers, if available, shall incorporate dehumidifiers.


If packaged cement is stored in bulk containers it shall be charged into the containers through a 5 mm mesh screen which is welded or bolted to and covers the entire feed area of the charging hopper.

Cement other than that stored in bulk shall be kept in the bags or containers in which it was delivered until use and shall be stored in a Dry Store large enough to contain such quantities as may be required with sufficient reserve to allow for the likely frequency of supply. Cement in bags or containers shall be unloaded under cover. This store shall be dry, well ventilated, perfectly weatherproof and waterproof and shall be so situated as not to be liable to flooding and shall have a floor raised not less than 60 cm from the ground in order to protect the cement from moisture. An air space shall be left between the floor and the bottom layer of the bags. Cement bags shall be stored well away from outer walls of the store and not more than 12 bags shall be stacked in any tier. Each consignment shall be stacked separately therein to permit easy access for inspection and a record shall be kept so that each consignment may be identified by a serial number and date of delivery.

Storage under tarpaulins shall not be permitted.

Each different type of cement approved for use and brought to Site shall be stored separately from one another.



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All cement shall be used in the order in which the consignments are delivered to the Site commencing with the consignment which has been in the store for the longest period of time. In general it shall be used as soon as possible after delivery and the cement procured by the contractor should not have aged more than 12 weeks, or when tests carried out on instruction of the Engineer show that the loss on ignition exceeds 4%.

Cement shall be adequately protected at all times from rain and spray. Cement which has set or partially set shall not be used in the Works.

Notwithstanding the above provision, any cement which the Engineer considers has become stale or unsuitable through absorption of moisture from the atmosphere or for other reasons shall be rejected and removed from the Site at the Contractor's expense. Any cement in containers damaged so as to allow the contents to spill or to be affected by atmospheric moisture prior to opening at the time of concrete mixing shall be rejected and removed from the Site at the Contractor's expense.

1.3.8. Performance Characteristics

Notwithstanding apparent compliance with all other requirements of this Specification, the Contractor shall be responsible for satisfying himself that the performance characteristics of the cement used in the Works are not such as to necessitate the use of excessive cement contents or be likely to cause or accentuate any undesirable properties in the fresh or hardened concrete.

1.4. Aggregates

1.4.1. Aggregates - Definitions

The term "Aggregate" shall mean all solid constituents of the concrete mix, other than cement or approved cementitious additives or approved admixtures, batched ready for charging into the mixers, whether such material is called "coarse aggregate", "fine aggregate" or "sand".

1.4.2. Aggregates - Standard Specifications

Aggregates supplied to the Site shall generally be naturally occurring gravel and/or crushed rock for coarse aggregates and naturally occurring river sand for fine aggregates complying with the requirements of I.S. 383, except as otherwise stated in this Specification. Lightweight aggregates shall not be used without the written approval of the Engineer unless specified as a requirement. Use of M-sand / crushed sand will be allowed if river sand is not available subjected to the satisfactory approval of the Engineer and sand satisfying all the requirements of river sand as per IS 383 requirements.

Aggregate shall be of approved quality, chemically inert, hard, clean, sharp and free from



injurious amounts of dust, silt, clay lumps, mica, shells, flaky particles, shales, alkali, organic matter, loam or other deleterious substances.

1.4.3. Sources of Aggregates

The Contractor shall supply the Engineer with full details of his proposed sources of supply of aggregates for the Contract, together with test results carried out by an approved laboratory, as soon as possible after receipt of the order to commence the Works. The Engineer shall have the right to inspect all proposed quarries and other sources of aggregate.

No aggregate shall be used in the Works until it has been approved by the Engineer and no change shall be made in any aggregate source without the prior approval of the Engineer.

The Engineer shall have the power to withdraw approval for any source of aggregate if the aggregate from that source fails to meet this Specification or for other reasons fails to produce concrete of required standard.

Any aggregate brought to Site which is not approved by the Engineer shall be immediately removed from the Site by the Contractor at his own cost.

1.4.4. Information Required on Aggregate Sources

The Contractor shall supply full details of the proposed sources of aggregates as listed below for approval by the Engineer, together with the results of sampling and testing carried out in accordance with these specifications, at contractor's cost.


- Name and address of supplier
- Location of deposits
- Nature of materials and principal rock type present
- History of previous use
- Method of extracting and processing
- Details of producers, laboratory facilities and technical staffing
- Stockpiling, loading and supply arrangements

1.4.5. Sampling of Aggregates

The following sampling of aggregates is required:-

- Each size of aggregate from each source shall be sampled as specified in I.S. 2430 at the discharge points on the production plant (i.e. conveyors or hoppers, NOT



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stockpiles) at three well-spaced time intervals during the course of each of three consecutive production days.

These samples shall be designated Production Samples.

- In addition selected samples shall be taken from producer's stockpiles or materials ready for loading which indicate any readily visible variations in physical characteristics, or appearance. These samples shall be designated Stockpile Samples.
- All samples shall be taken in the presence of the Engineer, if he so requires, and shall be tested as required below.
- Representative portions of the above samples which have been tested in accordance with these specifications, shall be taken for reference purposes and shall be split and retained on Site by both the Contractor and the Engineer to act as control samples for comparison with later deliveries.

1.4.6. Testing of Aggregates

Each Production Sample shall be tested in the following respect:-

- Proportion of natural (uncrushed) material (% by weight)
- Gradings; deleterious materials including clay, silt and fine dust and organic impurities (% by weight), I.S. 2386 (Parts I & II)
- Specific gravity and water absorption, I.S. 2386 (Part III)
- Flakiness and elongation indices, I.S. 2386 (Part I)

Representative portions of equal weight shall be taken from each of the nine Production Samples of each size of aggregate, and then combined to provide Composite Production Samples for each size of aggregate. The Composite Samples shall be tested in the same respects as the individual Production Samples and shall also be tested as follows, unless otherwise directed by the Engineer. Stockpile samples shall be compared with production samples and if differences are observed the Engineer will require appropriate tests to be carried out on the Stockpile samples.

The Engineer shall also have the option to test composite samples as follows if he so wishes:-

- Alkali Aggregate Reactivity tests. I.S. 2386 (Part VII)
- Soundness test: I.S. 2386 (Part V).
- Aggregate Crushing Value, I.S. 2386 (Part IV):
 - Test fraction in oven-dry condition
 - Test fraction in saturated surface-dry condition
- Aggregate Abrasion Value, I.S. 2386 (Part IV).
- Petrographic examination and description, including approximate composition,



I.S. 2386 (Part VIII)

1.4.7. Grading of Aggregates

Coarse Aggregate:

The maximum size of coarse aggregate shall be as specified. Coarse aggregate shall be delivered to the site and stored in single sizes and combined on batching to provide a graded aggregate all in accordance with the approved mix design. Where 10mm maximum size aggregate is required, 10mm single-sized grading shall be used.

Fine Aggregate:

Grading of fine aggregate shall be in accordance with Grading Zone II of Table IV of I.S. 383 and its fineness modulus shall not be less than 2.2 nor more than 3.2 Grading as well as fineness modulus shall be monitored regularly and continuously at source as well as at Site and if necessary sand from different approved sources shall be blended to achieve the desired grading and fineness modules.

All-in aggregate:

All-in aggregate and crushed stone sand shall not be used for reinforced concrete and shall only be used for un-reinforced concrete with the express written permission of the Engineer.

1.4.8. Aggregate Properties

While the aggregate properties given in the fore-going clauses are maximum values, lower values may be required to satisfy the overall limits required for concrete mixes as specified in subsequent clauses.

1.4.9. Staining


Aggregates shall not be composed of or contain inclusion of materials likely to cause staining or otherwise disfigure finished concrete surfaces.

1.4.10. Washing of Aggregates

Aggregates shall be Sieved and washed with fresh potable water, free of all silt, dust, chlorides, sulphates, organic or other impurities in an efficient washing plant before delivery to Site. The Contractor shall carryout the tests to check the efficiency of the washing of the aggregates shall be made at regular and frequent intervals in presence of Engineer's representative on site and the material for which the tests found to be unsatisfactory shall be rejected.

1.4.11. Sampling and Testing of Aggregates



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The method of sampling shall be in accordance with I.S. 2430. Tests, including grading and tests for chemical, physical and mechanical properties of the aggregate and the presence of deleterious impurities, including but not limited to silt, sulphates and chlorides, shall be carried out as required by the Contractor as instructed by Engineer, in accordance with relevant parts of I.S. 2386 except as specifically provided otherwise in the Specification.

The Engineer shall have the right to require the Contractor at any time to test samples of aggregates drawn from locations as indicated by the Engineer. Sampling shall be carried out in the presence of the Engineer.

1.4.12. Shipping of Aggregates

Whilst being conveyed to the Site, aggregates shall be covered to prevent dust or other contamination and all necessary precautions shall be taken to prevent segregation of sizes or crushing of aggregates.

Aggregates shall be delivered to the Site at least one day before use in such consignments as shall ensure satisfactory progress of the Works.

Aggregates from separate bins or from separate stockpiles at the source of supply shall be delivered to the Site in separate vehicles. Different sizes and grading shall not be transported in the same vehicle simultaneously.

1.4.13. Storage and Handling of Aggregates

Aggregates accepted for use in the Works shall be stored in accordance with I.S. 4082 in approved containers or on clean, hard, free draining paved areas draining away from the concrete mixing area, with adequate dividing walls of ample height and strength to prevent mixing of different types and sizes of aggregates. The surrounding areas where aggregates may be handled shall also be hard paved. All these areas shall not be liable to flooding. Details of the layout and siting of the storage areas shall be submitted to the Engineer for approval before they are constructed.

Containers and storage areas shall be self-draining. Particular care shall be taken in the construction and maintenance of such containers or storage areas and in the handling of materials to ensure that contamination by extraneous material such as air-borne dust, leaves or clay, organic and other deleterious matter or by harmful salts in the ground is prevented.

During delivery to and handling from the stockpile, care shall be taken to avoid crushing the aggregates or contamination with extraneous matter.



The general or localised build-up of fines or segregation of sizes in aggregate stockpiles shall not be allowed. If the Engineer is not satisfied that such segregation or build-up of fines has been prevented he may instruct the Contractor to turn over the contents of any stockpile or to remove all or part of the contents of any stockpile and either reprocess or dispose off such material.

The Contractor shall also employ such methods as may prove necessary to ensure effective cooling of the aggregates prior to batching for concrete (such as provision of sun-shades), subject to the approval and/or discretion of the Engineer. Spraying the aggregates with water will not be permitted.

1.4.14. Silt, Clay, Dust & other Deleterious Materials

The quantity of silt, clay, dust and other deleterious materials present in the aggregates for concrete at the time of use shall not exceed the limits laid down by I.S. 383. These shall be determined in accordance with the appropriate method given in I.S. 2386 (Parts I & II).

1.5. Water for Concreting

1.5.1. Water for Concreting

All water used for the mixing of concrete, grouts or mortar shall be clean fresh potable water. Potable water shall also be used for the curing of concrete and for the washing down of construction joints, removal of laitance, etc. It should not produce any stains or unsightly deposits on the concrete surface. The presence of tannic acid or iron compounds is objectionable. It shall have pH value of between 6.8 and 7.8. The water shall be free from deleterious matter in solution or suspension and shall meet the requirements of I.S. 456, in all respects. The permissible limits are given below:-

	Material	Maximum Limit (mg./litre)
a)	Suspended	2000
b)	Organic	200
c)	Inorganic	3000
d)	Sulphates (as SO ₄)	400
e)	Chlorides (as Cl)	2000 for plain cement concrete
		500 for reinforced cement concrete

However, the sulphate and chloride contents of the water shall be of such a level that, taking into account the sulphate and chloride contents of the other constituent materials, the overall sulphate and chloride contents of the various concrete, grout or mortar mixes do not exceed the limits laid down elsewhere in this Specification.

The Contractor shall make adequate arrangements to store sufficient water at the Site for use.



1.5.2. Source of Water

As soon as possible after receipt of the order to commence the Works, the Contractor shall supply the Engineer with full details of his proposed source or sources of water for use in the Works. These details shall at least include results of analysis listed below.

The Engineer's approval to use of a proposed source shall be obtained before water from that source is used for the Works.

Once the Engineer has approved any source of water this shall not be varied without his prior approval.

The Engineer shall have the power to withdraw approval for any source of water if the water from that source fails to meet this Specification.

1.5.3. Testing of Water

Tests on the purity, soluble sulphate, chloride or other chemical content, sediment and pH value shall be carried out generally once a month or at such times as the Engineer may direct. The Contractor shall arrange for the despatch of samples of water to an approved testing laboratory and for the testing required. Sampling and testing shall be witnessed by the Engineer.


1.6. Admixtures & Additives

1.6.1. Approval of Admixtures

No materials of any description shall be used in concrete mix other than aggregates, cement and water, except where specifically required by the Concrete Mix-Schedule without the written instruction or approval of the Engineer in each case. If more than one admixture is proposed for use in the same concrete mix, their interaction shall be checked by trial mixes by the Contractor to ensure their compatibility.

The Contractor should note that the description of any proposed admixture by trade or brand name will not be sufficient when proposing such admixture for the approval of the Engineer. In order to save delay the Contractor should submit the fullest possible description of the chemical composition of any admixture, together with its 'shelf life' and details of storage and handling requirements. He should also submit details of its anticipated effect on the particular mixes in which its use is proposed. The Contractor shall also submit details of how long the admixture has been used in India / abroad and details of the projects on which it was used and copies of independent test reports giving the effects of use of the admixture. If appropriate, the Contractor should also provide details of how the mix proportions are to be varied to



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produce the required characteristic strength and rate of strength gain.

The Contractor shall submit manufacturer's test certificates and technical literature of the admixture proposed to be used. If directed by the Engineer, the admixture shall be tested at an approved laboratory at no extra cost.

The Engineer will, wherever appropriate call for trial batches of concrete to be prepared to demonstrate the effect of the proposed admixtures both on the fresh concrete and on the hardened concrete before giving his approval. He may also lay down additional requirements for the control of the use of such admixtures.

Admixtures shall not be used which produce concretes that are less durable, more porous, have inferior surface structure, or are more susceptible to humidity or temperature movement than the corresponding concrete grade made without admixture. Admixtures that affect the density of the concrete, such as air-entraining agents, shall not be permitted.

Notwithstanding any previously given approval, the Engineer may withdraw such approval at any time with respect to any mix containing admixtures if, in his opinion, the performance of the particular admixture under actual Site conditions is not completely satisfactory.

1.6.2. Supply and Storage of Admixtures

Accelerating, retarding, water reducing admixtures shall conform to I.S. 9103, integral cement water proofing admixture to I.S. 2645, any other admixtures to B.S. 5075 if it is applicable, unless otherwise specified or agreed.


All admixtures to be used in dose forms shall be supplied in containers or packages marked with the recommended dosage for each type of mix in which they are to be used. Admixtures shall be stored strictly in accordance with manufacturers' recommendations and precautions shall be taken during delivery and storage to prevent damage to or adulteration of admixtures. This may include cleaning off sediment from the bottom of a storage tank, regular stirring, etc.

Any cement containing admixtures shall be supplied in bags or containers clearly marked to show the nature and quantity of such admixtures and shall be stored separately from any other type of cement.

1.6.3. Use of Admixtures

Any admixture used in any concrete mix shall only be used at the rate of dosage or in the proportions previously approved by the Engineer, method of mixing etc. all in accordance with the manufacturer's instructions and within the manufacturer's recommended ambient temperature range.



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In general, the dosage of retarders, plasticisers and super plasticisers shall be restricted to 0.5, 1.0 and 2.0 per cent respectively by weight of cement unless a higher value is agreed upon between the Engineer and the Contractor based on performance tests.

Any batch of concrete which has received an incorrect dose of an admixture or which shall show deterioration after placing as a result of incorrect use of admixtures, shall be broken out or otherwise replaced without charge to the Contract.

The relative density of liquid admixtures shall be checked for each drum containing the admixture and compared with the stated / specified value before acceptance. Liquid admixtures or powder admixtures that are to be used as solutions shall be dispensed by an appliance fixed to the mixer, which measures weight, volume or dosing time and is provided with a recorder. This appliance shall be accurately calibrated and the calibration and dosage shall be checked at regular intervals or as directed by the Engineer. All such admixtures shall be dispensed with the mixing water.

All admixture dispensers shall be thoroughly cleaned before commencing each day's work and at every interruption to the work.

Where admixtures are to be used in bulk form, these shall be weigh-batched as is provided in this Specification for the batching of cement.

Powder admixtures to be used in dose form shall only be allowed if premixed and used as solutions and then only if the premixing procedure has been previously approved by the Engineer.

Trial mixes shall be undertaken as described below, together with additional trial mixes showing the effect of overdosing and underdosing of the concrete mix.

1.6.4. Chlorides

Under no circumstances shall calcium chloride or chloride based admixtures be used in any concrete mix, grout or mortar. The chloride content of admixtures shall be independently tested in an approved laboratory for each batch of admixture before acceptance by the Contractor at no extra cost.

1.7. Mix Requirements

1.7.1. Concrete Grades

The concrete grades used in the Works shall comply with the requirements given in the



Design Mix Schedule.

1.7.2. Sulphate and Chloride Content of Concrete Mixes

The requirements laid down in this Specification for Sulphate and Chloride contents of the constituent materials of the concrete mixes, shall apply to all concrete mixes used in the Works and shall be calculated as the total of the various constituents of the mix.

1.7.3. Prior Approval of Mix Proportions

Within 15 days after the commencement of the Contract, the Contractor shall produce in writing, for the Engineer's approval, his proposals for all concrete mixes of the grades set out in this Specification including mix design calculations in triplicate, stating proportions of all constituent materials, including admixtures, Sieve analysis of aggregates, workability, etc.

The Contractor must note that ample time should be allowed for testing and obtaining the approval of the Engineer for all mixes, as provided below, before commencing the mixing of concrete for the permanent works on the Site. Notwithstanding any approval by the Engineer to any mix, the Contractor shall not be relieved of any of his responsibility to use in the Works at all times only concrete meeting the requirements of the Specification in all respects to the satisfaction of the Engineer.

1.7.4. Trial Mixes

Prior to the use of any concrete mix in the Works the Contractor shall either:


- (A) Prepare trial mixes for each different concrete mix to be used including the proposed admixtures. The trial mix shall be designed according to I.S. 456, I.S. 10262 and SP:23**

Preparation and testing of trial mixes shall be carried out in the presence of the Engineer. The Contractor shall afford facilities to the Engineer to enable the Engineer to make independent tests if he so desires.

For each trial mix three separate batches of concrete shall be made using the materials approved for use in the Works and, unless otherwise approved, under full-scale production conditions. If for any reason it is not possible to make any trial mix under full-scale production condition, then it may be made in a laboratory but only with the express permission of the Engineer and under such conditions as he may lay down.

Particular attention shall be given to the water/cement ratio and workability of these trial



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mixes. The free water content of all the aggregates used shall be accurately determined according to IS 2386 (Part III) by drying or other approved means before the mixing begins in order to give an accurate measure of the free water/cement ratio.

The consistency of each trial mix concrete batch shall be measured by the Slump Test using the equipment and method given in I.S. 1199. The target slump of the trial mixes shall consider the ambient temperature conditions expected at Site and shall be such that the slump of the production concrete when received at Site is as specified. The target slump shall have a tolerance of + 15 mm or + 1/5 the required value, whichever is greater. In hot weather conditions graphs of slump v/s time since adding the water to the mix and slump v/s concrete temperature shall be prepared for use in production testing.

If the target slump is not within the permitted tolerance specified, the proportions of the mix shall be adjusted accordingly, and new trial batches shall be made. Both the ambient temperature and the temperature of the fresh concrete shall be noted when each slump test is made.

For two of the trial mix batches a total of six 150mm cubes shall be made. These test cubes shall be made, cured and tested in accordance with the provisions of I.S. 516. Unless otherwise directed by the Engineer, three of the six test cubes shall be tested for compressive strength at 7 days and three at 28 days. The third trial mix batch shall consist of twelve cubes, three cubes being tested at each of 3, 7, 14 and 28 days.

OR

- (B)** If ready-mixed concrete is used, the Contractor may submit if approved by the Engineer, appropriate existing data as evidence of satisfactory recent previous performance for target mean strength with the proposed ingredients and admixtures, current margin, workability, water/cement ratio and rate of gain of strength. In addition to what is specified in (A) above, the target slump of the trial mixes and concrete production mixes produced at the plant shall consider the workability loss for the expected delivery time together with the concrete temperature at the time of delivery. The concrete mixes shall be so designed that due to any unforeseen problem they should be able to cope up with delays due to longer delivery period than expected.

Alternatively, if not satisfied as above and required by the Engineer, the Contractor shall carry out trial mix testing as specified in (A) above, at the ready-mix concrete plant.

Requirements of ready-mixed concrete specified in I.S. 4926 shall be followed except if and to the extent modified in this Specification.

1.7.5. Compressive Strength Requirement for Trial Mixes



The compressive strength of a trial mix shall be considered satisfactory if the following requirements are met:-

The six cubes from the three batches of a trial mix that are tested at 28 days age shall have an average compressive strength not less than

$$f_{ck} + (1.65 \times S)$$

where: f_{ck} is the required characteristic strength in N/mm²

S is standard deviation as per table 8 of IS 456 = 5 MPa.

For all cubes tested for strength, the density of the concrete represented by the cube shall first be determined before testing for strength and shall not be less than 2400 kg/m³.

1.7.6. Workability

Concrete shall be cohesive so that it does not segregate and of such consistency as to ensure full compaction by the means being used and such that it can be readily worked into the corners and angles of the formwork and around reinforcement without segregation of the materials or bleeding of free water at the surface. On striking the formwork it shall present a face which is uniform, free from honeycombing, surface crazing, or excessive dusting, and which shall not, in the opinion of the Engineer, be inferior to the standard specified.

To satisfy the Engineer that the workability of the proposed mixes is adequate for the requirements of the Specification, the Contractor shall carry out a series of workability tests on the preliminary trial mixes. The tests shall be carried out in accordance with I.S. 1199, or such other procedure as may be approved by the Engineer. The samples to be tested shall be obtained from the batches used for the preliminary test cubes.

In addition, the Contractor shall supply for each of the grades of concrete a section of formwork complete with reinforcement fixed in position and generally representative of the sections commonly to be employed in the Works. The capacity of this trial section of formwork shall be at least half a batch of concrete, but in any case, not less than half a cubic metre. The formwork shall comply with the requirements specified. The moulds shall be filled in the presence of the Engineer with concrete of the same mix and batch from which the preliminary test cubes are made and shall be compacted in the same manner and with the same equipment as are proposed for the Works. This procedure shall, if necessary, be repeated with modified mixes until the appearance of the concrete after striking the mould is acceptable to the Engineer, after which it shall be used as the standard for that grade.





Workability of production concrete mixes shall also be checked at the place of concrete deposition for each pour.

1.7.7. Alteration of Mix Proportions

If during the period of the Contract the Contractor wishes to alter the proportions of any mix or any constituent of the mix or the source of any constituent, he shall obtain the prior permission of the Engineer in each case. Additionally, if experience shows that any previously approved mix when used in the Works is inconsistent with satisfying the requirements of this Specification, then the Engineer may withdraw approval for this mix and direct the Contractor to produce an alternative. In either case the Engineer will require that additional trial mixes for the altered mixes be made and tested, all in accordance with the requirements of the preceding Clauses.

1.7.8. Minimising the Risk of Damaging Alkali-Silica Reaction

The Contractor shall submit to the Engineer for approval his proposals for minimising the risk of alkali-silica reaction which shall include the results of tests on the aggregates he proposes to use, the test being carried out according to I.S. 2386 (Part VII) - Alkali aggregate reactivity, using the cement proposed to be used in the Works. Generally basalts are of low reactivity. Aggregates which are chemically reactive with alkalis of cement shall not be used.

1.7.9. Temperature of Concrete


The strengths specified to be reached at 28 days or other earlier ages refer to test cubes tested at the temperatures specified in I.S. 516. In order to allow for the effect of temperature outside this range which may occur during the mixing and curing of concrete, the Contractor shall prepare for the Engineer's approval a table or graph showing the probable variation of characteristic strengths with temperature for each grade of concrete to be used in the Works taking the characteristic strengths quoted in this Specification at the temperature at test specified in I.S. 516 or if not specified at 20°C as a datum.

Once agreed these tables or graphs shall be used as a basis for the assessment of strength of concrete where the concrete was wholly or partly mixed and cured with temperatures outside the range specified in I.S. 516. Similar sets of tables or graphs shall be prepared for approval for the strengths at appropriate earlier ages.

1.7.10. Drying Shrinkage

The Total Drying Shrinkage Strain of all the proposed concrete mixes, prepared and tested under approved conditions in the laboratory on the Site or in an approved independent



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laboratory, in accordance with I.S. 6441 (Part II) (As appropriate) / BS 812-120, shall not exceed the limits given in concrete mix-schedule.

1.8. Batching

1.8.1. Approval of Concrete Batching Methods

The Contractor's concrete batching and mixing plant shall conform to I.S. 4925. The Contractor's arrangements for handling, batching, transporting and mixing of materials for concrete, together with all control procedures, shall receive approval in principle from the Engineer before any work commences on site.

Detailed arrangements and Contractor's personnel involved shall be approved by the Engineer before any concrete is mixed for the Permanent Works.

1.8.2. Batching of Materials

All materials for concrete shall be batched separately and by weight.

The grading of coarse and fine aggregate shall be checked as frequently as directed by the Engineer to ensure maintaining it in accordance with the grading used in approved mix design.

1.8.3. Weigh Batching Plant

Weigh batching plant shall control delivery of cement, aggregates and bulk admixture to an accuracy of not worse than $\pm 2\%$ on the individual weighment. For added water the accuracy shall be within $\pm 1\%$ and for any dose-type additive the accuracy shall be within $\pm 5\%$.

The weighing mechanism shall be checked and adjusted monthly and the Contractor shall provide simple and convenient means for this. He shall supply to the Engineer on request records of all check tests and adjustments made to the plant. The Engineer may at any time call for a check test to be made.

The weigh batcher shall be maintained in a clean, serviceable condition. It shall be set up level on a firm base and the hopper shall be loaded evenly. The needle shall be adjusted to zero when the hopper is empty.

1.8.4. Water Content

Due allowance shall be made for the weight of the moisture content of the coarse and fine aggregates and the Contractor shall make readily available to the Engineer assistance and equipment as required to carry out moisture content tests according to I.S. 2386 (Part 3), at

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intervals deemed necessary by the Engineer to suit local weather conditions. In general, the moisture content of the coarse aggregates and fine aggregates shall be ascertained daily and at any other times when alteration of the moisture content may be expected due to new deliveries of aggregates, inclement weather or any other reason.

The amount of water used shall also take into account the moisture content of the aggregates.

To allow for the variation in mass of aggregate due to variation in their moisture content, suitable adjustments in the masses of aggregates shall also be made.

Water shall not be added to the mixer until just prior to the time when the concrete is to be mixed.

1.8.5. Cement Batching

If the cement is delivered in bags or individual containers, the sizes of batches shall be such that only full bags or containers of cement shall be used.

1.8.6. Rejection of Batched Materials

Notwithstanding his previously given approval of the contents of any storage area, the Engineer may order the removal of any batch of cement and/or aggregates prepared for charging into the mixers if he has reason to believe that such a batch is contaminated in any way or the aggregates in the batch are improperly graded.

1.9. Mixing

1.9.1. Mixing Plant

Concrete shall be mixed in mechanical mixers complying with I.S. 1791 (batch type mixers). Water shall be fed into the mixers from a tank fitted with water measuring device and means of adjusting the flow of water. The type and manufacture of these mixers, together with all associated plant, shall be subject to the approval of the Engineer.

Where small quantities of high grade concrete are required the Contractor shall, if the Engineer so requires, provide small, portable, covered pan mixers complying with I.S. 12119 of approved type for this particular work. In such case the mix shall be adjusted to whole bags of cement and no splitting of bags will be allowed.

Such covered pan mixers shall only be used as the Engineer may direct and all the conditions covering the mixing of concrete for large scale concreting shall apply to any mix prepared in pan mixers.

Mixers shall be set up level on a firm base or floating pontoon in case of floating batching





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plant and maintained within the manufacturer's tolerances, with particular attention to mixing blade clearances and sizes, throughout the period of the Contract and any mixer or plant that is not so maintained or is faulty in any respect shall be removed from the Site.

All mixing plant, truck mixers and concrete delivery vehicles shall be wind proof. The requirements of Clause shall apply in hot weather conditions.

Before beginning concrete mixing operations, all hardened concrete and foreign materials shall be removed from inner surface of mixing and conveying equipment. All conveyances, buggies, barrows shall be thoroughly cleaned at frequent intervals during placing of concrete.

1.9.2. Mixing Requirements

The maximum size of the batch shall not exceed the maximum rated capacity of the mixer as stated by the manufacturer and as stamped on the mixer and the batch size shall not be less than 75% of such maximum.

Mixing shall begin immediately after the cement has been added, either to the water or aggregate, and shall continue until there is a uniform distribution of the materials and the mass is uniform in colour and consistency or as directed by the Engineer. In any event, concrete shall be mixed for at least 2 minutes or for the period and at the drum speed specified by the manufacturer of the mixer. Concrete shall be discharged from the mixer on to a level, clean, water-free platform or floor or into water-tight receptacles. The area surrounding the mixer shall be paved and kept clean. When skips or mobile concrete carriers are used, concrete may be directly discharged from the mixer into the skips or rotating drums of mobile carriers.


If there is segregation after unloading from the mixer, the concrete shall be remixed if approved by the Engineer, otherwise the mixed batch shall be rejected.

The entire contents of the mixer shall be removed from the drum before materials for a succeeding batch are placed in it. The solid materials composing a batch shall be deposited in the mixer in accordance with the manufacturer's directions for use.

Within 60 minutes after the introduction of the mixing water to the cement and aggregate, or the cement to the aggregate, the concrete shall be placed in its final position in the forms and fully compacted, except that this period may be extended with the prior permission of the Engineer provided the weather conditions are favourable and the concrete is continuously agitated in an approved purpose-built supply vehicle or an approved retarding admixture is included in the mix. If an initial set should take place, the concrete shall be rejected.

If any mixer is out of operation for more than 20 minutes, it shall be thoroughly cleaned out together with all the handling plant, before any further concrete is mixed and the first batch



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on recommencing shall have 10% additional cement to allow for sticking in the drum. This shall also be followed at the end of each shift of concrete mixing operation and for the first batch of concrete of the subsequent shift. All mixing and handling plant shall be thoroughly cleaned out before concrete, using a different type of cement or admixture is used.

1.9.3. Hand Mixing

Normally hand mixing of concrete will not be allowed, but where the total quantity is small, the mixing may be done by hand but only with the express permission of the Engineer.

For hand mixing the quantity of cement for any given concrete mix shall be increased by ten per cent and not more than one quarter of a cubic metre shall be mixed at one time. The water/cement ratio shall not exceed that approved for the particular grade of concrete concerned. Hand mixing shall not be permitted for any structural concrete or where there is a particular requirement for the concrete to be durable.

Hand mixing of concrete shall be done on a hard, even and impervious surface of adequate size. The materials shall be turned over not less than three times dry. A measured quantity of water shall then be added through a rose while the materials are being turned over not less than three times in a wet state and worked together until a mixture of uniform consistency is obtained.

1.10. Transportation, Placing and Compaction

1.10.1. Plant and Equipment


The Contractor shall provide adequate means of transporting and placing mixed concrete in sufficient quantities to meet the programme. All plant and equipment shall be properly designed and constructed with regard to the efficient and rapid placing of the concrete and the safety of the Works and shall be approved by the Engineer before being used. All plant and equipment used for transport and deposition of concrete shall be kept clean and shall be washed out after each interruption in the work and at the end of each shift.

Any proposal for placing concrete by tremie or the use of a concrete pump or placer and associated equipment shall be submitted to the Engineer, together with the fullest possible description of the apparatus and methods to be used. Trials may be required to demonstrate their suitability and that the concrete mix design is appropriate to this method of placing. The Contractor is to ensure that he has adequate back-up facilities to continue placing concrete if a mechanical breakdown occurs.

1.10.2. Transportation of Concrete

The contents of the mixer shall be discharged in one continuous operation and the concrete



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transported in such a manner that there shall be no segregation of its constituents. If, in the opinion of the Engineer, any segregation of the concrete materials has taken place during transport, the concrete shall be again turned over and mixed just before it is finally placed in position. No water shall be added to the concrete between the time of mixing and placing.

Whilst being transported from the mixer to the site of placing, all concrete shall be properly protected from loss of any of the ingredients, contamination by dust, sand or other foreign matter and from excessive moisture gain or loss from rainfall or high temperature, and all equipment used shall be purpose-made for the correct transportation of concrete. During hot weather, concrete shall be transported in deep containers; other suitable methods to reduce the loss of water by evaporation may also be adopted.

1.10.3. Preparation for Placing

In preparation for the placing of concrete, all construction debris and extraneous matter shall be removed from the interior of forms. Standing water on areas to receive concrete shall be removed before concrete is placed. All exposed reinforcement shall be free from loose rust, scale and windblown salts and spray.

Placing of concrete shall not be commenced until the Engineer has inspected and passed the formwork or other areas to receive concrete and any reinforcement, cast in fixings etc., against which the concrete is to be placed. Any approval so given shall not relieve the Contractor of any of his responsibilities under the Contract.

Where concrete is to be cast against an existing concrete face, that face shall have been prepared to expose the aggregate and all loose particles removed. This surface shall be wetted prior to receiving concrete. This preparation shall be subject to inspection by the Engineer.

Preparation for placing under water concrete is specified separately elsewhere in this specification.

1.10.4. Placing of Concrete


Concrete shall be placed and compacted in the shortest possible time after mixing is completed and before it has taken an initial set. It shall be placed as close as possible to its final position to avoid segregation of materials and displacement of reinforcement. Freshly laid concrete shall not be wheeled over or otherwise disturbed. When depositing concrete adjacent to a construction joint, special care should be taken not to disturb the dowels or other reinforcing bars projecting from the existing concrete.

Normally concrete may be deposited with a maximum free fall of 1.5 metres without the use of pipes / chutes / elephant trunks, provided suitable measures are taken to prevent segregation

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and premature coating of upper reinforcing steel. When pipes are used they shall, as far as is practicable, be kept full of concrete during placing and their lower ends shall be kept buried in the newly placed concrete. In certain circumstances greater heights than 1.5 metres may be allowed but only with the written authority of the Engineer following trials to establish the effect on the concrete.

Chutes may also be used and shall be of steel or steel lined. They shall be constantly kept clean from coatings or hardened concrete or other obstructions. Chutes shall not be set at such an angle that the concrete sticks to them or becomes segregated. Normally, chutes at an angle of more than 45 degrees to the horizontal will not be permitted.

Concreting of any section or unit of the work shall be carried out in one continuous operation between approved construction joints and no interruption of the concreting will be allowed without the approval of the Engineer. Sequence of placing shall be such as to avoid disturbance of partially set concrete.

In cases where the approval of the Engineer is obtained and where delays of more than one hour occur between successive concreting when, in the opinion of the Engineer, the previously placed concrete has had time to harden; the resulting joint shall be treated as a Construction Joint. The previously placed concrete shall be cut back to a vertical and/or horizontal face and the joint face treated as specified for construction joints, before placing the new concrete.

Where open ended pipes are cast in, care shall be taken that concrete cannot enter into the pipes.

Except when placing with slip forms each placement of concrete in multiple lift work, shall be allowed to set for at least 24 hours after the final set of concrete, before the start of subsequent placement. Placing shall stop when concrete reaches the top of any opening in walls or the bottom surface of slab in beam and slab construction, and it shall be resumed before concrete takes its initial set but not until it has had time to settle as determined by the Engineer.

In the event of rain storms or other severe weather conditions arising, concreting shall be stopped and appropriate temporary stop ends, vee grooves etc., placed as may be necessary and concrete shall be covered with tarpaulins immediately. To meet such circumstances, the Contractor shall always have in readiness approved framed sheeting, tarpaulins, etc., for the protection of newly placed concrete. Should any concrete be damaged due to rain storms or other weather conditions, the Engineer may order the cutting out and replacement of the damaged concrete, all at the expense of the Contractor.

Except where arrangements, approved by the Engineer are made for placing concrete under water, the areas on which concrete is to be deposited shall be made and kept free from standing water during concreting operations and running water crossing or entering such areas shall be brought under control for at least 12 hours after concreting is completed.





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Placing of concrete under water by tremie or pumping or by a placer is specified separately elsewhere in this Specification.

1.10.5. Compaction of Concrete

After concrete has been placed it shall be thoroughly compacted by mechanical vibration applied by immersion vibrators complying with I.S. 2505 or, for surface finishing on thin slabs, approved surface vibrators or vibrating tampers complying with I.S. 2506 / I.S. 2514. Form vibrators if approved for use shall comply with I.S. 4656. Vibrators shall only be used by competent operators properly trained in the correct handling of the particular equipment in use on the Site.

Immersion vibrators shall run at a frequency of not less than 120 Hz when immersed. The active part of the vibrator shall be fully immersed while in use and vibration shall be of sufficient duration and intensity to compact the concrete thoroughly, but shall not be continued at any one point to the extent that segregation occurs. Vibrators shall not be used to transport concrete in the forms. Vibrators shall be manipulated so as to work thoroughly the concrete around the reinforcement and embedded fixtures and into the corners and angles of the forms so that all entrained air is expelled and the concrete surface when exposed is found good and free from air pockets, honeycombing or other defects. Restamping of concrete or mortar which has partially hardened shall not be permitted. Concrete once vibrated shall not be vibrated again. Impression vibrators shall be inserted vertically at points not more than 450 mm apart and withdrawn slowly till air bubbles cease to come to the surface, leaving no voids. When placing concrete in layers advancing horizontally, care shall be taken to ensure adequate vibration, blending and melding of the concrete between successive layers. Vibrators shall not be applied directly, or through the reinforcement or formwork, to sections or layers of concrete which have hardened to the degree that the concrete ceases to be plastic under vibration. Use of impression vibrators for compacting concrete shall follow the recommendations of I.S. 3558.

Whenever vibration has to be applied externally, the design of the formwork and the disposition of vibrators shall receive special attention to ensure efficient compaction and to avoid surface blemishes.

Every care shall be taken to see that reinforcement, and fittings attached to the shutters are not disturbed and that no damage is caused to the internal face of the shutters when using immersion type vibrators.

Over-vibration shall be avoided.

Vibration shall be supplemented by such spading as is necessary to ensure smooth surfaces and





dense concrete along form surfaces and in corners and locations impossible to reach with the vibrators.

The Contractor's attention is drawn to the importance of achieving a high degree of compaction in order to produce as dense a concrete as possible, but not over vibrating concrete against shutters thus causing an increase in the water/cement ratio local to the shutter.

When casting against existing concrete surfaces compaction should be ensured by local use of vibration to remove pockets of air that may be trapped, especially under horizontal surfaces.

The requirements of this Clause do not apply in case of concrete placed under water.

1.10.6. Setting Concrete

After the initial set of the concrete the forms shall not be jarred and no strain shall be placed on the ends of reinforcing bars which project. Adjacent works, which may cause vibrations to be transmitted to any setting concrete, may be ordered to be stopped at the discretion of the Engineer.

1.10.7. Records of Concrete Placing

The Contractor shall maintain a Concrete Pour Checklist, the format of which shall be as that shown in Appendix B (At the end of this section) of this document. Unless otherwise directed by the Engineer, this checklist shall be completed in advance of each pour, and submitted to the Engineer within a reasonable time, to permit an inspection before concreting operations commence.

The Contractor shall also keep a record of the date, time, shade air temperature, mix temperature, mix type and samples taken, along with a record of the quantity and place of deposition in a Concrete Pour Card, the format of which shall be as that shown in Appendix 9B of this document.

The Engineer shall be permitted to inspect or request copies of these records at any time.

1.10.8. Hot Weather Concreting

Concreting during hot weather shall be carried out as per I.S. 7861 (Part 1). Specific arrangements shall be agreed with the Engineer for controlling the temperature of fresh concrete. These arrangements shall include night or early morning working, prior cooling and/or shading of reinforcement and forms, shading of aggregate stockpiles, and shading of placed concrete from direct rays of the sun. The Contractor shall further note that the times





quoted for mixing and placing and the frequency of cleaning of equipment may have to be modified in hot weather. Covering or other protection of concrete during transport may also be necessary. Trials shall be carried out to determine the adequacy of the control measures and the workability of the fresh concrete under those conditions.

Chillers shall be used to cool the mixing water. Ice shall not be used. The difference between the temperatures of the chilled water and the cement shall not exceed 34°C.

Temperature of concrete at the time of placement shall not exceed 34°C.

Unless otherwise directed by the Engineer, all items of equipment covered by this Clause shall be painted white to minimise solar heat absorption.

1.10.9. Protection against Rainfall

The Contractor shall provide adequate cover as necessary to protect concrete whilst being placed until it takes its initial set against damage from rainfall.

1.10.10. Contractor's option for concreting in stages

If the contractor intends to carryout concreting of any elements in stages, he shall submit to the engineer all calculations, layout and detailed drawings necessary for construction in stages. All these calculations and drawings shall be approved by the Engineer/ Employer before commencement of concreting work in stages.

1.11. Curing


1.11.1. General Requirements

The Contractor shall ensure that curing is carried out such that thermal and plastic cracking of the concrete does not occur.

Until a period of fourteen days has elapsed from the time of placing the concrete, the concrete shall be kept protected against loss of moisture, rapid temperature change, high internal thermal gradients, rain and flowing water, mechanical injury, vibration, impact, contamination by airborne dust and sand, drying winds and surface heating by the sun's rays. This curing period may be varied at the discretion of the Engineer.

Following the completion of the above period, a further period of controlled drying out will be required as directed by the Engineer. This may require that covers, sand layers and the like be kept in place for longer than the 14 day minimum curing period otherwise specified.



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The Contractor's attention is particularly drawn to the importance of starting curing as early as possible after placing concrete and maintaining full curing procedures throughout, as specified and directed.

Any concrete which exhibits plastic settlement or plastic or drying shrinkage cracking or which has not been properly cured is liable to rejection by the Engineer.

The requirements of this Clause do not apply to concrete placed under water.

1.11.2. Curing Methods

All methods to be used for curing and protection of freshly placed concrete must receive the prior approval of the Engineer. These methods shall include the use of curing membranes, continuous sprays of water or ponded water, or continuously saturated coverings of sacking, hessian, or other absorbent materials, shades and any other precautions that are required for the Contractor to ensure satisfactory curing of the concrete.

1.11.3. Curing Membrane

Where used, curing membranes shall be of non-wax resin based white reflective type which shall not impair the concrete finish in any way and shall be sprayed on the surface of the concrete as soon as all free water has evaporated from the surface, except where provided for below. In the case of formed surfaces, where formwork has been eased or struck before fourteen days have elapsed from the date of placing concrete within them, the curing membranes shall be applied immediately after the formwork has been removed.

The curing compound to be used shall be approved from the Engineer before use. In every case the rate of coverage and method of application, preferably by spraying equipment, shall be according to the manufacturer's instructions to produce a smooth, even textured coat. Where a surface treatment is to be applied to the concrete (e.g., a surface hardener) a curing membrane shall only be used if it is compatible with the surface treatment.

1.11.4. Water Curing

Where water curing is adopted, the concrete shall be covered with sacking, hessian, or other absorbent material, or a 75mm layer of sand, kept constantly wet for 14 days and, where directed by the Engineer, also covered with plastic sheeting to reduce loss by evaporation. Water for curing shall comply with Clause 2.5.1. Care shall be taken to ensure that the temperature of all water used at all stages of the curing process is as close as possible to that of the concrete being cured.

1.11.5. Use of Covers



Curing of concrete surfaces may be carried out by sealing with opaque, reflective plastic sheeting held in close contact with the surface of the concrete and forming an airtight fit around the element being cured. The sheeting shall form a continuous seal and be without tears or holes. If necessary, the Contractor shall provide frames for the plastic sheeting so that the covers can be placed over deck slab pours immediately after the concrete has been floated off and before the brush finish is applied. Such frames can be removed as soon as the concrete is strong enough to support the plastic sheeting without leaving an impression in the concrete surface.

1.11.6. Wetting of Formed Surfaces

Formed surfaces shall, to compensate for any surface drying that has occurred and as soon as the form is removed, be sprayed with water and allowed to reach a uniformly damp appearance before continuing with curing.

1.11.7. Curing of Concrete in Hot Weather

When the daytime ambient temperature is greater than 25°C or at such other times as the Engineer may direct, for example, when there is a hot dry wind or low relative humidity, curing shall proceed as detailed below. Any necessary repairs or finishing processes shall be carried out as soon and as quickly as possible, only exposing a small area at any one time.

- (a) Large Flat Areas, e.g. Slabs (Preferred Method)
 - i) Immediately after the required surface finish is applied, cover the concrete surface with polythene sheeting supported by wooden frames to minimise evaporation. Suitable weights must be used at all the edges to keep the polythene sheet in place. All gaps at sides and ends must be filled in to avoid wind-tunnel effects.
 - ii) When the surface can carry weight, replace the sheeting and frames by a layer of damp hessian laid directly on the concrete covered by polythene sheet. The hessian must be kept continuously damp for 14 days, (i.e., not wet/dry cycles), and suitable weights must be used to keep the polythene sheet in place.
 - iii) After 14 days wet curing, 7 days cover-only curing is required, using suitable weights to keep covers in place.
- (b) Alternative Method for Large Flat Areas (if potable water is in scarce supply)
 - i) As item (a) (i) above.
 - ii) When the surface can carry weight, apply white-pigmented non-wax resin-based curing compound as per the manufacturer's instructions. No curing compound shall be sprayed on construction joints.
 - iii) Cover with dry hessian for 14 days.
- (c) Flat Surface with Starter Bars



- i) As soon as concreting is complete, cure the surface with continuous sprays of water round the clock for 14 days.
- ii) Maintain cover-only curing from the 15th to the 21st day,
- iii) As item (a) (iii) above.
- (d) Vertical Surfaces
 - i) Leave formwork in place for at least 24 hours and keep it continuously wet, then, after removing the forms, immediately wet the surface as per Clause 2.11.6 and cover the sides with damp hessian (which is to be kept continuously damp for 14 days) or curing compound (as item (b) (ii) above), both of which are in turn to be covered by polythene sheet.
 - ii) Maintain cover-only curing from the 15th to the 21st day.

1.11.8. Thick Sections

The Contractor's attention is drawn to the need to take special precautions, such as careful planning of construction joint locations, to limit the build-up of heat in thick sections of concrete, particularly during hot weather. Locations of construction joints shall be subject to the approval by the Engineer.

1.11.9. Curing Notices

Curing notices shall be exhibited for each concrete pour, stating the time and date when the concrete was placed, date for last wet curing and the date for completing of cover curing.

1.11.10. Curing of Repairs

All concrete repairs shall be cured in accordance with this Section of the Specification.

1.12. Reinforcement

1.12.1. Reinforcement Steel Specifications

Steel used for concrete reinforcement shall comply with the following Indian Standard Specifications:

I.S. 432 (Part 1)	Specification for mild steel and medium tensile steel bars and hard-drawn steel wires for concrete reinforcement. Bars shall be of Grade I quality complying with the conditions and tests of this Standard.
I.S. 1786	Specification for high strength deformed steel bars and wires for concrete reinforcement.
I.S. 2062	Specification for steel for general structural purposes. Bars shall conform to Grade A of this Standard.





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I.S. 1566 (Part I) Specification for hard-drawn steel wire fabric for concrete reinforcement.

The reinforcement binding wires shall be of minimum 1.5 mm diameter or of the approved gauge soft annealed and conform to I.S. 280.

All reinforcement shall be clean, free from grease, oil, paint, dirt, loose mill scales, loose rust, dust, bituminous materials or other coatings which may destroy / reduce bond, and shall be thoroughly cleaned before being fabricated. Pitted and defective rods or containing cracks or splits shall not be used. Reinforcement of Corrosion Resistant (CR) Grade Fe500 may be used in accordance with provisions of IS: 13920 and IS: 1786.

1.12.2. Testing of Reinforcement Steel

A manufacturer's test certificate shall accompany each consignment, a copy of which shall be handed to the Engineer before such reinforcement is incorporated in the Works. If directed by the Engineer, Samples shall also be tested by the Contractor at his cost in a laboratory approved by the Engineer, before the reinforcement, which the sample represents, is incorporated in the Works.

1.12.3. Storage of Reinforcement Steel


Reinforcement shall be stored on racks clear of the ground/water and shall be protected to prevent accumulation of dust, wind blown salt and sand and other harmful substances and from sea spray and saline atmosphere and shall be kept in clean condition until it is required to be used.

The separate types and sizes of bar reinforcement shall be stored in separate racks, the type and diameter being clearly marked in each case. Similarly, different sizes and arrangements of mesh shall also be stored separately and clearly marked in each case. Where large daily variations in ambient temperature and/or humidity occur, storage racks shall be enclosed in a light building.

1.12.4. Cutting and Bending of Reinforcement

The Contractor shall prepare his own bar bending schedules on approved forms from the Drawings and his designs, if any. These shall also indicate the total weight of reinforcement covered in each schedule. They shall be in accordance with I.S. 2502 / I.S. 5525 and shall be submitted to the Engineer in triplicate for approval, at least two weeks before bars are to be cut and bent. The Engineer will check and return one copy with any corrections noted in red ink.



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Notwithstanding any comments or approval of these schedules by the Engineer, it is the sole responsibility of the Contractor to ensure their accuracy and compliance with good detailing practice and, where appropriate, the Engineer's Drawings. The Contractor shall allow sufficient time and resources to ensure that any deficiencies in the reinforcement noted once it has been fixed can be rectified without delay to the programme.

Reinforcing bars supplied bent or in coils shall be straightened cold without damage at no extra cost. No bending shall be done when ambient temperature is below 5°C.

Reinforcing bars shall be accurately cut and bent to the shapes and sizes shown on the Contractor's schedules. All bars shall be bent cold unless the written permission of the Engineer is obtained for hot bending. Any reinforcing bar that has already been bent shall not be regent at the site of the original bend without the Engineer's permission. High strength deformed steel bars shall not be re-bent or re-straightened without the Engineer's permission.

Reinforcement shall be bent by gradual and uniform application of pressure by suitable machines to the forms and dimensions shown on the Contractor's schedules and in accordance with I.S. 2502. The former used for making the bends shall have diameter specified in I.S. 2502. No reinforcement shall be bent when in position in the Works without approval of Engineer whether or not it is partially embedded in hardened concrete. Any bending of reinforcement left projecting from a construction joint or precast element shall be done only at locations and in a manner approved by the Engineer and without damaging the concrete.

Bars which are not required to be bent as per approved schedules shall be truly straight. Stirrups and binders shall be bent to the radius of the bars against which they are to be in contact to fit closely around these bars.

Bars incorrectly bent may be used if approved by the Engineer only if the means used for straightening or rebending have been approved by the Engineer.

Storage of cut and bent reinforcement shall comply with Clause 2.12.3. If instructed by the Engineer, the surface of the cut and bent reinforcement shall be treated with cement wash.

1.12.5. Fixing of Reinforcement

Reinforcement shall be bent and fixed in accordance with I.S. 2502 and as amplified herein. The Contractor shall be responsible for maintaining the reinforcement in the correct position during concreting and compacting and to this end reinforcing bars shall be accurately fixed together as shown on the Drawings with such laps as are indicated, all to form a rigid cage. Bar crossings shall be secured tightly with at least one turn of binding wire, the ends of the wire being twisted together and bent away from the concrete surface and in no case shall encroach into the concrete cover. Every bar shall be secured in at least 2 places and in addition





binding wire tying spacing shall be not greater than every fourth intersection along the bar length. Crossing bars shall not be tack-welded for assembly of reinforcement without the Engineer's permission.

Sufficient mild steel chairs shall be supplied to support rigidly the top reinforcement of all slabs. The legs of these chairs shall be kept off the bottom shutter by suitable cover blocks to provide the specified cover.

Substitution of reinforcement laps / splices not shown on the Drawings shall be subject to Engineer's approval. Splices / laps in adjacent bars shall be staggered.

Subject to the Engineer's approval, spacer units fixed to the reinforcement shall be used in all reinforced concrete to give the cover specified herein, on the Drawings or as directed.

Spacers and /or chairs shall be placed at a maximum spacing of 1m or at closer spacing as necessary.

No ferrous metal part of any device used for connecting bars or for maintaining reinforcement in the correct position shall remain within the specified minimum concrete cover to the reinforcement except where expressly instructed or provided for within the Contract. Within the concrete mass, different types of metal in Contact should be avoided to ensure that bi-metal corrosion does not take place.

No permanent spacers to reinforcement shall be allowed to affect the overall uniformity of the surface appearance of Class F2P surface finishes which shall, in any event, comply with the Specification requirements.

Reinforcement temporarily projecting from the concrete at construction or other joints shall be adequately supported and shall not be bent out of position unless expressly permitted or directed. No temporary supports to the reinforcement will be allowed to be incorporated in the finished concrete except for the mild steel chairs referred to above in this clause.

1.12.6. Spacers

Spacers shall be as small as practicable with sides not exceeding 50mm for their purpose and shall be securely fixed in place, by approved means, to ensure that they will not be displaced during the placing, vibration or finishing of the concrete.

Favourable consideration will be given to the use of proprietary plastic or precast concrete spacers provided these are suitable for the particular use required.

Any precast spacer blocks approved for use shall be at least equal in strength to the body of the



concrete in which they are being placed, with the largest size of aggregate limited to 10 mm, and the blocks cured for 14 days or more.

They shall be of equal durability and where used on an exposed face shall provide a good colour match as required under the preceding clause. Any blocks cast on site will normally be required to be of a similar mix to the main body of the concrete.

The use of spacer blocks with tying wires cast in will not normally be permitted but where approval for such blocks is given the wire shall be of plastic coated stainless steel as approved by the Engineer, embedded in the centre of the block.

The vertical distances required between successive layers of bars in beams or similar members shall be maintained by the provision of spacer bars at such intervals that the main bars do not perceptibly sag between adjacent space bars.

1.12.7. Welding

Generally welding of reinforcement shall not be permitted. However in specific cases, welding of reinforcement may be permitted provided the Engineer's written approval is obtained in each case. Where this is given welding shall be to I.S. 2751. Where butt welding is carried out the ends of the bars shall be prepared with single 45 deg V and a backing plate shall be used. The minimum root face shall be one quarter of the bar diameter. Special precautions as specified by I.S. 2751 and the Engineer shall be taken in the welding of high strength deformed reinforcing bars. Prior to giving approval the Engineer will require performance trials of samples of welded bars to be undertaken in an approved testing laboratory to prove that the joints are of the full strength of bars welded.

1.12.8. Mechanical Joints

The use of mechanical joints and/or mechanical jointing systems for reinforcing bars shall be subject to the prior approval of the Engineer who shall be provided with full details of such joints together with the proposed locations for use and the methods of installation before making a decision. Notwithstanding the provision of such information the Engineer may direct that site tests be carried out on the use and strength of such joints.

1.12.9. Concrete Cover

The minimum concrete cover to reinforcement including stirrups and binders shall be as follows:

Concrete permanently exposed to the elements, or	75 mm
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buried	
Surfaces of pre-cast elements which are covered with in-situ concrete	50 mm for deck / 30mm for buildings

Provided always that the required minimum cover is maintained, the actual position of any bar and the distance between adjacent bars shall be that indicated on the Drawings with a tolerance of plus or minus 5 mm for bars of all diameters.

Tolerance on specified cover shall be (+) 5 mm, (-) 0 mm.

1.12.10. Cleaning and Protection of Reinforcement

The Contractor shall ensure that all reinforcement is free from loose mill scale, excessive rusting or pitting, oil or grease, dust, salts, mud, paint, retarders, deposits or curing membrane, and other harmful matter immediately before concrete is placed. The Contractor shall take care to ensure that any matter cleaned off reinforcement does not become incorporated in the concrete or accumulate on other concrete surfaces.

Any reinforcement that the Engineer considers has become excessively rusted in storage or prior to casting in concrete shall be rejected and shall be removed from Site at the Contractor's expense.

Before concreting all reinforcement shall be carefully cleaned of all set or partially set concrete which may have been deposited thereon during previous concreting operations.

All reinforcement projecting from construction joints or likely to be exposed to the weather for long periods before concreting is commenced shall be covered with polythene, binding tape, cement grout or other materials to the satisfaction of the Engineer in order to prevent corrosion of reinforcement or staining of the surrounding concrete. Should, in spite of these precautions, rust staining occurs on any permanently visible surfaces, it shall be removed at once.


1.12.11. Steel Fixer in Attendance

The tied in-place reinforcement shall be checked and approved by the Engineer prior to concrete placement.

During concreting a competent steel fitter shall be in attendance to adjust and correct the positioning of the reinforcement and other embedded fittings, before and during placing and compaction of concrete.

1.13. Formwork



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1.13.1. Formwork Construction

Formwork shall be rigidly constructed and shall ensure that the finished concrete is true to the required shape, position and level, and to the standard of finish specified. Formwork including the props (number, sizes and locations) shall be of suitable design and substantial construction to carry the loads and pressures due to the wet concrete and any incidental loads such as during concreting and compacting operations without excessive bulging, distortion, settlement, deflection, instability and joints shall be tight enough to prevent leakage of cement slurry and fines from the concrete and which can be stripped and removed without causing any blemish or jar to the concrete. Guidelines of I.S. 14687 shall be followed.

Formwork for recesses, keys, chamfers and radius strips, pockets, apertures, internal voids etc. and all bolts and fittings shall be accurately positioned and securely fixed before commencement of concreting such that they are not dislodged by the concreting operation, nor hinder the striking of forms.


The shuttering for beams and slabs shall be so erected that the side shuttering of beams can be removed without disturbing the bottom shuttering of beam and slab. Formwork shall be capable of being easily removed without shock disturbance or damage to the concrete. All forms shall be constructed with removable panels or openings to permit inspection of the inside of the formwork and to allow removal of debris i.e. chippings, shavings, wires, saw dust, dust, etc. and water from the interior of the forms before the concrete is placed. If the shuttering for a column is erected for the full height of the column, one side shall be built up in section, as placing of concrete proceeds or windows left for placing concrete from the side to limit the drop of concrete to 1.5 m or as directed by the Engineer. The Contractor's attention is also drawn to the requirements of the clauses relating to Concrete Finishes that contain some particular requirements for formwork construction.

Formwork shall be securely braced, wedged and firmly supported. Folding wedges, where used for final adjustments shall be nailed together and to the props, struts or buttons to prevent their loosening during vibration.

All formwork shall be fixed to the proper lines and levels and trued up immediately before depositing the concrete.

The Contractor shall take into account the structural behaviour of the concrete elements being cast, and shall ensure that the formwork and staging's are adequately stiff to support the concrete being placed at all stages of placing. Any eccentric loads shall be properly provided for. If so desired by the Engineer, the drawings and calculations for the design of the formwork shall be submitted to the Engineer for approval before erecting the same; however the responsibility for the same shall be entirely of the Contractor.



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Forms intended for reuse shall be treated with care. Forms that have deteriorated shall not be used. Before reuse all forms shall be thoroughly scraped, cleaned, nails removed holes suitably plugged, joints repaired and warped lumber replaced to the satisfaction of the Engineer. Contractor shall have enough shuttering to allow for wastage so as to complete the Works in time.

Formwork showing excessive distortion, during any stage of construction shall be removed and corrected / strengthened, prior to placement of concrete.

The requirements of formwork construction for concrete placed under water are specified separately elsewhere in this Specification.

1.13.2. Internal Ties

Wire ties shall not be allowed; instead bolts passing through plastic sleeves shall be used where permitted by the Engineer. The plastic sleeves shall not be nearer than 75 mm to the finished surface of the concrete. The bolt for this length of 75 mm shall be wrapped in plastic sheet for easy removal. Holes left by the removal of bolts shall be fully grouted under pressure to the full length with 1:2 cement: sand grout and neatly plugged with same mix flush with the surface and finished to the satisfaction of the Engineer.

1.13.3. Permanent Void Formers

Permanent void formers, designed to remain in place after casting of concrete, shall be of a material approved by the Engineer.

1.13.4. Chamfers

Except where specifically detailed on the Drawings or where further elements are to be placed against them, all exposed horizontal and vertical arrises shall have a symmetrical chamfer.

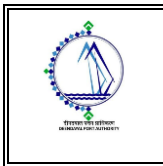
This chamfer shall be 25 mm x 25 mm unless detailed otherwise on the Drawings.

1.13.5. Preparation of Forms and Formwork

Before commencement of pouring concrete the faces of forms coming in contact with concrete shall be cleaned and interior of forms shall be thoroughly cleaned out of all materials mentioned in Clause 2.13.1 by approved means to the satisfaction of the Engineer. Where directed, cleaning of interior of forms shall be done by blasting with a jet of compressed air at no extra cost.

A thin uniform coating of approved mould oil or other approved material shall be applied





before fixing reinforcement to all surfaces coming into contact with the concrete to allow easy removal of the forms without damage to the concrete. No mould oil or other lubricating medium shall be allowed to come into contact with the reinforcement and embedded steelwork. Any material that will adhere to, discolour or impair the finish to the concrete shall not be used.

Where necessary and approved by the Engineer, to prevent absorption from the concrete, the formwork shall be thoroughly wetted shortly before concreting is commenced.

Shuttering shall be thoroughly scraped, cleaned and, if necessary, repaired before being re-used. Any part of a formwork panel which the Engineer judges incapable of producing a finish of the specified standard by reason of excessive use or the employment of sub- standard materials shall be replaced by the Contractor at his own expense.

1.13.6. Removal of Formwork

Formwork shall not be disturbed or stripped, unless otherwise approved, until the following times have elapsed after the concrete has been poured:

Vertical formwork to beams, walls, piers, columns 24 hours

Soffit formwork to slabs, (with props left under) 3 days

Removal of props to slabs

i) Spanning up to 4.5 m 7 days

ii) Spanning over 4.5 m 14 days

Soffit formwork to beams (with props left under) 7 days

Removal of props to beams

i) Spanning up to 6 m 14 days

ii) Spanning over 6 m 21 days

The above time periods are however subject to approval by the Engineer depending on the strength gain characteristics determined from testing of concrete test cubes with the particular cement being used. It is the Contractor's responsibility to ensure that the forms are not struck until the concrete has developed sufficient strength to support itself, does not undergo excessive deformation and resists surface damage and any stresses arising during the construction period. Any damage resulting from premature removal of forms shall be made good by the Contractor at his own expense.

In case of elements with re-entrant angles, the formwork shall be removed as soon as possible after the concrete has set, to avoid shrinkage cracking occurring due to the restraint imposed. In addition to the above, no loading (including self weight) shall be imposed on the concrete



which would cause a compressive bending stress greater than one-third of the concrete strength at the time of loading, or one-third of the 28 day strength, whichever is less.

Soffit formwork should be so designed as to facilitate striking, if required, without removal of props being necessary until the times stipulated above have elapsed. The Contractor's attention is drawn to the need to maintain side shutters as insulation on large concrete pours to prevent surface cracking due to thermal effects. The Contractor's proposals for stripping shutters on pours of greater than 25m³ shall be submitted to the Engineer at least 2 weeks before the pour is due to be made. No superimposed load shall be allowed on any part of the concrete work prior to the removal of the forms and props and/or until such loading is approved. Where concrete is to have filling placed against it the methods and materials of backfilling shall be approved by the Engineer.

Where there is a particular requirement for the early removal of formwork a procedure for establishing whether or not the concrete has reached the required strength shall be agreed with the Engineer beforehand. This shall be based on strength gain characteristics determined from testing of concrete test cubes.

At all times the Contractor shall delay the removal of the formwork if, in the opinion of the Engineer, the concrete contained has not attained sufficient strength.

1.13.7. Tolerances for Concrete Surfaces

Permissible tolerances for concrete surfaces are given in Table 1-1 If permissible tolerances are exceeded, the acceptance or otherwise of the concrete shall be decided by the Engineer. If concrete is rejected, it shall be removed and replaced by the Contractor at his own cost.

The template to be used in determining the deviation in long dimensions shall be:

- For straight surfaces, 3m;
- For curved surfaces, 1.5m.

Table 1-1 - Tolerances for Concrete Surfaces

Type of Structure	Type of Irregularity	Tolerances mm			
		Type of Finish			
		Formed		Unformed	
		Class F1	Class F2	Floated	Tamped
General Exposed Concrete	Departure from alignment and grade as shown on the Drawings	+10 -10	+10 -10	+5 -5	+10 -10
	Variations in cross-sectional dimensions	+10 -5	+10 -10	NA	NA
	Abrupt	0	5	5	5
	Deviations from template in long dimensions	+5 -5	+10 -10	+10 -10	+10 -10
Exposed	Departure from alignment and	+5	NA	+3	NA

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concrete where steelwork is to be fixed; also, tolerance for cast in steelwork	grade as shown on Drawings	-5	NA	-3	
	Variations in cross-sectional dimensions	+5 -3	NA	NA	NA
	Abrupt	3	NA	3	NA
	Deviation from template in long dimensions	+5 -5	NA	+3 -3	NA

(Note: NA denotes not applicable)

The tolerance in verticality for all types of finishes for walls, piers, and similar components shall be 0.05 degrees (i.e. approx 1 in 1145).

1.14. Finishes

1.14.1. Formed Concrete Finishes

Formed concrete surface finishes shall be as follows:-

a) Class F1

This finish is formed for surfaces at construction joints. The surface produced shall be free from voids, honeycombing or other large blemishes, steps, sharp protrusions or local hollows. The shutters shall be removed as soon as possible without disturbing the concrete or reinforcement and the surface shall be well wire brushed and hosed down to remove all excess laitance and fine aggregate. Coarse aggregate is to be left exposed but undisturbed.

b) Class F2

This finish is for surfaces that are permanently exposed to view. The surface produced by the formwork shall have smooth finish, free from board marks, voids, honeycombing or other large blemishes. Any small blemishes shall be carefully filled immediately after the removal of the formwork and other marked imperfections such as fins or steps or joint marks shall be smoothed off and made good. To achieve this finish, lined wrought timber boards, plywood forms, steel panels or such other material as is approved by the Engineer shall be used. In large pours, the forms shall be of uniform size and be as large as practicable and arranged in an approved uniform pattern with vertical or horizontal joints, unless otherwise directed. Joints between the forms shall be carefully filled or sealed before concreting. The same type and brand of shutter release agent shall be used throughout the Contract on surfaces of forms where a Class F2 finish has been specified.

c) Class F2P

This finish is similar to Class F2 except that in addition to the requirements for Class F2 the formwork is to be lined with a proprietary controlled permeability formwork liner as specified in Clause 2.13.4. The same type and brand of controlled permeability formwork liner shall be used throughout the Contract on surfaces of forms where a Class F2P finish has been specified.

d) Class F3

This finish is for surfaces not permanently exposed to view. The surface produced shall be





free from voids, honeycombing or other large blemishes, steps, sharp protrusions or local hollows. The formwork may be sawn boards, metal panels or other approved suitable material.

e) Class F4

Surfaces of precast elements which are later to be in contact with in-situ concrete, shall be roughened by air-water jetting, between the period of initial and final set, to remove all laitance, cement slurry and fine aggregate. Coarse aggregate is to be left exposed but undisturbed.

1.14.2. Remedial Treatment to Formed Surfaces

Any remedial treatment to formed surfaces shall be agreed with the Engineer following inspection immediately after removing the formwork and shall be carried out without delay unless otherwise specified or directed. Any concrete, the surface of which has been treated, before being inspected by the Engineer or has been treated by unapproved methods, shall be liable to rejection.

Normally, the only form of treatment which will be allowed for Class F2 concrete finish after removal of the formwork will be the filling of minor surface blemishes with a specially prepared approved cement and fine aggregate paste after removal of all loose materials and preparation of the surface by wetting or as directed by the Engineer and/or rubbing down with abrasive blocks and water to produce a smooth surface followed by a thorough washing down with water.

Apart from the filling of minor surface blemishes, as provided for above, plastering of defective concrete shall not be permitted. Any defective concrete finish will be rejected and the Engineer may order the defects to be cut out and repaired or may reject the entire section incorporating the defective concrete finish.

Bonding between fresh and hardened concrete shall be done by applying an epoxy coat if so directed by the Engineer at no extra cost. The use of epoxy for bonding fresh concrete shall be carried out as directed by the Engineer.


All cement and fine aggregate pastes used for remedying formed concrete surfaces shall be designed to produce, as near as is possible and to the satisfaction of the Engineer, a good colour match with the main body of concrete.

If concrete is rejected, it shall be removed and replaced by the Contractor at his own cost.

1.14.3. Unformed Concrete Finishes

Unformed concrete finishes shall be as follows:



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a) Screeded Finish - Class U1

A screeded finish shall be applied where indicated on the Drawings.

The concrete shall be levelled and screeded to produce a uniform surface to the profile shown on the Drawings.

Care shall be exercised not to work in excess fines to the top. Care shall be taken to ensure that the concrete is properly compacted and for this purpose vibrator screed boards or plates will normally be required. Slab concrete shall be tamped when it starts setting, to reduce shrinkage cracks.

b) Floated Finish - Class U2

A floated finish shall be applied where indicated on the Drawings. Steel floats shall be used unless otherwise approved or directed. Concrete shall be compacted and tamped as specified for class U1 finish.

Floating shall be done as soon as the concrete has hardened sufficiently and may be done by hand or machine. Care shall be taken that the concrete is worked not more than is necessary to avoid bringing excess fines to the top, to produce a uniform surface free from screed marks which is finished level or to the falls specified on the drawings.

c) Brushed Finish - Class U3

A brushed finish shall be applied to all unformed upper surfaces of concrete unless noted otherwise on the Drawings. The requirements of compacting, tamping and working concrete as specified for class U1 finish shall be applicable to this finish also.

The surfaces shall be finished to the levels and falls shown on the Drawings and shall be brushed with a stiff brush, as directed, to give a good running surface. A 100 mm wide strip at the edge of the slab and adjacent to all joints shall be finished smooth with a steel float.

The requirements for the surface finish of rigid concrete pavements shall be a brushed finish as defined above, subject to the approval of the Engineer.

1.14.4. Protection of Surfaces

The Contractor shall ensure that permanently exposed concrete surfaces are protected from rust marks, spillage, stains or damage of any kind. Any marks or damage shall be removed or remedied, all to the satisfaction of the Engineer. In the case of severe damage that may affect the serviceability of the concrete section involved or where unsatisfactory appearance of permanently exposed surfaces may result from repairs, the Engineer may order the breaking





out and reconstruction of any section.

1.15. Joints

1.15.1. Construction Joints

The position and form of construction joints, except where shown on the Drawings, shall be agreed with the Engineer before concreting begins. Normally no construction joints will be allowed within 600 mm below low water level or within 600 mm of the upper and lower levels of wave action. Unless otherwise directed they shall be made across planes of minimum shear. They shall be made only along a horizontal or vertical plane except that, in the case of inclined or curved members, they shall be at right angles to the principal axis of the member. There shall be no cold / construction joints in the casting of any precast elements.

Vertical construction joints shall be made against properly constructed stop-ends, firmly fixed and holed to permit the reinforcement to pass through, or by means of expanded metal. If expanded metal is used, it shall be kept back from the face of the concrete by a distance equal to the specified minimum concrete cover to reinforcement. It shall be securely held in position so as not to distort or move, in accordance with the requirements for normal formwork. It shall be left in position and new concrete placed against it when construction is resumed.

Horizontal construction joints in columns, walls, pedestals and like members shall show a clean straight line. Particular attention shall be paid to wedging of shutters against the previous lift to avoid unsightly lipping or runs.

All necessary steps shall be taken to ensure that good dense concrete is achieved against construction joints.

Prior to concreting, stop-ends may be treated with an approved surface retarder, instead of mould-oil, if required, to facilitate the exposing of the coarse aggregate. Such a retarder may also be applied after concreting to horizontal surfaces which subsequently are to form construction joints. All such uses of retarders for construction joint surfaces shall be subject to the prior approval of the Engineer.

Stop-ends shall be carefully removed, without disturbing the concrete and reinforcement, as soon as possible after concreting depending on the ambient temperature and curing conditions, as approved by the Engineer. Immediately on removal of the stop-ends, such concrete as passes through the stop end shall be hacked off and removed and the joint surface is to be well wire brushed / hacked if the concrete has set hard and hosed down with a high pressure water jet in order to remove all laitance, cement slurry and fine aggregate. In lieu of hacking, hammering with an approved power operated "bush hammer" may also be adopted. When hacking or hammering great care shall be taken to avoid breaking the edges and arises of the joint face.





Curing membranes and mould oil/release agents shall also be thoroughly removed from joint surface. Coarse aggregate is to be left exposed but undisturbed. Horizontal construction joints shall also be similarly treated immediately after initial setting of concrete, care being taken to avoid undue erosion of the mortar. After cleaning excess water shall be removed immediately, to limit absorption by concrete.

The positions of temporary stop-ends for vertical joints shall be as approved by the Engineer and the treatment of concrete surface at the stop-end shall be as for construction joints.

Where reinforcement bars up to 12 mm for high strength deformed steel bars and up to 16 mm for mild steel bars are bent aside at construction joints and afterwards bent back into their original positions, care shall be taken to ensure that at no time is the radius of the bend less than 4 bar diameters of plain mild steel or 6 bar diameters for deformed steel bars. Care shall also be taken when bending back bars to ensure that the concrete around the bars is not damaged.

When concreting is resumed against a construction joint prepared as above, the surface of the previously placed concrete shall be hosed down and the surplus water allowed to drain away so that the surface is in a clean saturated surface-dry condition before placing the new concrete.

Fresh concrete shall be thoroughly vibrated near, and against the construction joints to develop proper bond, by working the vibrator right up to the joint and into the angles and corners formed by the joint and the formwork.

1.15.2. Movement Joints

The spacing, location, dimensions and construction of all movement joints shall be as shown on the Drawings, unless otherwise instructed by the Engineer.

1.15.3. Debonding Coat


Where a debonding coat is required, e.g. at a movement joint between two concrete members, this shall be achieved by the use of an approved debonding membrane or bituminous paint.

1.15.4. Pre-formed Joint Filler

Where pre-formed joint filler is detailed on the Drawings, for expansion or other joints, it shall comply with one of the specifications given below.

Joint filler shall be of the thickness shown on the Drawings with a tolerance of ± 1.5 mm, fixed



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in single thickness sheets, unless otherwise directed, being of suitable lengths, not less than 1.2 metres. Wherever possible joints shall be filled with a single sheet of filler, but where the size of the joint is such that two or more sheets have to be used, these sheets shall be cut and butt-jointed so that the edges are in continuous contact. The sheet joint shall then be wrapped in approved self-adhesive PVC jointing tape to prevent any grout leakage through the joint.

The pre-formed joint filler used for expansion or other joints shall be as detailed or directed and shall normally be non-extruding and resilient type bitumen impregnated fibreboard conforming to I.S. 1838 (Part I). Bitumen coat to concrete surface for fixing the joint filler shall conform to I.S. 702.

Where detailed or directed, bitumen-bonded cork shall be used as pre-formed joint filler, complying with the requirements of ASTM D1751.

Where detailed or directed, low density cellular filler shall be used as pre-formed joint filler. All the above products shall be from a reputable manufacturer and shall be subject to the approval of the Engineer.

1.15.5. Joint Sealing Materials

Where detailed or directed, in particular for vertical or inclined joints, surface sealing of joints shall be by two-part, polysulphide liquid polymer sealant material, complying with the requirements of BS 4254 or equivalent I.S.

Where detailed or directed, hot-poured rubber/bitumen sealing compounds shall be used, for low movement horizontal joints only, complying with the requirements of Grade 'A' as per I.S. 1834.


For similar joints where the potential movement is outside the range of the hot poured rubber/bitumen sealing compounds, a suitable approved cold poured sealing compound shall be used complying relevant I.S. of a type approved by the Engineer.

All the above products shall be from a reputable manufacturer and shall be subject to the approval of the Engineer.

1.15.6. Application of Joint Sealants

Grooves for joint sealants at movement joints shall be formed to the dimension indicated on the Drawings or as otherwise approved or directed by the Engineer. Joint sealants of expansion, movement or other joints, shall be applied to the dimensions indicated on the Drawings or as otherwise approved or directed by the Engineer.



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All joint sealants shall be mixed and applied strictly in accordance with the manufacturer's instructions and the requirements of this Specification.

Immediately prior to permanent sealing, the groove shall be thoroughly cleaned and any dirt or loose material or any temporary sealing former or other filling material, grease or oil shall be removed. The surfaces of the groove shall be dry at the time of sealing. Any spalling at the edges of the grooves shall be repaired to the satisfaction of the Engineer using an approved material, compatible with the sealant, before the sealant is applied, and care shall be taken not to damage the edges of the groove during sealing. If recommended by the manufacturer or directed by the Engineer the groove shall be primed with an approved priming compound compatible with the sealant, and/or an approved bond breaker strip shall be applied to the back of the joint cavity before sealing.

Unless otherwise detailed or directed, sealants shall be applied so as to be 5 mm below the concrete surface.

1.16. Testing and Control

1.16.1. Inspection and Tests

The Contractor shall ensure that the Engineer is offered all facilities and assistance for the inspection of materials, storage, manufacture of concrete and precast concrete, workmanship and testing, and for carrying out all tests as specified or as instructed.

The following documentation shall be maintained at Site:-

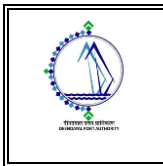
- a) Test reports and manufacturer's certificate for materials, concrete mix design details.
- b) Pour cards for clearance of concrete placement.
- c) Records of Site inspection & workmanship, field tests.
- d) Non-conformance reports, change orders.

1.16.2. Control of Mix Proportions

A check on the moisture content of the aggregate shall be made as required by this Specification for the purpose of assessing the amount of free water to be added at the mixer. The Contractor shall provide himself with a chart, a copy of which shall be given to the Engineer for approval, relating moisture content in the aggregate to water to be added at the mixer for all grades of concrete in use.

Full supervision of the concrete batching and mixing shall be provided by the Contractor to ensure correct proportions of all the various constituent materials. The Contractor shall





maintain records of the proportions of various constituents of each batch. If required by the Engineer, equipment shall be installed and maintained for making autographic records of the constituent materials of each batch. Control shall ensure that the proportions are within the tolerances laid down in this Specification.

The Engineer may direct that checking of mix proportions used shall be made by analysis of hardened concrete in accordance with I.S. 1199.

1.16.3. Determination of Fresh Concrete Temperature

In order to satisfy the requirements of this Specification for measurement of fresh concrete temperature, the following method shall be adopted: -

Within 2 minutes of taking a sample, a type A 100 mm immersion thermometer supplied by the Contractor having a range -5°C to +110°C, graduated at each 1°C and complying with BS 1704, shall be inserted in the sample to a depth of at least 100 mm. When steady conditions have been maintained for 1 minute the temperature shall be recorded to the nearest 1°C.

Unless otherwise directed by the Engineer, the above test shall be carried out on each delivery of concrete that is to be placed in the Works, at the point of delivery.

Temperature records, together with records of humidity and wind speed, shall be submitted daily.

1.16.4. Sampling of Concrete for Strength and Workability Testing

All sampling of concrete and making of test cubes shall be in accordance with the requirements of I.S. 1199, I.S. 516. All such sampling shall be carried out by the Contractor at the site of placing of concrete in the Works.

Sampling for making test cubes shall be carried out in accordance with the following table: -

Quantity of concrete placed of each concrete grade in one continuous Operation, m³	Number of Samples
1 - 5	1
6 - 15	2
16 - 30	3
31 - 50	4
51 and above	4 plus 1 additional sample for each additional 50 m ³ or part thereof





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Note: - At least one sample shall be taken from each shift. If the concrete is supplied from a ready-mixed concrete plant, the frequency of sampling shall be agreed upon mutually by the Supplier and Engineer

From each sample, taken as provided for above, Six 150 mm cubes shall be made for testing for strength.

Cubes required by the Contractor for his own use in determining the rate of increase of strength or other properties of any mass of concrete shall be considered as additional to the minimum six routine test cubes.

All cubes shall be marked at the time of casting with a serial number, the date, the grade of concrete and other necessary marks to identify the part of the Works from which such cubes were taken. A separate record shall be kept relating each cube to the part of the Works from which it was taken, the type and consignment number of cement from which the cube was made, particulars of aggregate, the water / cement ratio and slump. Workability (slump) of concrete of each sample shall be tested according to I.S. 1199 and recorded.

1.16.5. Curing of Concrete Test Cubes

Concrete test cubes shall be cured in accordance with the requirements of I.S. 1199, I.S. 516 / BS 1881. If required, additional test cubes, made as provided for above, shall be cured in conditions designed to approximate closely to the conditions being experienced by the mass of concrete from which the cubes were taken. However, the results of any tests carried out on such cubes shall only be used for comparison purposes and not as the basis for acceptance or rejection of any concrete in the Works.

1.16.6. Testing and Strength Requirements for Test Cubes

All concrete test cubes shall be crushed to determine compressive strength in accordance with the requirements of I.S. 516. For all cubes tested for strength, the density of the concrete represented by the cube shall first be determined before testing for strength.

For each set of six test cubes, three shall be tested at 28 days and the remaining three shall be tested at an earlier age, as directed by the Engineer. This earlier age shall normally be 7 days. The results of the tests made at 28 days shall be the basis of the standard of acceptance for concrete strength unless the Engineer directs that tests at an earlier age shall form this basis.

Each cube from the three shall be tested and the average of the three results shall be defined as the “test result” for that concrete sample at that age.



Compliance with the characteristic strength requirement for that grade of concrete shall be assumed if the “test results” from 28 days (or such earlier age tests as may be specified by the Engineer) meet all the conditions given in the respective clause.

1.16.7. Records

Cube test results shall be submitted in duplicate to the Engineer on standard certificate forms completed in ink and signed by both the laboratory manager and the Engineer’s representative. They shall be presented to the Engineer as soon as possible after the test results are known to the Contractor.

Works Cube Test Certificates, when presented to the Engineer, shall include the following information: -

- a) The date of casting the cubes
- b) The date of testing the cubes
- c) The age of cubes when tested.
- d) A note of any marks on the cubes
- e) The part of the Works from which the cubes were taken.
- f) The aggregate, type of cement and admixtures used and specified grade of concrete.
- g) The mixer employed (Site plant or ready-mixed concrete supplier)
- h) The curing conditions, including temperature.
- i) The conditions of the cubes when put into the testing machine.
- j) The weights of the cubes
- k) The volume of the cubes, determined by displacement.
- l) Density
- m) The compressive strengths
- n) The appearance of the concrete and the nature of the fracture if these are unusual.


In addition to the above detailed records, the Contractor shall make such records, in a standard form to be agreed with the Engineer, to show the long-term performance of the concrete for each grade with regard to strength and such other properties as can be assessed on this basis. These records shall be made available to the Engineer and may be used when assessing the need to change mix proportions, as provided for elsewhere in this Specification.

The results of all other routine tests, as required under this Specification, shall also be recorded in a standard form, to be agreed with the Engineer, and shall be submitted on a regular basis, all as directed by the Engineer.

1.16.8. Non-Destructive Testing

All methods of non-destructive testing of the hardened concrete in the Works shall comply



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with I.S. 13311 where applicable and shall be subject to the approval of the Engineer and any information submitted prior to approval shall include details of the calibration of the tests and shall show how the tests are able to indicate the desired properties of the concrete.

Where approved or directed by the Engineer such non-destructive testing methods may be used in the event of failure to meet the strength requirements by Works test cubes, as provided for above. Such methods may also be used in the routine control procedures if approved or directed by the Engineer.

1.16.9. Concrete Core Testing

As and where directed by the Engineer, following the failure by Works test cubes to meet the strength requirements or at such other times when the Engineer has reason to doubt the standard of the concrete placed in the Works, cylindrical core specimens, not fewer than three, shall be cut from the hardened concrete in the Works from locations selected by the Engineer for the purpose of examination and testing.

The cutting equipment and method shall be subject to the approval of the Engineer and shall, unless otherwise directed or approved, produce specimens of diameter 150 mm and height 300 mm.

If required by the Engineer ultrasonic testing of the concrete to I.S. 13311 (Part 1) shall be used to determine abnormalities or density changes within the concrete and to determine the location where cores will be taken.

All examination, preparation and testing of such Core specimens shall be carried out in accordance with the requirements of I.S. 516 and prior to testing the specimens shall be made available for examination by the Engineer.


Cores from suspect areas shall be tested as required by the Engineer, those tests will include:

- Analysis of hardened concrete to I.S. 1199
- Testing concrete core compressive strength to I.S. 516

A full report of examination and testing results, as required by above standards, shall be submitted to the Engineer for each specimen and the Engineer will then decide what further action may be required. In general, the criteria for acceptance of core compressive strength test results shall be as given in I.S. 456.

The Engineer's/ Employer's decision as to the acceptability or otherwise of any concrete work shall be final and binding on the Contractor. For any work not accepted, the Engineer may review and decide (i) whether remedial measures are feasible so as to render the work acceptable. The Engineer in that case shall direct the Contractor to undertake and execute the



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remedial measures, these shall be expeditiously and effectively executed by the Contractor at his own cost, or (ii) reject the work and instruct the rejected portion of the Works to be cut out and replaced at the Contractor's expense, all as per Engineer's directions. In case the Works are accepted in spite of deviation from the Specification, the Engineer may make a reduction in rate of appropriate items with the consent of Employer.



APPENDIX A – CEMENT RECORDS

CEMENT QUESTIONNAIRE (See Section 3.3)		To be completed by Contractor
MANUFACTURER	Company Name	
	Name and Address of producing works	
CEMENT TYPE	Manufacturer's description of cement and brand name	
COMPOSITION AND PROPERTIES	Give average values and corresponding maximum and minimum values for a continuous production period of at least six months, ending not earlier than three months before submission of the data. See Cement Properties Table.	
	Standard with which compliance is guaranteed.	
PRODUCTION CHANGES	State if any material or production process changes have been made since the end of the above period; if any are in prospect, give brief details.	

CEMENT PROPERTIES TABLE (See Section 3.3)			
Period covered: From.....20__ To.....20__			
a) Composition	Avg. Value	Max. Value	Min. Value
Silica (SiO ₂) Alumina (Al ₂ O ₃) Total Iron (Fe ₂ O ₃) Calcium (CaO) Tricalcium aluminate (C ₃ A) (C ₄ AF + 2C ₃ A) Magnesium (MgO) Potassium (K ₂ O) Sodium (Na ₂ O) Sulphur trioxide (SO ₃) Sulphide Sulphur (S) Chloride (Cl-) Certified Average Alkali Content (Na ₂ O) Guaranteed Alkali Limit (Na ₂ O) Lime Saturation Factor (LSF) Alumina / Iron (A/Fe) ratio Free Lime in Clinker (as CaO) Total Acid soluble alkalis Loss on Ignition Insoluble Residue			

CEMENT PROPERTIES TABLE (See Section 3.3)			
Period covered: From.....20__ To.....20__			
a) Composition	Avg Value	Max Value	Min Value
b) Properties			
Heat of Hydration @ 7 days @ 28 days Fineness (m ² /kg) Setting times - initial - final Soundness (mm) Compressive Strength 3 days 7 days 28 days 3 months			



APPENDIX B – CONCRETE RECORDS

EXAMPLE CONCRETE POUR CARD	
Client: Deendayal Port Authority	
Project: FABRICATION, INSTALLATION OF NEW PONTOON AND REPAIR AND MAINTENANCE OF EXISTING PONTOON FOR RORO/ROPAX FACILITY AT GHOGHA- GUJARAT.	
Contractor:	
Date:	Time:
Structure:	Pour no.:
Drg. No.:	Place of deposition:
Shade air temp:	Mix temp:
Concrete Grade: M	Quantity: m ³
Max. Aggregate Size: mm	Slump: mm
Start Time:	Completion Time:
Mixing Time:	

EXAMPLE CONCRETE POUR CHECKLIST								
Sl. No.	Item	Contractor's Representative Signature	Engineer's Signature	Remarks				
1.	Centreline Checked							
2.	Formwork and Staging Checked for Accuracy, Strength & Finish							
3.	Reinforcement Checked							
4.	Cover to Reinforcement Checked							
5.	Verified Test Certificate for Cement/Steel	Yes/No	Yes/No					
6.	Adequacy of Material/Equipment for Pour	Yes/No	Yes/No					
7.	Embedded Parts Checked (Location & Plumb) <table border="1" style="display: inline-table; vertical-align: top;"> <tr> <td>Civil Items</td> </tr> <tr> <td>Mechanical Items</td> </tr> <tr> <td>Electrical Items</td> </tr> </table>	Civil Items	Mechanical Items	Electrical Items				
		Civil Items						
		Mechanical Items						
Electrical Items								
Pour Authorised: Yes / No Site Engineer's Signature: Engineer's Name:								
8.	Soffit (S) and Pour Top(T) Levels Checked Before(B) and After(A) Form Removal (Only Of Beams Of Over 10m Span & Important Structures)	S(B) S(A)	T(B) T(A)					
9.	Construction Joint Location (if not as per drawing)							
10.	Cement Consumption:	kg	kg/m ³					
11.	Number Of Cubes and Identification Mark							
12.	Test Cube Results (7 Days/28 Days)	/						
13.	Concrete Condition Form Removal	V. Good / Good / Fair / Poor						
	Site Engineer's Name	Site Engineer's Signature:						
Notes: 1. Items 1 to 7 (both inclusive) to be checked & signed by the Engineer & Contractor's representative. 2. Items 8 to 13 (both inclusive) to be filled only by Engineer. 3. Each pour to have separate cards, in triplicate one each for Employer, Engineer & site office. 4. Under remarks, indicate deviations from drawings & specifications, congestion in reinforcement if any, unusual occurrences, such as failure of equipment, sinking of supports/props. Heavy rains affecting concreting, poor compaction, improper curing, other deficiencies, any other observations, etc.								

Prof. S. Nallayarasu

Dept. of Ocean Engg., IIT Madras





**FABRICATION, INSTALLATION OF NEW PONTOON AND
REPAIR AND MAINTENANCE OF EXISTING PONTOON FOR
RORO/ROPAX FACILITY AT GHOGHA- GUJARAT.
SPECIFICATION FOR CIVIL AND MARINE WORKS**

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Prof. S. Nallayarasu
Dept. of Ocean Engg., IIT Madras

2. SPECIFICATION FOR GEOTECHNICAL INVESTIGATION

2.1. Scope

The scope of geotechnical investigation includes the following for the purpose foundation design for proposed modification of RoRo/RoPax facility.

- 2 number of deep offshore geotechnical bore holes at the location of link span support structure to a minimum depth of 20m.

The location of proposed bore holes is shown in Drawing No. IITM-DPA-GHOGHA-DWG-009. The detailed scope of work for each bore includes the activities as specified in Table 2.1.

Table 2.1 Scope of work activities for geotechnical investigation

S. No.	Scope of work Activity
1	Mobilization of jack up barge or other suitable floating structure, drilling rig, other rig, other drilling tools and accessories including personnel for carrying out Geotechnical investigation work.
2	De-mobilization of barge, Drilling rig, other drilling tools & accessories and personnel for carrying out Geotechnical investigation work.
3	Setting up of barge at each borehole location as per the location coordinates provided by client
4	Boring through soils of various strengths
5	Drilling through all kinds of weathered rock, and hard rock
6	Collection of 90mm / 100mm dia meter, 450mm long undisturbed samples from bore holes and sealing the tube with molten wax.
7	Conducting standard penetration test (SPT) in soil
8	Laboratory Experiments and studies
9	Preparation and submission of factual report during the progress of boring and testing in draft form for comments.
10	Preparation and submission of geotechnical investigation report including detailed results of laboratory studies, recommendation for foundation design etc for comments and incorporating the same and final submission.

2.2. Borehole locations

Bore holes are located at the proposed link span support frame location. The tentative locations of the proposed bore holes are specified in the tender drawings and the contractor shall position them with coordinates based on the pre-construction survey during setting up of the site.

2.3. *Equipment and Manpower requirements*

The minimum manpower the successful execution of the geotechnical investigation is given in this section. Minimum Equipment and accessories to be deployed is given below.

- Hydraulic self-elevating jack-up platform
- Boats for personnel transfer, soil samples and equipment
- Hydraulic rotatory drilling rig
- Boring & drilling accessories
- Other necessary equipment as required to executive the work.

Minimum manpower to be deployed during the execution of boreholes is given below.

- Geotechnical Expert with minimum 10 years post graduate experience : 1
- Supervisor : 1
- Barge Master : 2
- Drilling Crew : 4

Marine spread proposed for the project shall be having experience of previous similar operations. The support for drilling operations shall be provided using hydraulic operated jack-up platform. The drilling crew shall be experienced to handle the hydraulic rig and boring operations.

2.4. *Technical Requirements*

2.4.1. Boring / Drilling and Rock Coring


The activities comprise of borehole drilling and either

- (a) In-situ testing in borehole and
- (b) Sampling and sample handling.

Boreholes of 150mm/100mm diameter boreholes in soil using open hole rotary drilling rig may be undertaken. In case rock is encountered, rock core drilling using diamond bit with double tube NX size core barrel and N type drill rod shall be undertaken. The borehole will be terminated at specified depth below the existing seabed level. The measurements for core recovery, RQD, weathering index, fracture index shall be carried out at site.

Typical borehole drilling apparatus shall have the various components as minimum.



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- a. Drilling equipment: Any equipment that provides a suitable clean open hole before insertion of down hole sampling and / or testing apparatus and ensures that sampling and / or testing is performed in undisturbed ground.
- b. Drill Rig: Machine capable of providing rotation, feed and retraction, to drill pipe casting and or auger. Drill fluid pumping capacity shall be as required to promote return of drilling fluid.
- c. Drill casing: cylindrical pipe with one or more of the following purposes:
 - To support the sides of the boreholes.
 - To support drill pipe above ground surface in case of over water drilling
 - To promise return of drilling fluid.
- d. Drill pipe: Cylindrical pipe connecting drill rig and drill bit.
- e. Drill Bit: Device attached to drill pipe and used as cutting tool to drill into the ground.
 - Core drilling is a ground investigation technique comprising simultaneous drilling and sampling.
 - Core bit: Device attached to the core barrel and used as a cutting tool to drill the ground.
 - Core catcher: Device that assists retention of core in the core barrel.
 - Core Box: Box with longitudinal separators for the protection and storage of core.

2.4.2. Sampling

The description of the sampling apparatus is as follows.

- a. Push sampling will be undertaken in highly sensitive clays or is the clay encountered is soft to firm is accomplished by
- b. Sampler insertion equipment: apparatus providing relatively rapid continuous penetration force.
- c. Reaction equipment: reaction for the sampler insertion equipment
- d. Sampling rods: Rods that connect the sampler insertion equipment to the sampler head.

2.4.3. Conducting standard penetration test (SPT)

The standard penetration test shall be conducted as per the general specification suggested by IS/BS code of practice. The test shall be conducted using auto trip SPT set at specified interval of 1.5mr at a depth where there is a stratigraphic change, whichever occurs earlier. SPT shall be terminated on recording 100 blows per 30cm or less penetration for three consecutive tests. The disturbed samples obtained from the split spoon sampler shall be visually classified, labeled for identification and preserved for laboratory testing.



2.4.4. Sampling Requirement

The feasibility of a particular laboratory test relates to the sampling practice and sample handling for a particular soil and depends on factors such as soil type, available amount of sample material and sample quality. The adopted classification system for sample quality is according to IS and BS standards. The classification system recognizes 5 classes on the basis of feasibility of these classes is as follows:

- a. Class 1: undisturbed: Strength, stiffness, and consolidation.
- b. Class 2: undisturbed: permeability, unit weight, boundaries of strata – fine. Class 3: disturbed: sequence of layers
- c. Class 4: disturbed: particle size analysis, Atterberg limit, boundaries of strata – broad. Class 5: disturbed: sequence of layers.
- d. The higher class includes laboratory tests of the lower class.
- e. This is to assist in Geotechnical classification, identification, and description of strata.

2.4.5. Factual Report

The factual report shall include an introduction outlining the objectives of the investigation, description of the procedures followed for carrying out the various field and laboratory works, equipment used, ground conditions encountered, and the generalized soil profile obtained from findings of field and laboratory investigations. Engineering properties of soils shall be described in detail along with specifications, codal provisions and some engineering practice.

2.5. *Laboratory tests*

The minimum laboratory tests to be conducted on soil and rock samples collected at each bore hole shall be as per Table 2.2.

Table 2.2 Laboratory Tests on soil and rock samples

S. No.	Laboratory tests
1	Particle size distribution
2	Atterberg's limits
3	Specific gravity / particle density
4	Bulk density
5	Sedimentation / hydrometer analysis
6	Chloride content, soluble sulphates, carbonate content
7	Natural moisture content
8	Tri-axial compression test – (Consolidated Un-drained)
9	Tri-axial compression test – (Unconsolidated Un-drained)
10	Direct shear test
11	Uniaxial compression test – rock sample
12	Point Load Test – rock sample

2.6. Deliverables

Following shall be minimum deliverables.

- Daily Field report including calibration of the devices and duly signed by Field Engineer's Representative and Engineer's Representative or his representative.
- Actual executed bore hole shall be plotted on the bathymetry chart with coordinates and submitted separately both in hard and soft copy in Autocad format.
- Geotechnical Investigation report including interpreted data including all laboratory results.

2.7. Report format

The geotechnical report shall be submitted as draft for review. Final report shall be submitted incorporating the comments from Engineer's Representative. The report shall contain the minimum as follows.

- Descriptive geology of the area
- Bore hole data (raw) and interpreted based on relevant Indian Standards
- Description of each soil strata indicating colour, consistency, grading in accordance with Indian Standards for soil classification.
- Laboratory test results
- Geotechnical soil profile at the proposed location.
- Soil characteristics including design strength for each bore hole strata.
- Soil strength includes SPT value, angle of internal friction, density, subgrade lateral soil modulus, modulus of elasticity of soil, undrained shear strength etc shall be provided for each soil layer either by direct testing or by interpretation from relevant literature.
- Pile (Bored cast in-situ RC pile) axial capacity chart prepared for 1200mm piles based on IS 2911, IRC 78 and IS 14593 as deemed appropriate.