

3 CONCRETE WORKS

3.1 General

- 3.1.1 Materials used in the Works shall be new, of the qualities and kinds specified herein and equal to the approved samples. Delivery shall be made sufficiently in advance to enable further samples to be taken and tested if required. No materials shall be used until approved and materials not approved shall be immediately removed from the Works.
- 3.1.2 Materials shall be transported, handled and stored on the site or elsewhere in such a manner to prevent damage, deterioration or contamination.

3.2 Cement

- 3.2.1 Cement shall be Ordinary Portland cement of an approved brand.
- 3.2.2 Cement shall conform to BS 12.
- 3.2.3 Cement shall be of recent manufacturer and used within 6 months of manufactured date.
- 3.2.4 The Contractor shall with each fresh consignment of cement delivered to the site furnish the Consultant with a copy of the Manufacturer's statement of compliance with the above Standard Specifications together with the date of manufacture, certified by an independent agency in the country of origin and its date of delivery to Site.
- 3.2.5 Check tests will be required by the Consultant. These tests shall be carried out at the Contractor's expense.
- 3.2.6 Any cement failing to meet the required standards will be rejected and replaced at the Contractor's expense.
- 3.2.7 Any cement not conforming to BS 12 shall not be used unless otherwise approved by the Consultant.

3.3 Aggregate

- 3.3.1 Fine aggregate shall be river sand conforming to BS 882.
- 3.3.2 Coarse aggregate shall be crushed stone excluding limestone or derivatives of limestone conforming to BS 812.
- 3.3.3 Aggregate shall not contain injurious amount of rubbish, dirt, organic impurities and other foreign matters.
- 3.3.4 Strength of aggregate shall be more than that of hardened concrete paste.
- 3.3.5 Shape of coarse aggregate shall not be flat or slender.
- 3.3.6 Aggregate to be used in concrete shall possess the qualities indicated in the following tables.

Quality of Aggregates

| Aggregate type | Open dry specific gravity | Percentage of water absorption (%) | Percentage of solid volume for the evaluation of particle shape (%) | Clay lump (%) | Loss in washing test (%) | Organic impurity (%) | Water soluble chloride (%) |
|------------------|---------------------------|------------------------------------|---------------------------------------------------------------------|---------------|--------------------------|----------------------|----------------------------|
| Coarse aggregate | 2.64-2.9 | 0.81% | □□□□ | 5.00% | 0.1% | 5 | 242 ppm |
| Fine aggregate | 2.4-3.0 | 1.50% | - | 8.00% | 0.15% | 5 | 219 ppm |

* Colour of test solution not to be darker than standard solution

Grading requirements for aggregates

Percentage passing each sieve by weight (%)

| Agg. | Max. size (mm) | Nominal sieve size (mm) | | | | | | | | | | | |
|--------|----------------|-------------------------|-----|-----------------|----------------|----|-----------------|----------------|----------------|---------------|---------------|---------------|--------------|
| | | 40 | 30 | 25 | 20 | 15 | 10 | 5 | 2.5 | 1.2 | 0.6 | 0.3 | 0.15 |
| Coarse | 25 | 100 | 100 | 90 □ 100 | 60 □ 90 | | 20 □ 50 | 0 □ 10 | 0 □ 5 | | | | |
| | 20 | | | 100 □ 100 | 90 □ 100 | | 20 □ 55 | 0 □ 10 | 0 □ 50 | | | | |
| Fine | | | | | | | 100 □ 100 | 90 □ 100 | 80 □ 100 | 50 □ 90 | 25 □ 65 | 10 □ 35 | 2 □ 10 |

- 3.3.7 Manufactured sand and blast furnace slag to be use in concrete shall not be used unless otherwise specified or approved by the Consultant.
- 3.3.8 In case of using fine aggregate with 0.01% or more water soluble chloride content, the necessary measures for corrosion inhibiting of reinforcement shall be instructed by the Consultant.
- 3.3.9 The maximum size of coarse aggregate shall be 25 mm.
- 3.3.10 Sources of aggregate shall be to the approval of the Consultant and samples of aggregate from the proposed source shall be submitted to the Consultant at least 28 days before its intended use.

3.4 Water

- 3.4.1 Water shall not contain injurious amount of impurities that may adversely affect concrete and reinforcement.
- 3.4.2 Ground water shall not be used for concrete works.
- 3.4.3 Water shall be obtained from a public supply where possible, and shall be taken from any other sources only if approved by the Consultant.
- 3.4.4 Only water of approved quality shall be used for washing out formwork, curing concrete and similar surfaces.

3.5 Handling and Storage of Material

3.5.1 Cement

- 3.5.1.1 Cement shall be stored in a manner to prevent weathering.
- 3.5.1.2 Bagged cement shall be piled no more than 10 bags so as to permit easy inspection
- 3.5.2 Cement caked even to the slightest extent shall not be used. Such cement and rejected cement shall be immediately separated from other bags of cement so that they shall not be mistaken for others.

3.5.3 Aggregate

- 3.5.3.1 Aggregate shall be stored in a manner effectively separating coarse and fine aggregate according to type and shall be prevented from inclusion of dirt, rubbish and other undesirable foreign matters.
- 3.5.3.2 Coarse aggregate shall be unloaded and piled in a manner not to cause segregation of small and large particles. Aggregate to be stored in piles shall be in mounds of moderate height and at a location where good drainage is provided.

3.6 Mix Proportion and Strength

- 3.6.1 Mix ratio for reinforced concrete shall be in the proportion 1:2:3 (cement: fine aggregate: coarse aggregate) by dry volume.
- 3.6.2 Mix ratio for lean concrete shall be in the proportion 1:2:6 (cement: fine aggregate: coarse aggregate) by dry volume.
- 3.6.3 Water-cement ratio for concrete shall be 0.4% to 0.45%
- 3.6.4 The specified design strength of reinforced concrete shall be 25 N/mm²
- 3.6.5 The required slump of concrete shall be 100 mm.
- 3.6.6 Design mix proportion shall be to obtain required workability, consistency and durability.

3.7 Production of Concrete

3.7.1 Field-mixed Concrete Plant

3.7.1.1 The Contractor shall select the necessary facilities for storage, batching, mixing and transporting of each of the materials and submit them for approval of the Consultant prior to start work.

3.7.2 Measuring

3.7.2.1 All materials shall be measured by volume for each batch and water may be measured volumetrically.

3.7.2.2 Cement shall be measured by number of bags unless automatic cement weight measure is in use.

3.7.3 Mixing Control

3.7.3.1 Concrete mixture shall be constantly controlled to obtain required workability and mixed strength. Mixing time for each batch shall be not more than 3 minutes.

3.7.4 Quality Control

3.7.4.1 The Contractor shall conduct tests for quality control toward insuring that concrete of the required quality is constantly produced.

3.7.4.2 The Contractor shall have all quality control tests report ready for submission as required by the Consultant.

3.7.5 Quality Inspection of Concrete at the Point of Placement

3.7.5.1 The Contractor shall conduct tests on concrete at the point of placement. When test results meet the tolerances given below, the concrete shall be qualified to have passed the tests.

(a) The tolerance between actual slump and required slump of the concrete shall be ± 2.0 mm

3.7.5.2 For the estimation of compressive strength of concrete in compressive strength tests, when the average value of compressive strength of concrete obtained in a test is not less than the specified design strength, it shall be qualified to have passed the test. In case of failure to the above requirements, the Contractor shall take necessary measures such as to perform appropriate test as instructed by the Consultant.

3.8 Transporting and Placing

3.8.1 General

3.8.1.1 The Contractor shall establish a manner and schedule for transporting and placing of concrete and obtain approval of the Consultant.

3.8.1.2 Concrete shall be transported in a manner to minimize segregation, spill, age and other changes in quality thereof.

3.8.1.3 Concrete shall be placed and consolidated in a manner to insure uniformity and optimum density.

3.8.1.4 In case of rain or other conditions that may affect the quality of concrete during concreting, the Contractor shall take necessary measures as instructed by the Consultant.

3.8.2 Time Limit

3.8.2.1 The time limit from start of mixing to completion of placing of a batch as rule shall be 30 minutes.

3.8.3 Preparation prior to Placing

- 3.8.3.1 The place where concrete is to be deposited shall be cleaned and sheathing shall be sprinkled with water. Subsequently, water accumulated in the form shall be removed.

3.8.4 Construction Joint

- 3.8.4.1 Joint surfaces shall be cleaned, made free of laitance and other foreign matters, and wetted prior to concreting. Joint surface shall be roughened if directed by the Consultant.
- 3.8.4.2 The locations of shapes of construction joints shall be consulted and approved by the Consultant.

3.8.5 Concrete Placing

- 3.8.5.1 Concrete placing shall be proceeded to keep the surface of placed concrete as horizontal as possible.
- 3.8.5.2 Concrete shall be continuously poured to compact around reinforcing bars and corners of formwork.
- 3.8.5.3 The maximum time interval between placements of continuous concreting shall not exceed 0.5 hours. However, when special measures are taken this time limit may be changed according to instruction or approval of the Consultant.

3.8.6 Consolidation

- 3.8.6.1 Vibrating of concrete and tapping of formwork shall be performed to wall, column and other places difficult for concrete to proceed. Proper number of workers for placing and compacting concrete shall be arranged.
- 3.8.6.2 Vibrator shall be operated for concrete called for water tightness, difficult portion for concrete to proceed and other cases directed by the Consultant. However, vibrator shall not be touched reinforcing bars and shall not be operated more than 30 seconds at same spot.
- 3.8.6.3 Concrete shall be placed 300 - 600 mm thickness at once in case vibrator is performing. In case flexible-insert-vibrator is called for, concrete shall not be placed thicker than the length of the insert or vibrator at one pouring.

3.8.7 Placing Speed

- 3.8.7.1 Concrete shall be placed at the speed suited for the workability of the concrete and condition of the place of placement, which insures proper consolidation of concrete.

3.9 Concrete Curing

3.9.1 Curing Method

- 3.9.1.1 After concrete has been placed, the concrete surface shall be kept moist by sprayed with water or by other appropriate methods, and shall be protected from direct sunlight and rapid drying. The top surface of slabs shall be kept flooded with water at all times after concreting for the duration of curing period. This curing period shall be for not less than 14 days.
- 3.9.1.2 As a rule, no foot traffic or loads shall be permitted on concrete for at least 24 hours after placement.

3.10 Test

3.10.1 General

- 3.10.1.1 The contractor shall be required to conduct all tests according to BS (British Standard) method and procedure.
- 3.10.1.2 Test, as a rule, shall be conducted at the locations directed or at the testing institutions approved by the Consultant.
- 3.10.1.3 The Consultant shall conduct test, as a rule.
- 3.10.1.4 In case of failure in test, measure shall be taken as instructed by the Consultant.
- 3.10.1.5 The Contractor shall keep test records during the work and for 2 years after completion of the contracted work.

3.10.2 Material

3.10.2.1 Cement Test

- (1) Setting test
- (2) Soundness test
- (3) Compressive strength test

Note: Item (1) shall be conducted once in every manufacturer.

Item (2) & (3) shall be conducted once in every 2,000 bags.

3.10.2.2 Aggregate test

- (1) Grading and fineness modules

3.11 Concrete

3.11.1 Fresh concrete

Slump, air content, shall be conducted daily, and more often at request of the Consultant.

3.11.2 Compressive strength test of concrete

Test for estimation on strength of concrete in structure:

- 3.11.2.1 In order to assume estimated strength of concrete in structure, compressive strength test shall be conducted for prepared test pieces on the 7th day and 28th day and those test pieces shall be made for sampling at placing of concreting.
- 3.11.2.2 Strength test shall be conducted for each of the following conditions: each day's pour and each class of concrete, each change of supplies or source and each 100 cubic meters of concrete or fraction thereof. The number of test pieces to be used in a test shall be not less than 3 for each test of the 7th day and the 28th day unless otherwise instructed by the Consultant.
- 3.11.2.3 Test pieces shall be made in accordance with British Standards, and sampling shall be taken as near as possible at the point of placement.
- 3.11.2.4 Test pieces shall be stored without being disturbed and shall be covered during the first 24 hours, and carefully transported specimens to the testing laboratory. Test pieces shall be cured in water after de-moulding. The temperature of test pieces shall be kept as close as possible to the temperature of the concrete in structure until the time of testing.
- 3.11.2.5 The test results shall be expressed in the average value by calculating the average compressive strength of all test pieces. The average value must be equal to or greater than the specified strength.

3.12 Defective Concrete and Finishes

- 3.12.1 Honeycombed surfaces shall be made good or on the instruction of the Consultant be cut out by the Contractor and make good at his own expense.
- 3.12.2 Concealed concrete faces shall left as from the formwork except honeycombed surfaces shall be made good. Faces of concrete to be rendered shall be roughened by approved means to form a key. Faces of concrete that are to have finished other than those specified shall be prepared in an approved manner as instructed by the Consultant.