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GUIDE LINES
FOR
QUALITY CONTROL AND QUALITY ASSURANCE
Vol. 1



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CONTENTS

FOREWORD

PREFACE

I EARTH WORK

General	E – 1
Borrow area investigation	
Embankment construction	E – 2
Sampling Methods (Table 1)	E – 5
Simple field tests for identification of soils (Table 2)	E – 6
Testing of soils (Table 3)	E – 7
List of Indian Standards – Soils (Table 4)	E – 11
Quantity of soil sample required for tests (Table 5)	E – 14
On earth work (Table 6)	E – 15
O. K. Card for Earth work (Table 7)	E – 16
List of records to be kept (Table 8)	E – 17
Statement showing daily tests carried out for the earth work (Table 9)	E – 18

II MATERIALS

Concrete	M – 1
Recommended values of slump for different conditions	M – 8
Field tests for common materials	M – 9
Materials – Name of tests, frequencies, equipment, acceptance criteria and purpose of testing	M – 11
O. K. Card for concreting at structures	M – 39
O. K. Card for concrete (at batch mix plant)	M – 40
O. K. Card for C C lining	M – 41
O. K. Card for brick lining	M – 43
List of Indian Standards	M – 46

FOREWORD

It has been said that “entirely safe and substantial design may be entirely ruined by careless and shoddy execution. Careful attention to the details of the construction is, therefore, as important as the preliminary investigation and design. The consequences of being ignorant of, or ignoring the quality aspects may result into catastrophic failure of the structure.”

All civil engineering projects deal with a large variety of natural construction materials as well as factory made products. Before execution of any structure, properties of these materials are required to be determined. Selection of suitable materials and their use in building a safe and economical structure forms a very crucial process in the whole construction project. This process is known as quality control and quality assurance.

Determination of properties of natural as well as factory made products is done by laboratories as per standard test procedures laid down by the Bureau of Indian Standards. These standards also lay down frequency of testing and acceptance criteria. These criteria should be followed to meet with the assumptions made in design of the structure. This is the only way of providing guarantee for structural safety.

Quality control is obtained through testing of raw materials and end products. Inspection of workmanship and insistence on good performance by those who executes a project is also a part of quality control. But they collect samples subject them to various tests and receive results from laboratories. These results have to be interpreted and then they have to assure the owner of the structure (Government) and the people, about quality of the work as it is envisaged in the design. These guideline when used in consultation with various standards enlisted will provide with an effective tool to achieve quality control and provide quality assurance to the owner.

These guidelines should not be used as specifications of any particular work. A specific work has its own set of specifications. It should naturally and legally override the contents of this manual. As such, the constructing agency has to follow this guideline in conjunction with the standard specifications and use appropriate the information for filling up gaps in the requirements of inspection and quality control.

The manual is divided into two sections viz, (i) Earth work (i.e. Soils) & (ii) Materials

Part 1, “EARTHWORK” include construction sequence of planning, borrow area investigations, and embankment construction. The specific points to be inspected and looked into are mentioned. Frequency of testing, acceptance criteria, purpose of testing are also included to help constructing agency. "DO" and "DON'Ts" are also highlighted.

Part 2, "CONSTRUCTION MATERIALS" include guidelines for concrete making, brick and stone masonry, plaster, analysis of cement and concrete, quality control of brick/tiles for canal lining etc. It also includes field tests for common construction materials. Particulars of test with frequency, equipment, acceptance criteria, purpose of testing for different construction materials are given. List of related Indian Standards is also given.

These guidelines serve as a ready reckoner for the construction engineers. They are made considering work tender provisions in general, however if there are any aspects beyond such provisions leading to other implications, the guidelines may be adopted only after obtaining requisite approval from competent authority.

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EARTH WORK

1.0 GENERAL

Earthwork is required for earth dam, road embankments, bridge approaches, canal embankments, C. O. T, filling behind retaining walls etc., different zones of embankments require soils with different properties. They therefore call for similar construction techniques and hence similar quality control. General activities carried out for earthwork are given below

- Stripping of borrow area and excavations to the required limiting depth or as per site conditions
- Laboratory testing of various materials available from excavation and / or borrow areas
- Suitability decision for specific application
- Determination of Natural Moisture Content (NMC) of borrow area material
- Determination of Proctor density values i.e. Maximum Dry Density (MDD), Optimum Moisture Content (OMC) and degree of compaction
- Determination of moisture to be added to account for Natural Moisture Content (NMC), Optimum moisture Content (OMC) and construction needs
- Preparation of seat of embankment after removal of vegetation roots and other organic material by stripping to required depth
- Determination of type of soil and testing for its properties
- Field test for compaction of filter or necessary test for rubble/rock toe as the case may be
- Placing of uniform layers of specified thickness of soils for embankment
- Watering and compaction
- Checking Field Dry Density (FDD) and Field Moisture Content (FMC)
- Preparation of daily and monthly reports on results of compaction

2.0 BORROW AREA INVESTIGATIONS

Construction of embankment involves utilization of natural material, viz., Soils. Required soil is taken from borrow area and/or cuttings of excavations. This soil, before using in construction requires suitability testing for design of particular embankment. This needs borrow area investigations. The programme of borrow area investigation should be decided in consultation with Central Design Organisations & GERI.

Borrow area investigations consist of four major parts, Viz., collection of samples (Table-1), field tests and visual examination of soils (Table -2), laboratory testing for suitability of material at required frequency (Table -3). Table-1, shows brief details of sampling methods. Suitable method/methods as per site condition and soil type or for any other requirement may be adopted. Table - 2 shows simple field identification tests which are required to be performed on field. These tests can be performed as and when required. Table - 3 gives details of different soil tests, which can be performed as per requirements.

2.1 Laboratory Testing:

Soil samples collected from the borrow area are tested for different properties. The main physical and engineering properties are listed below.

1. Determination of water content (moisture content)
2. Specific gravity
3. Grain size analysis
4. Atterbergs limits (LL, PL, PI)
5. Density moisture relationship (light), Std. Proctor Density
6. Density moisture relationship (heavy), Modified Proctor Density
7. Shear strength properties
8. Density Index (Relative density) for granular soils
9. Permeability

In addition to these properties, determination of consolidation characteristics, swell pressure, swelling index etc. is required for certain soils. The list of relevant Indian Standards is given at

Table-4. Quantity of the soil sample required for various tests is given at Table -5.

3.0 EMBANKMENT CONSTRUCTION

Embankment construction can be defined as laterally unsupported fills built on the natural ground surface. Embankments are of two types Govt. circular M/S 1077-V-255-K2-1977 should be referred.

3.1 Homogeneous embankment: This consists of practically uniform quality of material. There is no designed plan of material distribution in the embankment in to zones.

3.2 Zoned embankment

From borrow area excavation

(i) General points to be observed before zoned embankment is constructed.

- Sources of material suitable for different zones should be properly demarcated
- Flow charts should be prepared showing borrow areas along with quantity of material available for different zones
- Excavated material available and suitable for embankment for different zones should be tested and stacked separately and carefully
- Advance planning is required so that whenever need arises excavated material is directly utilized in respective zone of embankment

Various tests carried out as per relevant IS for investigation, design as well as quality control are detailed in Table-4.

(ii) Preparation of embankment

- Strip off all trees, shrubs, jungle growth, roots, top soil containing small or large roots, organic matter etc
- Remove deep roots of trees at least up to one-meter depth below the ground surface
- Scarify the stripped surface to a depth of 100 mm to 200 mm

- Break the clods before spreading any material over surface
- Any ridges or mounds should be stepped so as to provide a close bond between new and old work

(iii) Laying

- All the acceptable material free from organic matter, is to be laid or placed in the embankment in 15 to 25 cm (loose) layers as per IS : 4701 or as specified
- The laying is to be done for full width of the embankment and is built up regularly in layers in accordance with the designed embankment section, with provision for dressing the shoulders or proudes
- All clods are broken at the borrow pits. Any remaining small clods are broken before compaction is commenced on the embankment section
- The surface is graded at all the times and crowned in center so that during rains, water is carried away rapidly to the edges and down the slope of the fill
- For the zoned embankments, the change over from one material to another is made and compacted with some allowance beyond the critical line of contact
- In case the whole length are not being taken up for lying at a stretch, the end edges of embankment are provided with steps is an overall slope of 1 in 5 to permit satisfactory contact with the length of embankment to be taken up

(iv) Compaction

- The dry density and the optimum moisture content at which the material in to be compacted is predetermined in the laboratory
- Compaction is achieved by using appropriate rollers necessary bed thickness of each layer

- Proper care is to be taken to see that required compaction is achieved around embedded instruments
 - While compacting back fill material along abutment contacts or adjacent to cut-off walls and rigid parts of any structure, care is to be taken to achieve intimate contact. Such surfaces are thoroughly cleared prior to placing the material. In general, clayey material as available is used at these locations to avoid seepage through the contact faces.
- (v) Moisture control
- Materials are conditioned to the desired moisture content at the site of excavation or embankment by surface inundation of the borrow pits prior to excavation by ponding or by sprinkling on embankment under construction.
- (vi) Field control
- It is necessary to establish a field laboratory to carry out requisite tests in field while compaction operations are in progress. The lab provides a continuous approximate of materials used and compaction attained. Following field tests are carried out.
- (1) Field moisture content test
 - (2) Density tests for both cohesive and non-cohesive material
 - (3) Optimum moisture content test
- Table-3, (Field Test) indicates the relevant IS and other relevant details for the testing.
- Penetrometer test provides a quick guide for field compaction control. Equipment like moisture and density gauge is deployed to indicate such appraisal quickly.
- A complete record is kept for all the tests made and compared carefully with the laid down standard. Any deficiencies are made good by suitably adjusting the moisture content and number of passes of the roller. The density determination tests are done

- (i) in area where degree of compaction is doubtful,
- (ii) in area where embankment operations are concentrated,
- (iii) for every 300 m³ of embankment where compaction is doubtful in isolated areas,
- (iv) for representative tests for every 4500 m³ of earth fill, and
- (v) for record tests at location of all embedded instruments

As general guidelines for field staff, specific "DO"s and "DON'Ts" are given in Table 6 for quality control. For rapid check, O. K. Card given in Table 7 is used. The list of records to be maintained and format of maintaining daily test report are given in Table 8 and 9 respectively.

- (vii) Filter materials
- Filter is required to prevent migration of soil particles with water as well as to allow the water to safely pass without building of excessive pore water pressure. Following aspects are taken care of to form a good filter.
- Layer of finer filter material is placed next to the earthwork in IP zone, as well as on the foundation, this followed progressively coarser layer of filter to form a graded filter
 - The filter material is laid in layers of not exceeding 15 cm thickness or as specified.
 - The gradation curve of filter is kept nearly parallel to that of the base material
 - Filter material is clean, sound, well graded and free of debris, silt and clay
 - The finer filter material consists of sand passing 2 mm sieve
 - Laying of filter material is done side by side with casing and hearting materials
 - It is saturated with water and properly rolled
 - Mixing of filter material with adjoining soil is avoided
 - No segregation is allowed
 - Density are fulfilled as minimum of 70% RD or as specified

Following filter between casing and core material or between two consecutive casing materials if more than one casing material is used.

$$(a) \frac{D_{15(f)}}{D_{15(b)}} > 4 \text{ and } < 20$$

$$(b) \frac{D_{50(f)}}{D_{50(b)}} < 25$$

$$(c) \frac{D_{15(f)}}{D_{85(b)}} < 5$$

where (f) indicate filter material or the material on d/s side in the direction of seepage and (b) indicates base or u/s material.

As an alternative to graded filter, non-woven geofabrics can also be adopted. The minimum required properties including filter criteria of fabric are included in the chapter of "Sub Materials".

TABLE -1
SAMPLING METHODS

Disturbed samples

- (a) From trial pits : From individual stratum by cutting a notch in the side
- (b) From bore holes
 - (i) Auger samples
 - (ii) Samples from S. P. T. spoons
 - (iii) Wash samples in case of granular soils or bailer samples

Undisturbed samples

- (a) From trial pits
 - i) Chunk sample
 - ii) Core cutter samples
- (b) From bore holes
 - i) Shelby tubes
 - ii) Piston tube samples

Note: When it is not possible to collect undisturbed samples in cohesionless soils, the following tests are conducted in addition to testing of disturbed samples, if required, to assess insitu status of the soil.

- (i) Dry density in place at accessible locations by sand or water replacement method
- (ii) Standard penetration tests in bore holes
- (iii) Dynamic cone penetration tests in bore holes
- (iv) Pressuremeter tests in bore hole
- (v) Plate load test

TABLE - 2
SIMPLE FIELD-TESTS FOR IDENTIFICATION OF SOILS

Sr. No.	Field test or visual examination	Procedure
(a)	Shaking or dilatancy test	<p>Take a small representative soil sample to form a pat of size of about 5 cm³ by addition of adequate quantity of water to nearly saturate it, mix thoroughly and place the soil pat in open palm of one hand and shake horizontally, striking vigorously against the other hand several times. Squeeze the pat between the fingers. The appearance and disappearance of the water with shaking and squeezing is referred to as reaction. This reaction is called quick if water appears and disappears rapidly; slow, if water appears and disappears slowly, and no reaction, if the water condition does not appear to change. Observe and report type of reaction as descriptive information.</p> <ul style="list-style-type: none"> • Fine clean sands react quickly & distinctly • Very fine-grained cohesionless soils like silt and rock flour react somewhat slowly than fine sands • Plastic clays do not react to this • Cohesionless soils when moist do not stain the hands when rubbed
(b)	Surface tests	<p>Cohesive soils are identified by rubbing a small ball or remoulded moist soil with a clean knife blade or fingernail. A small sample of the soil at above plastic limit is kneaded into a ball about 25 mm in diameter and rubbed with a clean knife blade or fingernail. If the knife blade leaves a shiny surface, the soil is highly plastic.</p>
(c)	Dry strength or crushing resistance	<p>Dry the prepared soil pat completely. Then measure its resistance to crushing and powdering between fingers. This resistance, called dry strength is a measure of the plasticity of soil and is influenced largely by the colloidal fraction content. The dry strength is designated as low, if the dry pat can be easily powdered; medium, if considerable finger pressure is required and high, if it cannot be powdered at all. Observe and record the dry strength as descriptive information.</p>
(d)	Toughness or Consistency near plastic limit	<p>Dry the pat used in the dilatancy test by working and moulding until it has the consistency of putty. The time required to dry the pat is the indication of plasticity. Roll the pat on a smooth surface or between the palms into a thread of about 3 mm in diameter. Fold and reroll the thread repeatedly to 3 mm in diameter so that its moisture content is gradually reduced until the 3 mm thread just crumbles. The moisture content at this time is called the plastic limit and the resistance to moulding at the plastic limits is called the toughness. After the thread crumbles, lump the pieces together and continue slight kneading action until the lump crumbles. If the lump can still be moulded slightly drier than the plastic limit and if high pressure is required to roll the thread between the palms of the hand, the soil is described as having high toughness. Medium toughness is indicated by a weak thread, it breaks easily and can not be lumped together when drier than the plastic limit. Highly organic clays have very weak and spongy feel at the plastic limit. Non-plastic soils can not be rolled into threads of 3 mm in diameter at any moisture content. Observe and record the toughness as descriptive information.</p>

**TABLE - 3
LABORATORY TESTING OF SOILS**

SR. NO.	TEST	FREQUENCY	EQUIPMENTS	ACCEPTANCE CRITERIA	PURPOSE OF TESTING
1	Grain size analysis IS : 2720-4-1985 (2001 RA)	As per relevant specification provisions or 1 per 1000m ³	Coarse sieve (80mm, 63, 37.5, 25.0, 20.0, 10.0, 6.3, 4.75 mm) Fine sieves (2mm, 600 micron, 425, 212, 75 micron), balances oven, stirrer, hydrometer with jars	As specified	For classification of soil and there by getting indication of properties
2	Plasticity index IS : 2720-V-1985 (2001 RA)	As per relevant specification provisions or 1 per 1000m ³	Uppal's cone penetrometer, sieves, oven, ground glass, spatula balance, containers	As specified Workable range for Hearting LL PL PI 35 20 15 to to to 50 30 30	Indicates properties of soils. Test not possible for nonplastic soils which are used for casing
3	Standard compaction IS : 2720-VII-1980 (1997 RA)	As per relevant specification provisions or 1 per 1000m ³	Standard compaction mould 1000m ³ with base, collar and rammer of 2.6 kg, soil extractor, balance 20 kg, oven, spatula	As per design	For determining the maximum density which can be attained on field at optimum moisture content, with standard energy in put
3 A	Heavy compaction IS : 2720 (Part-VIII)-1983 (2001 RA)	As per relevant specification provisions or 1 per 1000m ³	Same as above except compaction mould is 1000cm ³ and 2250 cm ³ & rammer of 4.9 kg	As specified	Some as above but with heavy energy
4	Relative density IS : 2720-XIV-1983 (2001 RA)	As per relevant specification provisions or 1 per 1000m ³	Relative density apparatus, vibrator, balance 50 kg, oven surcharge plates, Moulds with base plate	As specified	Similar as above but for coarse grained soils
5	Permeability IS : 2720-XVII-1986 (1997 RA)	As per relevant specification provisions or 1 per 1000m ³ or as required	Permeability apparatus, soil extractor, oven.	Workable range for hearting, less than 10 ⁻⁶ cm/sec. Casing more than 10 ⁻⁴ cm/sec or as specified	To decide drainage conditions under which the soil will behave in field, to anticipate probable, seepage and design drains

6	Direct shear (for soil up to 4.75 mm size) IS : 2720-XIII-1986 (1997 RA)	As per relevant specification provisions or 1 per 1000m ³ or as required	Direct shear apparatus, soil extractor, balance 5 kg. Shear moulds with grid plates, porous stone, loading pad, dial gauge, proving ring	As per design	To determine shear strength of soil in foundation or in an embankment To find out safe bearing capacity of soil
6 A	For soil containing gravel more than 4.75 mm size IS :2720-XXXIX-1979 (1997 RA)	As per relevant specification provision or 1 per 1000m ³ or as required	Direct shear apparatus - large size with all accessories, balance 20kg, dial gauge, proving ring etc.	As per design	To determine shear strength of soil in foundation or in an embankment
7	Triaxial compression (uu) IS : 2720 (Part XI)-1993 (1997 RA)	As per relevant provision	Triaxial shear apparatus, loading frame, Bishop por pressure apparatus, Constant pressure system, Soil extractor, Balance 5 kg, Membrane stretcher, Split mould, Proving ring, Dial gauge etc.	As specified	To determine shear strength of soils in unconsolidated undrained condition
7 A	Triaxial compression (cu) IS : 2720 (Part - XII)- 1981 (1997 RA)	As per relevant provision or 1/1000m ³	Triaxial shear apparatus, loading frame, Bishop por pressure apparatus, Constant pressure system, Soil extractor, Balance 5 kg, Membrane stretcher, Split mould, Proving ring, Dial gauge etc.	As specified	To determine shear strength of soils in foundation or in embankment in consolidated undrained condition To find out S. B. C. of soil
8	Consolidation IS : 2720-XV-1986 (1997 RA)	1 set of 3 samples per season per zone at end of season or as specified	Consolidation test apparatus. Stop watch, oven, extractor. balance	As per design	To determine settlement rate and magnitude & to assess whether soil is normally consolidated or preconsolidated To determine allowable bearing pressure
9	Unconfined compression IS : 2720-X-1973 (2001 RA)	As per relevant specification provisions or 1 per 1000m ³	Compression device sample extractor, Dial gauge, Oven, Balance	As specified	To determine unconfined compressive strength of soil and shear parameter

10	Free swell index IS : 2720-(Part XL-1977) (1997 RA)	As per relevant specification provision	Sieve graduated glass cylinder 100cc capacity	As specified	To determine swelling index of soil
11	Swelling pressure of soils IS : 2720-(Part XLI-1977) (1997 RA)	As per relevant specification provision	Swell pressure apparatus or consolidometer, dial gauge, proving ring etc.	As specified	To determine swelling pressure of soil
12	Pin hole test ASTM : D-4647-1993	As per relevant specification provision	Pin hole test apparatus, graduated cylinder, compaction equipment, balance centering guide etc.	As specified	To know the dispersive characteristics of soil
FIELD TEST					
1	Field density and moisture IS : 2720-XXVII-1977 (1997 RA) 2720-XXIX-1975 (2001 RA) 2720-XXXIII-1971 (2001 RA)	1 per 300m ³ , minimum one in each zone per layer or as specified, 1 per 5000m ³ for Rock fill	Core cutter, sand replacement kit and water replacement kit	95 percent of MDD or 70 percent of RD Moisture OMC \pm 2 percent or as specified Above 70 percent RD or as specified	To determine the placement density and to monitor compaction effort. It also indicates adequacy of moisture content
2	Moisture content IS :2720 (Part-2)-1973 (2001 RA)	1 per 300 m ³ or as specified	Balance & oven or rapid moisture meter	Depending upon OMC results	To determine degree of saturation, consistency rate of natural strata or a compacted soil

3	Field permeability IS : 5529-I-1985 (1995 RA)	1/3 m depth or as required	Field permeability apparatus like water storage drum, shovels, augers etc.	Workable range for hearting, less than 10^{-6} cm/sec. Casing more than 10^{-4} cm/sec or as specified	To determine the drainage condition of soil in situ.
4	Standard Penetration Test (SPT) IS : 2131-1981 (1997 RA)	1.5m to 2.0m depth in bore hole or as specified	Drilling equipment, Split spoon sampler, Drive weight assembly, screw jack etc.	As specified	To determine penetration resistance of sub soil in terms of standard penetration number (N).
5	Dynamic Cone Penetration Test (DCPT) IS : 4968-Part-I- 1997 (1992 RA) IS : 4968-Part-II- 1976 (1997 RA)	Continuous in bore hole up to specified depth	Standard cone, Driving head, Hoisting equipment hammer etc.	As specified	To determine penetration resistance of sub soil (Strata wise)
6	Load Test on soil IS : 1988-1982 (1888 RA)	As specified	Plate of different sizes, loading device, dial gauge, hydraulic jack, datum bar etc.	As specified	To determine load deformation characteristic of sub soil and to determine SBC and ABP values
7	Pressuremeter Test I S : 1892-1979 (1997-RA)	As specified	Pressuremeter assembly	As specified	To determine SBC and deformation characteristic of soil

TABLE - 4
LIST OF INDIAN STANDARDS – SOILS
UPDATED FROM CATALOGUE OF BUREAU OF INDIAN STANDARDS 1997

Sr. No.	IS: Code No.	Title	Sr. No.	IS: Code No.	Title
1	1498-1970	Classification and Identification of soils for general engineering purposes (First revision), (amendments 2) Reaffirmed-1997	11	2720 (Part 4) – 1985	Methods of test for soils: Part 4. Grain size analysis (Second revision), Reaffirmed 2001
2	1888-1982	Method of load test on soils (Second revision), Reaffirmed 1997	12	2720 (Part 5) – 1985	Methods of test for soils: Part 5. Determination of liquid and plastic limit (Second revision), Reaffirmed 2001
3	1892-1979	Code of practice for sub surface investigations for foundations (First revision), Reaffirmed 1997	13	2720 (Part 6) – 1972	Methods of test for soils: Part 6. Determination of shrinkage factors (First revision), Reaffirmed 2001
4	1904-1986	Code of practice for design and construction of foundation in soils, General requirements (Third revision), Reaffirmed 2000	14	2720 (Part 7) – 1980	Methods of test for soils: Part 7. Determination of water content-dry density relation using light compaction (Second revision), Reaffirmed 1997
5	2131-1981	Method of standard penetration test for soils (First revision), Reaffirmed 1997	15	2720 (Part 8) – 1983	Methods of test for soils: Part 8. Determination of water content-dry density relation using heavy compaction (Second revision), Reaffirmed 2001
6	2132-1986	Code of practice for thin walled tube sampling of soils (Second revision), Reaffirmed 1997	16	2720 (Part 9) – 1992	Methods of test for soils: Part 9. Determination of dry density – moisture content relation by constant weight of soil method (First revision), Reaffirmed 1997
7	2720 (Part 1) – 1983	Methods of test for soils: Part 1. Preparation of dry soil samples for various tests. (Second revision), Reaffirmed 1995	17	2720 (Part 10) – 1991	Methods of test for soils: Part 10. Determination of unconfined compressive strength (Second revision), Reaffirmed 2001
8	2720 (Part 2) – 1973	Methods of test for soils: Part 2. Determination of water content. (Second revision), Reaffirmed 2001	18	2720 (Part 11) – 1993	Methods of test for soils: Part 11. Determination of the shear strength parameters of a specimen tested in unconsolidated undrained triaxial compression without the measurement of pore water pressure (First revision), Reaffirmed 1997
9	2720 (Part 3/Sec.1) – 1980	Methods of test for soils: Part 3. Determination of specific gravity, Sec. 1, Fine grained soils (First revision), Reaffirmed 1997			
10	2720 (Part 3/Sec.2) – 1980	Methods of test for soils: Part 3. Determination of specific gravity Sec.2, Fine medium and coarse grained soils (First revision), Reaffirmed 1997			

Sr. No.	IS: Code No.	Title	Sr. No.	IS: Code No.	Title
19	2720 (Part 12) 1981	– Methods of test for soils: Part 12. Determination of shear strength parameters of soil from consolidated undrained triaxial compression test with measurement of pore water pressure (First revision), Reaffirmed 1997	28	2720 (Part 22) 1972	– Methods of test for soils: Part 22. Determination of organic matter (First revision), Reaffirmed 2001
20	2720 (Part 13) 1986	– Methods of test for soils: Part 13. Direct shear test (Second revision), Reaffirmed 1997	29	2720 (Part 23) 1976	– Methods of test for soils: Part 23. Determination of calcium carbonate (First revision), Reaffirmed 2001
21	2720 (Part 14) 1983	– Methods of test for soils: Part 14. Determination of density index (relative density) of cohesionless soils (First revision), Reaffirmed 2001	30	2720 (Part 27) 1977	– Methods of test for soils: Part 27. Determination of total soluble sulphates (First revision), Reaffirmed 2001
22	2720 (Part 15) 1986	– Methods of test for soils: Part 15. Determination of consolidation properties (First revision), Reaffirmed 1997	30 A	2720 (Part 29) 1975	– Methods of test for soils: Part-29: determination of dry density of soils in-place by the core-cutter method. (First Revision) Second Reprint Feb. '87. Reaffirmed 2001
23	2720 (Part 16) 1987	– Methods of test for soils: Part 16. Laboratory determination of CBR (Second revision), Reaffirmed 1997	31	2720 (Part 31) 1990	– Methods of test for soils: Part 31. Field determination of California Bearing Ratio (First revision), Reaffirmed 2001
24	2720 (Part 17) 1986	– Methods of test for soils: Part 17. Laboratory determination of permeability (First revision), Reaffirmed 1997	32	2720 (Part 36) 1987	– Methods of test for soils: Part 36. Laboratory determination of permeability of granular soils (Constant head) (First revision), Reaffirmed 1997
25	2720 (Part 18) 1992	– Methods of test for soils: Part 18. Determination of field moisture equivalent (First revision), Reaffirmed 1997	33	2720 (Part 39/Sec.1) – 1977	Methods of test for soils: Part 39. Direct shear test for soils containing gravel, Sec.1, Laboratory test (Amendment 1) Reaffirmed 1997
26	2720 (Part 19) 1992	– Methods of test for soils: Part 19. Determination of centrifuge moisture equivalent (First revision), Reaffirmed 1997	34	2720 (Part 39/Sec.2) – 1979	Methods of test for soils: Part 39. Direct shear test for soils containing gravel. Sec.2 In-situ shear test Reaffirmed 1997
27	2720 (Part 21) 1977	– Methods of test for soils: Part 21. Determination of total soluble solids (First revision), Reaffirmed 2001	35	2720 (Part 40) 1977	– Methods of test for soils: Part 40. Determination of free swell index of soils. Reaffirmed 1997
			36	2720 (Part 41) 1977	– Methods of test for soils: Part 41. Determination of swelling pressure of soils, Reaffirmed 1997

Sr. No.	IS: Code No.	Title	Sr. No.	IS: Code No.	Title
37	2809-1972	Glossary of terms and symbols relating to soil engineering (First revision), Reaffirmed 2001	45	6403-1981	Code of practice for determination of bearing capacity of shallow foundations (First revision) (Amendment 1), Reaffirmed 2000
38	2911 (Part 4) – 1985	Code of practice for design and construction of pile foundations. Part 4, Load test on piles (First revision)(Amendment-1), Reaffirmed 2000	46	6955-1973	Code of practice for subsurface exploration for earth and rock fill dams, Reaffirmed 1995
38 A	4332 (Part I) - 1967	Methods of test for stabilised soils Part-1 -Method of sampling & preparation of stabilised soils for testing (Second Reprint March '84) Reaffirmed 1995	47	8009 (Part 1) – 1976	Code of practice for calculation of settlement of foundations (Part 1) Shallow foundations subjected to symmetrical static vertical loads (Amendment 1), Reaffirmed 1998
39	4434-1978	Code of practice for In-situ vane shear test for soils (First revision), Reaffirmed 1997	48	8009 (Part 2) – 1980	Code of practice for calculation of settlement of foundations (Part 2) Deep foundations subjected to symmetrical static vertical loading (Amendment 1), Reaffirmed 2000
40	4701-1982	Code of practice for earthwork on canals. Reaffirmed 1999	48 A	8237 - 1985	Code of practice for protection of slope for reservoir embankment (1 st Revision), Reaffirmed 1997
41	4968 (Part 1) – 1976	Method for subsurface sounding for soils (Part 1) Dynamic method using 50 mm cone without bentonite slurry (First revision) (Amendment 1), Reaffirmed 1997	49	8763-1978	Guide for undisturbed sampling of sand and sandy soils, Reaffirmed 1997
42	4968 (Part 2) – 1976	Method for subsurface sounding for soils (Part 2) Dynamic method using cone and bentonite slurry (First revision) (Amendment 1), Reaffirmed 1997	50	9214-1979	Method for determination of modulus of sub grade reaction (K-value) of soils in the field (Amendment 1), Reaffirmed 1997
43	4968 (Part 3) – 1976	Method for subsurface sounding for soils (Part 3) Static cone penetration test (First revision), Reaffirmed 1997	51	9451-1985	Guidelines for lining of canals in expansive soils (First revision), Reaffirmed 1999
44	5529 (Part 1) – 1985	Code of practice for In-situ permeability test (Part 1) Test in overburden (First revision), Reaffirmed 1995	52	9640-1980	Split spoon sampler (amendment 2), Reaffirmed 1997
			53	10042-1981	Code of practice for site investigations for foundation in gravel boulder deposits, Reaffirmed 1997

TABLE - 5**QUANTITY OF SOIL SAMPLE REQUIRED FOR DIFFERENT TESTS**

Sr No	Test	Quantity required for soils having maximum particle size of				
		4.75 mm	10 mm	20 mm	40 mm	80 mm
1	Grain size analysis	400 gm	1.5 kg	6.5 kg	25 kg	60 kg
2	Liquid limit	270 gm	-	-	-	-
3	Plastic limit (Passing 425 micron)	50 gm	-	-	-	-
4	Shear	3 kg	120 kg	120 kg	120 kg	120 kg
5	Consolidation	Undisturbed sample 75 mm dia	-	-	-	-
6	Permeability	5 kg	15 kg	30 kg	120 kg	120 kg
7	Proctor					
	(a) Light compaction	20 kg	20 kg	20 kg	-	-
	(b) Heavy compaction	20 kg	20 kg	20 kg	-	-
8	Relative density	12 kg	25 kg	50 kg	100 kg	120 kg
Total for all tests		65 kg	200 kg	250 kg	365 kg	420 kg

TABLE -6
EARTH WORK

DO'S	DON'TS
● Conduct density test at random intervals for specified quantum of earthwork	● Have square grid locations for density determinations
● Correction for oversize material should be effected in evaluation of placement density	● Careless rolling operation near a structure
● Always drive core-cutter to its full length	● Improper choice of roller for different types of soils
● Use standard equipment for density test based on thickness of layer and compacting material used.	● Over drive the core cutter
● Determine moisture content immediately after weighing the wet soil	● Deploy non standard equipment
● Insist on specified thickness of layer	● Delay moisture determination
● Provide extra width for slope dressing	● Allow thicker layers
● Allow next layer only after attaining specified density	● Work with tight widths and lengths
	● Allowing of next layer without attaining specified density

TABLE - 7

O. K. CARD FOR EARTH WORK

Name of work :
Reach & Location :

Name of Division :
Name of Sub-Division :

A BANK SEAT PREPARATION

Authorised sign.

- (1) Whether the overburden, roots and foreign material are removed from the bank seat? Yes/No
- (2) Whether the width of bank seat demarcated at site? Yes/No
- (3) Whether bank seat has been moistened sufficiently and compaction done? Yes/No
- (4) Whether the levels are recorded? Yes/No
- (5) Whether density and FMC are taken for approval of seat? Yes/No
- (6) Findings of test results
% compaction-----
% FMC-----

B BORROW AREA

- (1) Name and Location-----
- (2) Whether the required overburden roots and foreign materials are removed? Yes/No
- (3) Whether the grid lines marked (3 m x 3 m or as specified) and levels taken? Yes/No
- (4) Whether samples were collected for testing and test results are available? Yes/No
- (5) Type of material-----
- (6) Quantity of material expected to be available

C EMBANKMENT

- (1) Whether the seat for the embankment is approved? Yes/No
- (2) Whether filter is required? Yes/No
- (3) Are filter criteria fulfilled? Specify the details-----
- (4) Whether proper compaction of filter is achieved?
----- % compaction
- (5) Layer number/R. L.-----m
- (6) Whether the embankment in different zones and different layers is raised in specified thickness? Yes/No
- (7) Whether the required watering and compaction done? Yes/No
- (8) Are density and moisture content test taken Yes/No
% compaction-----
% FMC-----
- (9) Whether trip cards for dumpers, water tankers are maintained and available on site? Yes/No
- (10) Remarks

Signature of Deputy Ex. Engineer

Signature of field staff

TABLE - 8
RECORDS TO BE MAINTAINED

- (1) Data of earth work as indicated in design note and drawing of embankment section
- (2) Record of properties of soils available from excavations and borrow areas
- (3) Confirmatory tests of soil being used for embankment (during construction)
- (4) Compaction test results of earth layer and base seat of embankment
- (5) Data for proctor test for each type of material used
- (6) Moisture control (before spreading NMC & comparison/difference of OMC)
- (7) Determination of FDD/FMC and comparison with design data
- (8) Layer wise R. L. location etc
- (9) Daily and Monthly progress report
- (10) Record for filter material used shall be maintained such as filter criteria, gradation, curve, compaction/watering etc
- (11) Records of machinery deployed/trips/output etc

TABLE - 9
DAILY REPORT ON TESTS TO BE CARRIED OUT FOR EARTH WORK

Date: Month : Year :

Name of work : Chainage/Location :

Agreement No. : :

Name of Agency : :

Name of Division : Sub-Dn.: Circle :

Sr No	Item	No. of test required as per norms or as per tender provisions	Quantity of earth work m ³ /m ²	No. of tests carried out per Norms	Nos. of tests satisfying the acceptable criteria as per tender	Nos. of tests repeated and Nos. of test satisfactory after re-rolling and watering	Remarks
1	Embankment						
	(a) FDD/FMC						
	(b) Compaction (Proctor)						
2	Backfilling						
	(a) FDD/FMC						
	(b) Proctor test						
3	Lining						
	(a) Sub grade						
	(b) Compaction FDD/FMC						

Signature of Deputy Ex. Engineer

Signature of field officer

GUIDELINES FOR CONCRETE

1.0 Introduction:

Concrete, which externally appears to be crack-free, is sometimes found to be defective especially with layer lines and other discontinuities inside against requirement of monolithic nature of concrete when tested with non destructive methods. Hollows below reinforcement, inadequate cover, displacement of reinforcing bars and heavy corrosion to reinforcement were noticed after removal of cover in concrete of slab and beam. Surficial defects like honeycombing shrinkage cracking, pourlines, entrapped air voids, unevenness of surface are very common. The cold joints occur in concrete because pouring rate is inadequate. The cold joints when left untreated, developed into plane of separation. This is the result of non-observance of standard/good practices to produce good concrete on field at the time of concreting. It is therefore necessary that good practices for manufacture of good concrete and necessary precautions are taken during concreting. Guidelines during inspection for preparatory work i.e. batching, mixing, conveying, placing, consolidating, finishing & curing are as follows.

2.0 Inspection for preparatory work:

Before concreting work begins, preliminary field inspection is essential to ensure better results.

2.1 Mixer : Check

- Revolution of drum per minute
- Cleanliness inside drum
- Number of mixing blades inside drum and the gap between drum & blades shall not be larger than 25mm
- Water tightness of drum
- Levelling of mixer on levelled ground
- Working of discharge of chute and hopper
- Working of water tank fitted with mixer, gauge mark
- Capacity of drum

2.2 Weight/Volume batching arrangement : Check

- Sensitivity of balances
- Measurement of boxes
- Adjustable arrangement in boxes
- Weight of boxes

2.3 Materials :

2.3.1 Cement : The requirements and the other details of various tests on cement are given in Table No. 3 & 4.

- Type of cement and source
- Freshness of cement (should not be older than three months)
- Weight of cement bags
- Storing condition, dry floor
- Cement account and adequate stock to complete concrete work

2.3.2 Sand: The requirements and the other details of various tests on sand are given in Table No. 11.

- Source and type
- Moisture content
- Gradation, fineness, silt content
- Adequate stock

2.3.3 Gravel/Metal: The requirements and the other details of various tests on gravel/metal are given in Table No. 10.

- Type and source
- Gradation
- Adequate stock

2.3.4 Water: The requirements and the other details of various tests on water are given in Table No. 21.

- Potable water
- Silt free
- Measuring arrangement

2.3.5 Admixture: The requirements and the other details of various tests on Admixture are given in Table No. 24.

- Type and Source
- Dosage
- Measuring arrangement

2.4 Foundation:

2.4.1 Rock Surface

- Check-lines & levels, obtain clearance of geologist
- Inspect with hammer for hollow sound
- Remove loose rock
- Clean with air and water jets under pressure
- Keep surface wet for 24 hrs before placement of concrete

- 2.4.2 Soil Surface:
 - Ensure adequate drainage or dewatering or caulking for leaks
 - Remove loose or soft patches
 - Moisten the surface to a depth of about 15 cm
 - Do tamping or rolling
 - Cover the surface with tar paper or closely woven burlap with proper lap and fastening
- 2.4.3 Concrete surface
 - Remove loose material
 - Existing concrete should be wet sand blasted & washed thoroughly
 - Completely dried immediately prior to placement
- 2.5 Computations
 - Work out batch weights of cement/sand and gravel/metal to suit the capacity of mixer, in proportion of design mix
 - Apply moisture/bulkage corrections to sand and gravel/metal
 - Check water meter / gauge
- 2.6 Quality control tests: The requirements and the other details of various tests on cement concrete are given in Table No. 17.
 - Mixer efficiency test, decide mixing time and batch weight of cement.
 - Slump test
 - Yield test
 - Air content test
 - Set of specimens for compressive strength and permeability
 - Records – Batch weight register, cement consumption register, F.M. register, gravel/metal register, weight/volume register, slump test register, air content register, yield test register, compression and permeability test register, work order book and progress book.
- 2.7 Form work:
 - Firmness of ground supporting props when it becomes wet.
 - Straightness of props
 - Adequate bracing
 - Nailing loose or tight, adequate penetration of nail in lower member
 - Leak proof

- Strong enough to resist movement of labourers and vibrations
- Cleanliness of form work
- Evenness of planks or plates, within tolerance limits as per IS 456:2000 as given below:
 - a) Deviation from dimensions of cross-section of columns and beams -6mm, + 12mm
 - b) Deviation from dimensions of footings:
 - i) Dimension in plan – 12 mm
 - ii) Eccentricity – 0.02 times the width of footing in direction of deviation but not more than 50 mm
 - iii) Thickness \pm 0.05 times the specified thickness
 - c) Check calculation for formwork of heavy structure
- 2.8 Reinforcement: The requirements and the other details of various tests on steel are given in Table No. 7 & 8.
 - Check size, spacing, location, numbers etc. as per schedule of reinforcement/design drawing
 - Ensure staggering of overlaps
 - Embedded fixtures and openings
 - Reinforcement free from grease, oil and rust
 - Check up welding joints, bent up bars, hooks and cold bending
 - Rack arrangement for movement of labourers to prevent disposition of reinforcement
- 3.0 **Batching:**
The aim of batching and fixing is to produce uniform concrete at required proportion. To attain this it is necessary that -
 - 3.1 Materials are maintained homogeneous and non-segregated prior to and during batching
 - 3.2 The equipment provided for batching will accurately batch the required amount of material
 - 3.3 The required proportions of materials are maintained from batch to batch
 - 3.4 All materials are introduced into the mixes in proper sequence
 - 3.5 Weigh batching:
 - a) Quantity of cement and aggregates should be determined by mass. Where bag is considered as batch weight, reasonable number of bags should be weighed periodically to check net mass

- b) Water should be measured by volume in calibrated tank or weighed
- 3.6 Blending of aggregates may be carried out as and when required
- 3.7 Gradation of coarse and fine aggregates should be done frequently
- 3.8 In case uniformity in the materials used for concrete making has been established over a period of time, the proportioning may be done by volume batching, provided periodic checks are made on mass/volume relationships of the materials
- 3.9 Moisture/bulkage corrections should be applied for moist materials.
- 4.0 Mixing:**
- 4.1 The mixing shall be continued until there is a uniform distribution of the materials and the mass is uniform in colour and consistency.
- 4.2 If there is segregation after unloading from the mixer, the concrete should be remixed.
- 4.3 For guidance, the mixing time may be one and a half to two minutes.
- 4.4 In exceptional circumstances such as mechanical break down of mixer, work in remote areas or when the quantity is small, hand mixing may be permitted subject to adding 10 percent extra cement. When hand mixing is permitted, it shall be carried out on a watertight platform and care shall be taken to ensure that mixing is continued until the concrete is uniform in colour and consistency.
- 4.5 Workability shall be checked at frequent intervals.
- 4.6 The freshly mixed concrete should be finally placed in position within 30 minutes.
- 4.7 Freshly mixed concrete, should be tested for slump, mixer uniformity tests, yield test, unit weight, air content and compressive strength etc.
- 5.0 Conveyance/Transportation :**
- 5.1 Concrete shall be conveyed from mixer to final place of deposition as rapidly as practicable by methods which will prevent segregation or loss of slump and loss of materials including water.
- 5.2 Conveying method and equipment shall be approved by the engineer-in-charge not below the rank of Deputy Executive Engineer.

- 5.3 Newly mixed concrete is susceptible to segregation if dropped through height. The unrestrained dropping of concrete on apex of a pile also results in coarser particles segregating and concentrating at the toe of the slope. Unrestrained dropping, chuting and horizontal flow of concrete should not be permitted.
- 5.4 Minimum handling and persistent precautions should be observed to prevent segregation and to see that concrete remains a cohesive mass.
- 5.5 During hot or cold weather, concrete shall be transported in deep containers. Other suitable methods to reduce the loss of water by heat loss in cold weather may also be adopted.
- 6.0 Placement:**
- 6.1 When slabs and beams & the supporting walls & columns are cast monolithically the concrete in the top 60 or 90 cm of walls & columns should be of the lowest slump that can be vibrated adequately & should be fully consolidated at the surface
- After placing the fillet, beam and slab concrete, the vibrator should penetrate & revibrate the concrete in the tops of walls and columns
 - Concrete should be continued without avoidable interruptions until the placement is completed or until satisfactory construction joints can be made.
- 6.2 Concrete should be deposited in horizontal layers. Each layer should be compacted thoroughly before succeeding layer is placed. In reinforced concrete work, it is good practice to place concrete in layers 0.25m thick. However, thickness shall be decided in view of size and shape of section, consistency of concrete, spacing of reinforcement, method of concrete placement, method of compaction and necessity of depositing concrete of next layer before hardening of previous layer which takes place within 30 minutes.
- 6.3 Concrete shall be deposited continuously in order to avoid appearance of slightest layer line on the finished structure. No construction joint should be allowed to form unless directed by the designer.
- 6.4 Placement of concrete shall be carried out at such a rate that lower layer concrete which is being integrated with fresh concrete is always plastic. Normally this will be achieved if next layer is placed within 30 minutes. If this is not done, cold joints will

develop which must be avoided. The cold joints are interfaced which remain as discontinuities and cause separation when subjected to tensile stresses.

6.5 Placing of concrete in supported elements shall not be started until the concrete previously placed in columns or wall is no longer plastic and has been in place at least for two hours.

6.6 The concrete should be worked thoroughly into all positions around reinforcement, embedded fixtures and into corners of form work. Only slurry, if allowed to pass below reinforcement gives a firm finish but leaves voids near reinforcement and hence causes loss of bond and corrosion.

7.0 Consolidation:

7.1 Concrete shall be consolidated by vibration, spading, rodding or forking so that concrete is thoroughly worked around the reinforcement, around embedded items and into concrete of forms, eliminating all air or stone pockets which cause honeycombing, pitting or planes of weakness

7.2 Internal vibrators shall have a minimum frequency of 8000 vibrations per minute with sufficient amplitude to consolidate concrete effectively.

7.3 Vibrators shall be inserted vertically and withdrawn gradually at points approximately 0.4 to 0.5m apart. At each insertion, the duration shall be 5 to 15 seconds which is sufficient to consolidate the concrete but to disallow segregation and increase in surface laitance.

7.4 Where the concrete is to have coat finish, a full layer of mortar shall be brought against the form by vibration process.

7.5 Vibrations shall be operated by competent workman.

7.6 A spare vibrator shall be kept on site of work during all concrete placing operations.

7.7 Whenever vibration has to be applied externally the design of form work and the disposition of vibrators should receive special consideration to avoid surface blemishes.

7.8 The use of suitable mechanical vibrators complying with IS:2505-1968, IS:2506-1968, IS:4656-1968 is recommended.

7.9 Over vibration or vibration of very wet mixes is harmful and should be avoided. Under vibration is also harmful. Complete consolidation can be judged by evidence of levelled appearance of concrete at exposed surface, embedment of surface aggregate,

expulsion of entrapped air, formation of cement skin and appearance of cement slurry at surface.

8.0 Finishing:

The quality of concrete surface is judged by condition and appearance of the finished surface. The exposed surfaces are subjected to more or less severe conditions of wetting or drying, temperature changes, mechanical wear etc.

8.1 Concrete proportions and consistency and methods of compaction should be such that sufficient mortar is available at the surface for finishing purposes.

8.2 Floats shall be used to remove high and low spots and to produce a true plane surface. High and low areas should be corrected at once.

8.3 Over sanded or too wet or over consolidated mix is likely to be covered with bleed water. They may be corrected for better finishing. Such water shall be allowed to drain or absorb or scrap.

8.4 Any water which comes to surface during darning or floating operations should be allowed to evaporate before surface is floated with hand floats or trowelling. If the amount of water of laitance is excessive it should be scooped off before surface is again floated.

8.5 Sprinkling of dry cement or a dry mortar should not be permitted.

8.6 All finishing operations should be controlled so as to prevent bringing an excess of paste to the surface.

8.7 Trowelling should be delayed as long as possible. Final floating is used to remove remaining minor irregularities. The concrete is ready for floating when any sheeny water has disappeared and when a man stopping on surface will leave an imprint of about 5mm.

8.8 The proper time of trowelling varies with cement, weather and other conditions. It is ready when surface just reaches the stage that it can no longer be dented with finger.

8.9 If surface is trowelled too soon, a layer of laitance is found, if too late, the partly hardened concrete is too hard to be trowelled effectively.

8.10 During trowelling the steel trowel should be tilted at a slight angle and heavy pressure should be exerted to compact the paste and form a dense hard surface.

9.0 Stripping Period:

Removal of form depends upon grade of concrete, type of member, weather conditions, winds, strength attained, type of cement etc. Early removal of form is desirable for finishing and is usually desirable from points of view of ailing.

- 9.1 Forms shall not be struck until the concrete reaches a strength at twice the stress to which the concrete may be subjected at the time of removal of formwork.
- 9.2 Wherever possible, the formwork shall be left longer as it would assist the ailing.
- 9.3 In normal circumstances and where ordinary portland cement is used, forms may generally be removed after expiry of the following periods as per IS: 456-2000
- a. Walls, columns and vertical faces of all structural members
16 to 24 hours
 - b. Slabs (props left under)
3 days
 - c. Beam soffits (props left under) 7 days
 - d. Removal of props under slabs:
 1. Spanning upto 4.5 m 7 days
 2. Spanning over 4.5 m 14 days
 - e. Removal of props under beams and arches:
 1. Spanning upto 6 m
14 days
 2. Spanning over 6 m
21 days
 - f. Modify stripping time suitably for other cements
- 9.4 The number of props left under, their sizes and disposition shall be such as to be able to safely carry the full dead load of the slab, beam as the case may be, together with any live load likely to occur during further construction.

10.0 Curing:

Curing is defined as maintenance of humidity and temperature of freshly placed concrete during definite period following finishing to assure satisfactory hydration of cementitious material and proper hardening of the concrete. The curing period depends upon type of cement, weather condition, wind speed, stripping time, sections of concrete, methods of curing, etc. Improper curing results in formation of surface / shrinkage cracks, loss of strength, increase in permeability, spoilage of surface finishing, decreases durability

and quality of concrete is affected. Moist curing, membrane curing are normally used. Former is predominantly used.

- 10.1 Exposed surface of concrete shall be kept continuously in damp or wet condition by ponding or by covering with a layer of sacking, canvas, hessian or similar materials and kept constantly wet for at least seven days.
- 10.2 The curing period should be increased by one week for pozzolonic cement for best results.
- 10.3 The freshly laid concrete shall be protected from direct exposure to sun and high winds.
- 10.4 The curing in hot weather conditions i.e. temperature above 40°C needs special attention to disallow rapid evaporation and prevent plastic shrinkage cracking.
- 10.5 Membrane curing: Approved curing compounds may be used in lieu of moist curing. Such compounds shall be applied to all exposed surfaces of the concrete as soon as possible after the concrete has set. The requirements and other details are given in Table No.22
- 11.0 Concreting under special conditions:**
- a) Underwater concreting: Do not place concrete in running water, use rich mixes, use tremie or direct pumping, ensure continuous placement.
 - b) Hot weather concreting: Dampen the subgrade and forms, place concrete at the lowest practicable temperature, start curing early, use cold water or ice as a part of mixing water.
 - c) Cold weather concreting: Prevent concrete from freezing, concrete should be placed at temperature not lower than 5°C, maintain curing condition which fosters normal strength development without excessive heat, keep surface at a temperature that may not cause early freezing or seriously prolong hardening.

12. Records and reports:

Check registers of cement consumption, fineness modulus, aggregate quality and quantity, weight/volume batching, tests for fresh concrete and for specimens for compressive strength and permeability, examine critically work order book, review test results and review design mix, ensure monthly summary reports giving compliance of instructions recorded in work order book.

Points to remember while laying masonry

a) **Brick work:** The requirements and the other details of various tests on bricks are given in Table No. 12 & 13.

- 1) Ensure thorough soaking of bricks in clean water for 24 hrs. before use
- 2) See the workmanship for bond, thickness of joint, finishing of joint etc.
- 3) Courses should be truly horizontal and joints truly vertical
- 4) Restrict use of brickbats to a minimum
- 5) English bond preferable
- 6) Thickness of joint should be uniform and not more than 13 mm
- 7) Specified cement mortar should be placed within 30 minutes after addition of water
- 8) Bricks on edge should not be used unless specified
- 9) Disallow vertical joint filling by spreading mortar
- 10) Masonry may be raised up to 90 cm in a day. Raising with all connected brickwork be carried out at one level
- 11) The buttress, counter forts should be built simultaneously, maintaining proper bond with main wall and not added afterwards
- 12) Fixtures of frame should be embedded while raising masonry
- 13) The joints should be raked to a depth of 13 to 19 mm when mortar is green. If plaster or pointing is not to be done, the joints should be struck flush
- 14) Curing should be done for at least seven days or as laid down in specifications
- 15) Old or dry surface should be thoroughly cleared and wetted, joints raked before starting

b) **Stone work:** The requirements and the other details of various tests on stone are given in Table No. 9.

Additional points for stone masonry are as under

- 1) Rubble should be as per specifications
- 2) Stone should be laid on their natural bed
- 3) Through stones should be used at regular intervals in staggered manner
- 4) Quoins should be used for openings. The width should be at least 1.5 times the depth of course and its length should be twice its depth
- 5) Wet the stones before use

- 6) Spalls shall be used wherever necessary to avoid thick mortar beds for joints and shall not exceed 10 %
- 7) The use of wooden mallet must be carried out to hammer down stone in to position and solidly bedded in the mortar
- 8) Iron templates shall be used to compact the mortar in joints
- 9) Every stone shall be carefully fitted to the bed and adjacent stone so as to form neat and close joints. No joints shall be thicker than 35mm.
- 10) All exposed surfaces shall be kept moist at least for 21 days.
- 11) Permeability tests shall be carried out as provided in specifications.

c) **Plaster work:**

- The details are covered in IS: 1661 – 1972
- Thickness of single coat shall be between 10 to 15mm
- Thickness of two coat plaster shall not exceed 20mm (Backing coat 10 to 12mm, finishing coat 8 to 10 mm)
- Plastering work to be suspended during frosty weather. It shall also be suspended in extreme dry condition
- The walls shall be damped evenly before application of plaster.
- Drying shrinkage of first coat or backing material should be complete before application of subsequent coat

14 **Storage of cement:**

1. Check for age of cement – Retesting to be done if cement is older than three months
2. To be stored on raised platform
3. Shall be stocked properly away from walls, facilitate for physical verification
4. Maintenance of cement register and it shall be checked by senior officers
5. Leak-proof ceiling

15 **Analysis of cement & concrete** When large work of cement mortar or cement concrete is to be done, analysis of cement testing is important. For analysis, first arrive at the limit of variability i.e. standard deviation or co-efficient of variation. On the basis of the target average strength of cement samples and the statistical parameters of variability, the test results should be compared with suitable control charts. These charts are very convenient device to keep track on the monitoring of

activity. Very useful guidelines on control charts for concrete are given in ACI 214-1977. Recommended Practice for evaluation of strength test results of concrete, Indian Standards IS:397 (Part 1 to 3) also cover control charts for general and special application in industrial application. Different charts for cement and concrete are (1) Master chart (2) Moving average strength chart (3) Within-test moving average range chart (4) Between test moving average range chart. The control charts can also incorporate certain reference lines as limits. As a general concept, four limits can be defined viz. Lower as well as upper warning and action limits.

Cement Concrete Lining

Points to be observed for proper exercise of the functions

- Sub grade approval i.e. degree of compaction & moisture content
- Testing of construction materials i.e. fine aggregate, coarse aggregate, cement, water, Air entraining agent, PVC strips & curing compound
- Checking of paver's Jack level, girder's alignment, roller movement
- Test for concrete
- Placement of concrete & arrangement of conveyor belt etc.
- Proper insertion of crack inducing joints in transverse and longitudinal directions, if specified
- To ensure specified thickness of cement concrete lining
- Testing of hardened concrete
- Cores to be taken to check positioning of PVC insertion in C.C. lining
- To undertake screening of green concrete for examining consistency of concrete (occasionally)
- Proper curing arrangements

Quality control of Brick / tiles lining

- Sub grade approval i.e. degree of compaction & moisture content
- Testing of construction materials i.e. Brick / Tiles, Sand, cement and water
- To ensure the correct batch weight as per the mix design of mortar and to check the mortar consistency
- Proper arrangement for soaking of brick / tiles
- Curing arrangement
- Mixing of mortar – consistency
- Casting of cubes for compression strength at 28 days
- Maintaining records for consumption of mortar & cement, curing period, joint testing etc.

TABLE - 1

**Recommended Values Of Slump For Different Conditions Of Placing
(To enable concrete to be fully compacted)**

Placing Conditions	Degree of Workability	Slump (mm)
Blinding concrete; Shallow sections; Pavements using pavers	Very low	See 7.1.1 of IS: 456-2000
Mass concrete ; Lightly reinforced sections in slabs, beams, walls, columns ; Floors ; Hand placed pavements ; Canal lining ; Strip footings	Low	25 - 75
Heavily reinforced sections in slabs, beams, walls, columns ; Slipform work; Pumped concrete	Medium	50 - 100
Trench fill; In-situ piling	High	100 - 150
Tremie concrete	Very high	See 7.1. 2 of IS: 456-2000

NOTE :- For most of the placing conditions, internal vibrators (needle vibrators) are suitable. The diameter of the needle shall be determined based on the density and spacing of reinforcement bars and thickness of sections. For tremie concrete are not required to be used (see also 13.3 of IS: 456-2000).

TABLE - 2

**Field-Tests For Common Materials Of Construction
Procedure**

Sr. No.	Material	Field test	Procedure
1	Cement	Initial setting time	Take three parts of cement and one part of water. Mix it thoroughly to get a plastic cement paste and fill it up in an empty cigarette tin, observe penetration of an uncut butt of a pencil, Note time since addition of water when resistance to penetration is felt. Normally it should not be less than 30 minutes.
2	Lime	Visual	Colour : dirty white, white, pure white State of aggregation : Lumpy, powdery, soft and hard Class C lime : White or pure white colour-hard Quick lime : Lumpy but porous
		Acid test	Take a tea spoon full of powdered lime and add 10 ml of 50 percent HCl by volume in a test tube, stir with glass rod. Effervescence indicates unburnt lime Residue after 24 hours indicates inert material, comparison with original volume of lime indicates its proportion Classification : Class A : Good thick gel at top and inert material at bottom Class B : Medium thick gel which does not flow when turned Class C : No gel is formed
		Ball test	Take lime, add enough water, prepare egg size ball, allow to set for six hours and then place in water Classification : Class A : No expansion Class B : Little expansion and numerous cracks on surface Class C : Expansion and disintegration within few minutes
		Impurities test	Take known weight of lime from kiln, add water, wash it on 250 micron sieve, determine residue weight Classification : Good – less than 10 per cent residue. Fair – 10 to 20 percent, Poor – above 20 percent
		Blotting paper test	Prepare thick cream like consistency and leave over night-then spread like butter on a blotting paper with knife-Compare it with behaviour and performance of standard lime of good quality and judge
3.	Pozzolana	Workability test Visual	Prepare mortar, apply on rough surface and observe area covered Clay pozzolana Colour : well burnt indicated by red copper colour Fineness : feels finer than cement between fingers
4	Sand	Silt content	Take 300-400 cm ³ of sand in a measuring jar, add water to submerge the sand under 3.5 cm depth of water after removal of air– close the mouth of jar with rubber cork or palm of hand, shake or turn the jar up side down two-three times and allow sand to settle. Silt will settle on sand top. Read

depth of silt and compute percentage, of depth of sand which has settled below the silt.

Coarseness of sand – gradation can be judged by comparison with bottle specimens, missing fractions indicate gap gradation

Physically deleterious material like coal, clay-balls, mica, lime kankar can be picked out, percentage occurrence can be judged

5	Metal / gravel	Visual	Identify rock types, judge shape and size-rounded, sub-rounded, flaky, cubical, angular-also percentage of undersize and oversize fractions. Basalt-dolerite, granite, quartzite, hard limestone, siliceous sandstone serve well as road metal. Shales absorb water and give earthy smell, phyllite and mica schists are flaky and show shining surface. Avoid both.
6	Water	Visual	Examine in glass beaker or test tube for suspended sediment. Use potable water. If brackish or saline use only after testing, check pH with indicator paper.
7	Bricks	Visual	Red copper colour indicates well burnt bricks, check shape, size, frog, weight, presence of nodules, cracks, corners, Metallic sound when struck with each other or by hammer, no damage when allowed to fall free from about five feet on either header or stretcher face.
8	Stones	Visual	Metallic sound when struck with hammer. Iron nail streak indicates softness; observe joints, cracks, cavities, veins, weathered skin and re-entrant angles, check weight, look for fresh fracture when broken with hammer, rocks like basalt, granite, quartzite, dolerite, compact sandstone and limestone serve well as rubble. Shales, phyllites and mica schists are not good.
9	Steel bar	Bending	Shales absorb water and give earthy smell Free from rust, grease, oil; mild steel can be bent to 'U' shape with mandrel of 2 d with indicating cracks. Check diameter and weight per unit length
10	Tiles	(a) Visual (b) Strength	Check dimensions, colour, expose tiles to sunlight for few days and observe for loss of colour Saturate the tile with water, support it at the edges, ask one adult to stand in the centre, should not break as wet transverse strength is about 80 kg.
11	Flush door	Adhesion	Cut 150 mm square four specimens from all corners, immerse in boiling water for four hours; examine delamination which should not exceed 50 mm in length and 3 mm in depth

Sampling

Any material shall be collected as per relevant Indian Standard of materials & shall be sent to laboratory for testing. Frequency of sample requirement are given in the manual. The material shall be reduced to required size as under

1. Coning and quartering:

The material shall be mixed and then scooped into a cone shaped pile. Care shall be taken to drop each scoopful over the same spot. After cone is formed it shall be flattened. Then it is divided into quarters by two lines intersecting at right angles at the centre of cone. The bulk of sample is reduced by rejecting either set of two diagonally opposite quarters. The process is continued till the sample is reduced to required size.

2. Stacks of bricks and tiles:

The stacks shall be divided into sections of approximately equal dimensions. Required samples shall be drawn from each section in a random number.

TABLE - 3
CEMENT OF VARIOUS TYPES & GRADES
IS 4031- (part 1 to 15) - 1988 to 1996, 4032-1986

Sr. No.	Particulars of Tests	Frequency	Equipments	Acceptance criteria	Sample : 15 kg. Purpose of testing
1.	Consistency IS:4031-(Part-4)-1988	Upto 50 T. - 1 50-100 T. -2 100 - 200 T -3 each sample or as required	Vicat apparatus with plunger 10 mm dia. (G type), Triple beam balance	About 30 percent	Determines mixing water requirements for subsequent tests and minimum water requirement for hydration of cement.
2.	Setting time IS:4031-(Part-5)-1988				
	(a) Initial setting time	Each sample or as required	Vicat apparatus with needle 1 mm sq. (c-Type)	Not less than 30 minutes	Placement compaction is to be completed within initial time.
	(b) Final setting time		Vicat apparatus with annular attachment (F-type)	Not more than 600 minutes	Final setting time limit indicates hardening and gain in strength.
3.	Fineness				
	(a) By sieving IS:4031-(Part-I)-1988	Each Sample or as required	90 micron IS sieve and balance	Residue less then 10 percent	More volume retained on sieve indicates cement having undergone moisture attack or inadequate grinding.
	Specific surface by Blain air permeability IS:4031-(Part-2)-1988	Each sample or as required	Blain air permeability apparatus with accessories	Not less than 2250 cm ² /g for OPC (33,43,& 53 grade) & SRC. Not less than 3000 cm ² /g for PPC	Less volume indicates cement having undergone moisture attack or inadequate grinding.
4.	Soundness IS:4031-(Part-4)-1988				
	(a) Le Chatelier's method	Each sample or as required	Le Chatelier's apparatus with accessories	Expansion not more than 10 mm	More expansion indicates likely excessive and harmful chemical reactions.
	(b) Autoclave method	1 in 10 samples	Autoclave, length comparator, 25 x 25 x 250 mm mould and other accessories.	Expansion not more than 0.80 percent.	-do-
5.	Compressive strength IS:4031-(Part-6)-1988	Each sample or as required sample	Cube mould (7.07 cm) 50 cm ² face area, baby vibrator, compression testing machine, curing tank etc.	As per Table-4	Higher strength indicates acceptability
6.	Chemical Analysis IS:4032-1986	1 in 10 sample	Muffle furnace, oven, platinum crucible, chemical balance etc.	As per Table-4	

TABLE - 4
VARIOUS TYPES OF CEMENT

Sr. No.	Particulars of Tests	Acceptance criteria					Purpose of testing
		33-G	43-G	53-G	PPC	SRC	
1.	Compressive strength (Min.) <u>N/mm²</u>						
	3 days	16	23	27	16	10	
	7 days	22	33	37	22	16	
	28 days	33	43	53	33	33	
2.	Chemical analysis						
	(a) Ratio of % of lime to % of Silica, alumina & iron oxide	Between 0.66 and 1.02	Between 0.66 and 1.02	Between 0.80 and 1.02	–	Between 0.66 and 1.02	
	(b) Ratio of % of alumina to % of iron oxide	Not less than 0.66	Not less than 0.66	Not less than 0.66	–	--	
	(c) Insoluble residue %	Not more than 4	Not more than 2	Not more than 2	$\frac{X+4(100-X)}{X}$	Not more than 4	X is the % of declared pozzolana
	(d) Magnesia %	Not more than 6	Not more than 6	Not more than 6	Not more than 6	Not more than 6	Higher MgO indicates harmful expansion at a later age
	(e) SO ₃ %	Not more than 2.5 & 3 when C ₃ A % is 5 or less & > 5 respectively	Not more than 2.5 & 3 when C ₃ A% is 5 or less & > 5 respectively	Not more than 2.5 & 3 when C ₃ A% is 5 or less & > 5 respectively	Not more than 3	Not more than 2.5	Higher SO ₃ indicates less durability
	(f) Loss on ignition %	Not more than 5	Not more than 5	Not more than 4	Not more than 5	Not more than 5	It indicates the freshness of cement
	(g) C ₃ A%	--	--	--	--	Maximum 5.0	
	(h) C ₄ AF+2C ₃ A%	--	--	--	--	Maximum 25.00	

TABLE - 5
Pozzolana (Calcined clay, flyash)
IS:1344 – 1981, IS:3812-1981, IS:1727-1967

Sr. No.	Particulars of Tests	Frequency	Equipments	Acceptance criteria			Sample – 15 kg. Purpose of testing
				Constituent	Unburnt Clay (Soil)	Flyash	
1.	Lime reactivity IS:1727-1967	1/100 t	Flow table, mixing apparatus, humidity cabinet, 5 t loading frame	Not less than 40 kg/cm ²			Less lime reactivity indicates inadequate content of reactive silica to combine with free lime
2.	Fineness by specific surface area by Blain's method IS:1727-1967	1/5 Samples	Blains permeability apparatus	For calcined clay not less than 2250 cm ² /g For flyash not less than 3200 cm ² /g			Higher the fineness greater the strength, lesser bleeding and better workability
3.	Compressive strength IS:1727-1967	1/100 t	Vibrating machine 40 t compression testing machine	At 28 days minimum 80 percent of the strength of plain cement mortar cube. At 90 days it shall not be less than that of 28 days strength			Higher strength is acceptable
4.	Chemical analysis IS:1727-1967	1/5 Sample	Muffle furnace, Platinum crucible, Balance	Constituent	Unburnt Clay (Soil)	Flyash	Silica constituent has to be the major one. MgO causes expansion and disintegration
				SiO ₂ + Al ₂ O ₃ + Fe ₂ O ₃	Not less than 70 %	Not less than 70%	
				SiO ₂ (min)	40 %	35 %	
				Na ₂ O+K ₂ O(max.)	3 %	1.5 %	
				Water Soluble alkali (max.)	1 %	-	
				Loss on ignition(max.)	10 %	12 %	
				CaO (max.)	10 %	-	
				MgO (max.)	3 %	5 %	
				So ₃ (max.)	3 %	2.75 %	

TABLE - 6
Building lime
IS: 712-1989, 6932 (Part 1 to 11) – 1973

Sr. No.	Particular of Test	Frequency	Equipment	Acceptance Criteria	Sample – 10 kg packed tin Purpose of testing
1.	Workability IS:6932-(Part-8)- 1973	1/100 T 2/300 T Each sample	Flow table with moulds, Oven, Triple beam balance	Bumps more than 12 for flow from 11 to 19 cm for C and D types	Determines water requirement for subsequent tests
2.	Fineness IS:6932-(Part-4)- 1973	-do-	Sieves 2.36 mm, 850 micron, 300 micron	No residue on 2.36 mm. 5 percent residue on 850 micron for A and B Class No residue on 850 micron for C class. 10 percent residue on 300 micron for A and B class 5 percent residue on 300 micron for C class	Higher residue indicates inadequate calcination and slaking
3	Setting time IS:6932-(Part-2)- 1984	-d0-	Vicat needle apparatus	For Class A Initial – Not less than 2 hours Final – Not more than 48 hours	Placement and compaction is to be completed within initial limit, final limit indicates hardening
4	Compressive strength IS:6932-(Part-7)- 1973	-do-	Pug mill, 5 cm cube three moulds, 5 ton loading frame	A class 17.5, 28 kg/cm ² at 14 and 28 days B Class 12.5, 17.5 kg/cm ² at 14 and 28 days	Hardening is measured in terms of compressive strength which further indicates class of lime
5	Transverse strength IS:6932-(Part-7)- 1973	1 in 5 samples	2.5X2.5X10 cm moulds Transverse strength tool, 5 ton loading frame	A class 10.5 kg/cm ² at 28 days B Class 7.0 kg/cm ² at 28 days	Hardening is measured in terms of transverse strength and indicates type of lime
6	Soundness IS:6932-(Part-9)- 1973	1 in 5 samples	Le Chaterlier apparatus	Maximum expansion 10 mm	Excessive expansion indicates higher content of MgO

Sr. No.	Particular of Test	Frequency	Equipment	Acceptance Criteria	Purpose of testing																														
7	Chemical analysis IS:6932-(Part-1)-1973	Each sample	Muffle furnace, Oven, Platinum crucible, Chemical balance, Water bath	Analysis percentage <u>Class</u> <table border="1"> <thead> <tr> <th></th> <th>A</th> <th>B</th> <th>C</th> <th>D</th> <th>E</th> </tr> </thead> <tbody> <tr> <td>CaO+MgO min</td> <td>60</td> <td>70</td> <td>85</td> <td>85</td> <td>25</td> </tr> <tr> <td>MgO...max</td> <td>5</td> <td>5</td> <td>5</td> <td>5</td> <td>5</td> </tr> <tr> <td>SiO₂+R₂O₂ min</td> <td>25</td> <td>15</td> <td>-</td> <td>-</td> <td></td> </tr> <tr> <td>Cementation Value to min.</td> <td>0.6</td> <td>0.3</td> <td>-</td> <td>-</td> <td></td> </tr> </tbody> </table> to 0.6 As per IRC-51-1992		A	B	C	D	E	CaO+MgO min	60	70	85	85	25	MgO...max	5	5	5	5	5	SiO ₂ +R ₂ O ₂ min	25	15	-	-		Cementation Value to min.	0.6	0.3	-	-		Excessive content of MgO causes expansion. Relative percentage of CaO and SiO ₂ indicate class of lime
	A	B	C	D	E																														
CaO+MgO min	60	70	85	85	25																														
MgO...max	5	5	5	5	5																														
SiO ₂ +R ₂ O ₂ min	25	15	-	-																															
Cementation Value to min.	0.6	0.3	-	-																															
8	Lime content for lime stabilised soil/moorum IS:1514-1959 or 712-1984	a) Before 1 consignment mixing subject to minimum of 1 test per 5 T lime b) After 1/250 m ² mixing		Lime as CaO not less than 50 percent and 60 percent for lime soil and lime flyash stabilisation respectively No result shall be less than 75 percent of specified lime content Average of 10 samples should not be less than specified lime content	Larger variation indicates inadequate mixing																														

TABLE - 7
Steel

**IS: 432 (Part 1 & 2) – 1982, IS: 1785 (Part 1 & 2) – 1983, IS: 1608-1993,
IS: 1599-1985, IS: 1786-1985, IS:1716-1985**

Sample: 60 cm long

Sr. No.	Particulars of Tests	Frequency	Equipments	Acceptance criteria	Purpose of testing
1.	Tensile, Yield, Elongation IS: 1608-1995	1 per 40 t	Universal testing machine, Vernier calliper, centre-Punch, Hammer	As per table 8	The measure of its strength and elasticity
2.	Bend IS: 1599-1985	1 per 20 t	Universal testing machine	Round bars, above 25mm dia, should be able to bend without fracture with sides parallel and internal diameter not greater than three times the thickness of the test piece.	It is an indication of carbon content in steel so as to ensure its use in any bent form.
3.	Rebend (in the case of deformed bars only) IS: 1786-1985	1 per 20 t	For Fe 415 & 500 Universal testing machine, mendrels of suitable dia. (5D for bars upto 10mm dia & 7D for bars over 10mm) of 135° and 157½° angle	The bar should withstand without fracture on the bent portion	To evaluate effect of deformation
4.	Reverse bend for ductility (in the case of wires only) IS: 1716-1985	Sample: Number of coils 3 in 25 – 4 - 65 5 - 180 7 - 300 10 over 300	Vice with Jaws of radius 10.0, 12.5, 15.0, 20.0 and 25.0 mm	The wire should withstand without showing any sign of fracture. Permissible defective number in coils tested. 0 in 3 to 4, 1-5 to 7 and 2-10	Measure of its ductility

**TABLE - 8
VARIOUS TYPES OF STEEL**

Sr. No.	Material	Nominal thickness diameter (mm)	Ultimate Tensile strength Min. (N/mm ²)	Yield stress Min. (N/mm ²)	Elongation , Percent Min. Gauge length <u>5.60S₀</u>
1.	Mild steel and medium Tensile steel Bars and Hard-Drawn Steel wire for concrete reinforcement IS: 432(Part I) – 1982 (Third Revision) Mild steel and medium tensile steel bars	<u>Mild steel gr.I</u> 0 – 20	410	250	23
		20 – 50	410	240	23
		<u>Mild steel gr.II</u> 0 – 20	370	225	23
		20 – 50	370	215	23
		<u>Medium Ten. Steel</u> 0 – 16	540	350	23
		16 – 32	540	340	20
		32 – 50	510	330	20
		IS:432(Part-2)-1982, Hard drawn steel wire	All sizes	570	480
2.	High strength deformed steel bars and wires for concrete Reinforcement IS: 1786-1985 (Third Revision)	All sizes	<u>Grade Fe 415</u> 485	415 *	14.5
			<u>Grade Fe 500</u> 545	500 *	12.0
			<u>Grade Fe 550</u> 585	550 *	8.0
3.	Plain Hard-Drawn steel wire for prestressed concrete IS: 1785 (Part I) – 1983 Cold Drawn Stress – Relieved Wire (Second Revision)	2.50	2010	85 Percent of the minimum specified tensile strength	2.5 } 2.5 } Gauge 3.0 } length 4.0 } 4.0 } 200 mm 4.0 }
		3.00	1865		
		4.00	1715		
		5.00	1570		
		7.00	1470		
		8.00	1375		
4.	Plain Hard-Drawn Steel Wire for prestressed concrete IS: 1785 (Part II) – 1983 As – Drawn Wire (Ist Revision)	3.00	1765	75 Percent of the minimum specified tensile strength	
		4.00	1715		
		5.00	1570		

Sr. No.	Material	Nominal thickness diameter (mm)	Ultimate Tensile strength min. (N/mm ²)	Yield stress min. (N/mm ²)			Elongation , Percent Min. Gauge length 5.60S ₀
				< 20mm	20-40 mm	>40mm	
5.	Steel for General structural purposes – specification IS: 2062 – 1992 (Fourth Revision) Steel plates, strips, sections, flats, Bars etc.	Gr. A Fe 410 WA (All sizes)	410	250	240	230	23
		Gr. B. Fe 410 WB (All sizesa)	410	250	240	230	23
		Gr. C. Fe 410 WC (All sizes)	410	250	240	230	23

*Indicates proof stress at 0.2 percent of the original gauge length

TABLE - 9
Building Stone
IS:1597(Part 1 & 2)-1992 IS:1121 (Part - 1 to 4)-1974, IS:1122-1974,
IS:1124-1974, IS:1125-1974

Sample-2 Rubble 25x25x25 cm

Sr. No.	Particular s of Tests	Frequency	Equipments	Acceptance criteria	Purpose of testing
1	Specific gravity (apparent) & water absorption IS:1124-1974	1/week	Mortar & pestle, 150micron sieve, sp.gr.bottle, balance, cylinder	Absorption: Not more than 5% for rubble masonry. Not more than 2.5% for sand stone flooring	Lesser the water absorption higher the durability, lesser the weathering. For dams higher porosity causes more leakage
2	Specific gravity (true) IS:1122-1974	1/week	Mortar & pestle, 150micron sieve, sp.gr.bottle, balance, cylinder	As per relevant specifications	Higher the specific gravity more is the durability & economy
3	Porosity IS:1124-1974	1/week	Mortar & pestle, 150micron sieve, sp.gr.bottle, balance, cylinder	As per relevant specifications	
4	Compressive strength IS:1121(Part -I)-1974	Building /bridges 2 sets of tests per working season	Rock cutting machine 200 t compression testing machine	Workable range: Granite-1000kg/cm ² Basalt-400kg/cm ² Sand stone-300kg/cm ²	Indicates load carrying capacity & integrity
5	Transverse strength for flooring IS:1121(Part-2)1974 IS:3622-1977-	1/800Nos.	5t loading frame, transverse block	Sand stone-70 kg/cm ²	Ensures least breakage
6	Shear strength IS:1121(Part-4)1974	2 sets of tests per working season	Shear tool	Workable range: Granite-140-500kg/cm ² Basalt-200-600kg/cm ² Sandstone-80-400kg/cm ²	Ensures integrity against vertical sustained load.
7	Weathering IS:1125-1976	2 sets of tests per working season	Balance, gypsum powder	As per design	Measure of durability & strength

TABLE - 10
Coarse Aggregate (Metal, gravel etc.)
IS: 2386-1963 (Part 1 to 8), IS: 383-1970

Sample : 100 kg.

Sr. No.	Particulars of Tests	Frequency	Equipments	Acceptance criteria	Purpose of testing
1.	Gradation : IS:2386(Part-1)-1963	1/150 m ³ for concrete or as per specification	Set of coarse sieves 80mm to 4.75mm, balance	As per relevant specifications' provision	Gradation governs the bulk density and void content.
2.	Sp.gravity & water absorption IS:2386(Part-3)-1963	2/season	Wire basket, two pan balance, oven	As per relevant specifications' provision Sp.gravity generally 2.5 to 3.0 and water absorption 1 to 1.5%	Higher the specific gravity the higher the density and greater the durability.
3	Flakiness & elongation indices IS:2386-(Part-1)-1963	As per specification	Balance, length gauge, thickness gauge, sieves	As per design	Flaky material needs more sand, water & cement for same strength.
4	Impact value IS:2386(Part-4)-1963	2/season	Impact testing machine, triple beam balance, sieves	As per IS: 383-1970 Concrete-wearing-surface-30% max. Overlaid surface 45%max.	Lower impact value gives better performance in facing successive moving loads
5	Abrasion value IS:2386(Part-4)1963	2/season	Los angel's abrasion machine, balance, sieves	As per IS:383-1970 Concrete- Wearing surface-30%max. Over laid surface-45%max.	Higher abrasion value indicates more wear & tear & higher cost of repairs & maintenance
6	Soundness IS:2386(Part-5)1963	2/Season	Sieves, oven	As per-IS:383-1970 Concrete- Loss with Na ₂ SO ₄ -12%max. Loss with MgSo ₄ -18%max.	Higher loss indicates less ability of the stones to withstand effect of freezing & thawing
7	Alkali reactivity IS:2386-(Part-7)1963	2/Season	Reactivity container, water bath, balance	As per Sc/Rc curve of IS or relavant specifications provisions	Deleterious aggregate cause disintegration of concrete
8	Petrographic examination IS:2386(Part-8)-1963	2/Season	Microscope, hammer, balance	Relevant specifications provision or deleterious constituents not more than 5% including silt content	Deleterious material beyond 5% leads to chemical reactions, cracking of concrete etc.

TABLE - 11
Fine aggregate(Sand)
IS:2386-1963(Part - I to 8), IS:383-1970

Sample 20 kg

Sr. No.	Particulars of Tests	Frequency	Equipments	Acceptance criteria	Purpose of testing
1	Gradation Fineness modulus IS: 2386-(Part-1)1963	1/150m ³ or as per requirements of the relevant specification	Fine sieve set of 4.75,2.36,1.18mm & 600,300.150,75 micron, balance	As per relevant and specification provision and looking to the purpose of the use For concrete IS:383-1970 Masonry mortar IS:2116 –1980 Plaster IS:1542-1992	Poor gradation & lower F.M.give low strength, demand more water for mixing
2	Specific gravity & water absorption IS: 2386-(Part-3)1963	2/Season	Pycnometer, oven, two pan balance	As per relevant specifications & design	Lower specific gravity & higher water absorption decrease durability & density & increase shrinkage
3	Silt content IS: 2386-(Part-1)1963	1/150m ³	75 micron sieve, balance, oven	Not more than 3% or the relevant specifications' provision	Higher silt content reduces strength, increases water requirement & inhiibits bond
4	Alkali reactivity IS: 2386-(Part-1)1963	2/Season	Reactivity container, water bath, balance	As per Sc/Rc curves of IS or Relevant specifications provisions	Amorphous silica,glass,mica content lead to chemical disintegration
5	Petrographic examination IS: 2386-(Part –8)1963	2/season	Microscope, balance	Relevant specifications' provision or deleterious constituents plus silt content not more than 5%	Deleterious material beyond 5% affects durability

TABLE - 12
Building Bricks
IS : 1077 - 1992, IS : 3495 (Part 1 to 4) - 1992.

Sr. No.	Particulars of Tests	Frequency	Equipments	Acceptance criteria			Purpose of testing	
				Length	Width	Height		
1.	Dimension and tolerance IS:1077-1992	50 bricks from 50,000 (20 bricks)	Steel tape	For 19 x 9 x 9 cm (for 20 bricks)	3720 to 3880	1760 to 1840	1760 to 1840	Sample : 20 bricks. Uniform bricks need minimum thickness of joint and hence less mortar. Bond improves. More absorption means inadequate burning and less durability. Excess absorption leads to dampness, leaching of salt. Strong and durable masonry is ensured. More load can be laid on the wall. High strength bricks are ideal for hollow brick masonry. Excess efflorescence causes disintegration and defacement.
2.	Water absorption IS : 3495 (Part-2) 1992	5 bricks	Oven, two pan balance, water tank.	Not more than 20 percent or as specified in relevant specifications.				
3.	Compressive strength IS: 3495-(Part -1)-1992	5 bricks	Compression testing machine	Not less than 3.5 N/mm ² or as specified in relevant specifications.				
4.	Efflorescence IS : 3495-(Part-3)-1992	5 bricks	Glass dish or porcelain or stoneware dish	Classified as Nil - No deposition of salt on Bricks. Slight - Deposit of salt covering 10 % of exposed brick area. Moderate- Thin deposit of salt covering upto 50 % of the exposed brick area.				
5.	Chemical analysis of soil for suitability of preparing bricks. IS : 2117 - 1991	Each soil sample (5 bag)	Chemical balance furnace, water bath.	CaO+MgO Water soluble Salts	Not more than 1% for alluvial and not more than 15 % for other than alluvial. maximum 1 %			

TABLE - 13
Acid Resistant Bricks
IS: 4860 – 1968

Sample – 24 Bricks

Sr. No.	Particulars of Tests	Frequency	Equipments	Acceptance criteria	Purpose of testing
1.	Dimensions and tolerances 230 X 114 X 64mm IS:4860-1968	50 Bricks from 1000 & sub sample of 24	Tape	Permissible tolerances shall be as follows Tolerances Length ± 3.5 mm Width ± 2.0 mm Height ± 1.0 mm	Acceptable bricks mean economy, less joints and more durability
2.	Water absorption IS:4860-1968	5 Bricks	Oven, Balance	Class I – Not more than 2 % Class II – Not more than 4 %	Indicates integrity of bricks and masonry or lining
3.	Compressive strength IS:4860-1968	5 Bricks	200 t Compression testing machine	Class I – Not less than 700 kg/cm ² Class II – Not less than 500 kg/cm ²	Strength and durability are ensured
4.	Flexural strength IS:4860-1968	5 Bricks	40 t Universal testing machine of loading frame	Class I – Not less than 100 kg/cm ² Class II – Not less than 70 kg/cm ²	Strength and durability are ensured
5.	Resistance to acid IS:4860-1968	1 Brick	Chemical balance	Class I – Not more than 1.5 % Class II – Not more than 4.0 %	Indicates capacity to withstand corrosive action and hence durability

TABLE - 14
Cement Concrete Flooring Tiles
IS: 1237 - 1980

Sample - 18 Nos

Sr. No.	Particulars of Tests	Frequency	Equipments	Acceptance criteria	Purpose of testing												
1.	Water absorption	6/2000 tiles	Balance, Oven, Water Tank	Not more than 10 percent.	Ensures dryness of flooring and durability.												
2.	Transverse strength	6/2000 tiles	5 T loading frame, transverse apparatus	Shall not be less than 30 kg / cm ²	Capacity to withstand load if support is lost												
3.	Abrasion	6/2000 tiles	Tile abrasion machine, stone cutting machine.	Average wear shall not exceed 3.5 mm - wear on any individual specimen shall not exceed 4.0 mm	Lower the abrasion value, higher the durability and lower the maintenance.												
4.	Size	-do-	Steel tape	The size of cement concrete flooring tiles shall be as follows. <table style="margin-left: auto; margin-right: auto; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left;">Length mm</th> <th style="text-align: left;">Breadth mm</th> <th style="text-align: left;">Thickness mm</th> </tr> </thead> <tbody> <tr> <td>200</td> <td>200</td> <td>20</td> </tr> <tr> <td>250</td> <td>250</td> <td>22</td> </tr> <tr> <td>300</td> <td>300</td> <td>25</td> </tr> </tbody> </table>	Length mm	Breadth mm	Thickness mm	200	200	20	250	250	22	300	300	25	
Length mm	Breadth mm	Thickness mm															
200	200	20															
250	250	22															
300	300	25															
5.	Tolerances	-do-	Steel foot rule	Length or Breadth Thickness	± 1 mm $+ 5$ mm												

TABLE - 15
Low Density Polythelene Film (LDPE)
IS:2505-1989

Sample : 10 m²

Sr. No.	Particulars of Tests	Frequency		Equipments	Acceptance criteria	Purpose of testing
		Lot size	No.of samples			
1	Tolerance on thickness	1	1	Micrometer or thickness gauge meter	Up to & including 40 μ - \pm 25% Above 40 μ \pm 20%	Uniformity, assurance of performance, economy
		2-15	2			
		2-16	3			
		41-65	5			
2	Tensile strength	-do-	-do-	Tensile testing machine	Tensile strength MN/m ² (min) a)length wise 11.77 b)cross wise 8.33	The measure of tensile strength
3	Elongation	-do-	-do-	Tensile testing machine	Elongation %(min) a) length wise 200 b)crosswise 400	The measure of film elasticity, durability
4	Impact test	-do-	-do-	Impact tester	Impact failure load shall not be less than 1.20N for 100 μ LDPE film	To examine resistance to impact

TABLE - 16
Flush Door
IS: 2191 (Part – I) – 1983, IS: 2202 (Part – I) – 1991

Sample : 2 Nos.

Sr. No.	Particulars of Tests	Frequency	Equipments	Acceptance criteria	Purpose of testing	
1.	Dimension and tolerances	Lot 26-50 51-100 101-150 From above 2 samples to be selected	Sample size 8 13 20	Steel taper, vernier caliper	Height + 3mm Width + 3 mm Thickness \pm 1.2 mm Thickness variation not more than 0.8 mm Permissible limit for defective upto 50-0 number, 300-1,	Trueness of shape and form defined edges ensure tight fitting
2.	End immersion	-Above-	Curing tank, Steel foot rule	No delemination	To check the quality of glue resin used in the flush door, so as to ensure durability	
3.	Adhesion	-Above-	Water heater, Vernier caliper	No delemination in the plywood 3 pieces out of 4 should not have single delemination measured continuously more than 50mm in length and 3mm in depth	To know the strength of adhesion in flush door and hence durability	

Note : In case of solid core type flush door when physical tests are not satisfied, two additional shutters for each unsatisfactory shutter are tested for particular test and all shutters ought to satisfy the requirement of test.

TABLE - 17
Cement Concrete
IS: 456-2000, IS:516-1959, IS: 1199-1959

Sr. No.	Particulars of Tests	Frequency	Equipments	Acceptance criteria	Purpose of testing
1.	Mixer efficiency IS:4634-1968	At start of job and occasionally for each batching plant/mixer - Requirement of work	Container, Mixer, weighing balance etc.	Maximum unit weight variation within batch 0.8 percent from average. Maximum average variability 0.6% for 3, 0.5% for 6, 0.4% for 9, 0.3% for 10 batches	Ensures intimate homogeneous mixing and uniform dispersal of cement paste
2.	Workability IS: 1199-1959	Daily for each shift at plant and site	Slump cone, Tamping rod, steel tape	It should be as per "Hand book on concrete mixes" based on Indian Standards	Ensures proper placement and minimum voids
3.	Yield & Unit weight IS: 1199 – 1959	Occasionally or as directed by Engineer in charge	0.03 m ³ container, Weighing balance, Tamping rod	± 2% from design or as specified in the specification	Useful for determining and controlling cement level
4.	Air content IS: 1199-1959	-do-	Air entrainmeter with accessories	± 1% from design or as specified in the specification	Higher air content causes reduction in strength
5.	Compressive strength IS: 516-1959	As per IS and as specified in the relevant specification Quantity of concrete in work m ³	200 t compression testing machine, 15 cm cube mould, Vibrating machine	As per relevant specifications provision Grade designation	To evaluate the quality of concrete, its acceptability. If not acceptable measures to improve are tried.
		1-5	1	M 10	Specified characteristic compressive strength at 28 days, N/mm ² (kg/cm ²) Approx 10 (100)
		6-15	2	M 15	15 (150)
		16-30	3	M 20	20 (200)
		31-50	4	M 25	25 (250)
		51 & above	4 plus one additional sample for each additional 50 m ³ or part thereof	M 30 M 35 M 40 Upto M80 in increment of 5	30 (300) 35 (350) 40 (400) Upto 80 (800) in increment of 5 (50)

Sr. No.	Particulars of Tests	Frequency	Equipments	Acceptance criteria	Purpose of testing
Note :	(1) At least one sample is taken from each shift (2) Each sample consists of three test specimens for testing at 28 days. Additional cubes are required for various purposes such as to strength of concrete at 7 days or at the time of striking the form work, or to duration of curing, or the size testing error.			<p>(A) The concrete shall be deemed to comply with the strength requirements when both the following condition are met :</p> <p>a) The mean strength determined from any group of four consecutive test results complies with the appropriate limits in col 2 of Table below</p> <p>b) Any individual test result complies with the appropriate limits in col 3 of Table below</p> <p>(B) If the concrete is deemed not to comply pursuant to (B), the structural adequacy of the parts affected shall be investigated (see clause 17 of IS:456-2000) and any consequential action as needed shall be taken</p> <p>Note :</p> <p>1. The total number of test results required to constitute an acceptable record for calculation of standard deviation shall be not less than 30. Attempts should be made to obtain the 30 test results as early as possible, when a mix is used for the first time.</p> <p>2. Concrete of each grade shall be assessed separately</p>	

Sr. No.	Particulars of Tests	Frequency	Equipments	Acceptance criteria	Purpose of testing
				Specified Grade	Individual Test Results In N/mm^2
		(1)		(2)	(3)
		M 15		$\geq f_{ck} + 0.825 \times$ established standard deviation (rounded off to nearest $0.5 N/mm^2$) or $f_{ck} + 3 N/mm^2$ whichever is greater	$\geq f_{ck} - 3$ N/mm^2
		M 20 or above		$\geq f_{ck} + 0.825 \times$ established standard deviation (rounded off to nearest $0.5 N/mm^2$) or $f_{ck} + 4 N/mm^2$ whichever is greater	$\geq f_{ck} - 4$ N/mm^2

NOTE: In the absence of established value of standard deviation, the values given in Table 8 of IS:456-2000 may be assumed, and attempt should be made to obtain results of 30 samples as early as possible to establish the value of standard deviation.

Sr. No.	Particulars of Tests	Frequency	Equipments	Acceptance criteria	Purpose of testing
(B)	Ordinary and controlled concrete for road bridge	3 cubes/60 m ³ each for 7 and 28 days age, Further that every day for first six days and once in three days there after.	200 tonne compression testing machine	Average compressive strength of each day should not be less than specified strength subject to that 20 percent cubes per day (i.e. 1 per 5 may fall below specified strength upto its 85 percent).	
(C)	Concrete pavements roads and runways IRC-SP-11-1981 IRC-15-1981	3 cubes/beams for each age of 7 and 28 days for every 30m ³ .	200 tonne compression testing machine	Lower control limit calculated for a tolerance level of 1 in 15 test results, shall not be lower than the specified minimum strength. The lower control limit is given by the mean-value of the set of tests minus 1.6 times the standard deviation.	
2	Hardened concrete				
	(A) Concrete pavement/Bridge. IRC-Sp.-11-1981 IRC:15-1981;Test if failure in test 1	2 cores/30m ³	Core drilling machine	The crushing strength of cores shall not be less than 0.8 times the corresponding crushing strength of cubes	To evaluate the quality of concrete, its acceptability. If not acceptable measures to improve can be tried.
	(B) Dams	3 cores/1500m ³	Do	As in 1(A) + 1(B)	

Note: For tests 1 and 2, if individual results vary by more than ± 15 percent from average strength, reject those only (maximum rejection 1 in 3 or 2 in 5 cubes), and rework the average.

TABLE - 18
R.C.C. Precast Concrete Pipes
IS:458-1988 & IS:3597-1985

Sample-4Nos

Sr. No.	Particulars of Tests	Frequency	Equipments	Acceptance criteria	Purpose of testing
1	Dimension test IS:458-1988	As per table 15 of IS:458 or as specified in the relevant specification	Steel tape	Tolerance as specified in IS:458 or as per the relevant specification	Uniformity, economy, performance
2	Hydraulic test IS:3597-1985	As per table 15 of IS:458 or as specified in the relevant specification	Hydrostatic testing machine & pump	No leakage sign should be seen when the specimen is filled with water & pressure of 0.7.kg/cm ² is applied & maintained for the specified time	To know the leakage at certain pressure. To ensure water tightness
3	Three edge bearing test IS:3597-1985	As per table 15 of IS:458 or as specified in the relevant specification	Testing machine with accessories, Pressure applying device, crack measuring gauge	No crack should develop up to the load to produce 0.25 mm crack as specified in IS:458 or the relevant specifications	Structural safety against bridging on subgrade
4	Absorption test IS:3597-1985	-	Oven, Balance	a) Absorption in the first 10 minutes shall not exceed 2.5 percent of the dry mass b) Total absorption at the end of 24 hrs. shall not exceed 6.5 percent of the dry mass	To know the porosity of the pipe material

Note: 1) The concrete for non-pressure pipes shall have a minimum cement content of 360 kg/m³ & minimum comp. Strength of 20 N/mm² at 28 days.
 For pressure pipes minimum cement content 450 kg/m³ and minimum comp. strength of 20 N/mm²
 2) Reinforcement used for the manufacture of RCC pipes shall be as per relevant specifications of steel

TABLE - 19
Masonry Mortar
IS : 2250 - 1981

Sr. No.	Particulars of Tests	Frequency	Equipments	Acceptance criteria	Purpose of testing
1.	Consistency (Workability) IS:2250-1981	Each working day	Standard cone apparatus, flow table	As specified in the relevant specification	Ensures proper placement and minimum voids.
2.	Compressive strength IS:8605:1977	3 Cubes / 100 m ³ or / day whichever is more for each age	Compression testing machine, 5 x 5x5 cm cube mould, mixing bowl.	1 in 5 samples may fall below specified strength upto 80 percent.	Governs strength and durability.
3.	Permeability IS: 3085-1965	1 / week	Permeability apparatus	As specified in the relevant specification	Ensures water tightness
4.	Water retentivity IS:2250-1981	When mortar is to be used with masonry unit which has got high suction characteristics.	Water retentivity apparatus, straight edge, mixing bowl, flow table.	Flow after suction in the test shall not be less than 10 percent of the flow before suction.	To know the ability of mortars to retain water against suction and evaporation.
5.	Air content	1/50 m ³	Air entrainmeter	± 1 per cent from design	Higher air content causes reduced strength.
6.	Yield & Unit weight	1/50m ³	0.03m ³ containers	± 2 per cent from design cement level unit volume of mortar or as specified in relevant specification	Useful for determining and controlling cement level.
7.	In situ permeability	As per specification	Drilling machine, insitu permeability apparatus with pressure gauge and packers.	As per design	Ensures water tightness.

33TABLE - 20
Sealing Compound
IS:13143-1991, 5256-1968

Sr. No.	Particular of Test	Frequency	Equipment	Acceptance Criteria	Sample – 3 kg. Purpose of testing
1	Softening Point IS:1205-1978	As per specification	Ring and Ball apparatus, Bath & Stirrer	It shall not be less than 85° C	For determination of softening point of sealing compound
2.	Penetration at 25 °C 100 g 5%, 1/10 IS:1203-1978		Penetrometer with accessories	Minimum – 15, Maximum – 30	To determine the grade of sealing compound
3.	Flash Point IS:1209-1978		Pensky-Martens closed Tester	Minimum 200 °C	To determine the flash point & fire point of sealing compound
4.	Pour Point IS:1834-1984			Maximum 170 ° C	To ensure viscosity & workability
5.	Increase in softening point after heating to 20 ° C above the maximum pour point for 3 hrs. IS:1205-1978		Ring & Ball apparatus, Bath & Stirrer	Maximum 5 ° C	To determine increase in softening point of sealing compound
6	Extensibility at 0°C IS:1834-1984			Minimum 6 mm	Determination of capacity to extend
7	Water content IS:1211-1978		Dean & Stane Assembly, Heater	Maximum 0.5 percent by weight	To determine water content of sealing compound

TABLE - 21
Water (For concrete & Mortar)
IS : 456 - 2000

Sr. No.	Particulars of Tests	Frequency	Equipments	Acceptance criteria	Sample 1 liter Purpose of testing
1.	Chemical Analysis.	Once for approval of source	Muffle furnace, water bath Oven, PH meter & Platinum Crucible.		Chemical suitability & stability
	pH			Generally not less than 6	pH lower than 6 is acidic, leads to corrosion, loosens bond. pH more than 8 causes excessive leaching.
	Chlorides (mg / l) IS : 3025 (part-32) - 1988			2000 mg/l for plain concrete & 500 mg/l for RCC work max.	Higher chlorides cause corrosion.
	Organic matter (mg/l) IS : 3025 (part - 18) -1984			200 mg/l max.	Excess organic matter may adversely affect the hardness of concrete, may stain the concrete.
	Inorganic matter (mg/l) IS : 3025 (part-18)-1984			3000 mg/l max.	Excess inorganic matter causes efflorescence.
	Sulphate (mg/l) IS : 3025 (part-24) -1986			400 mg/l max.	Excess sulphate attacks calcium carbonate to form calcium aluminosulphate which is weak, expands and disintegrates concrete.
	Suspended matter IS : 3025 (part - 17) - 1984			2000 mg/l max.	
	Neutralization of alkalinity IS : 3025 (part-23) - 986			25 ml with 0.02 N H ₂ SO ₄ max.	
	Neutralization of acidity IS : 3025 (part-22) - 1986			5 ml with 0.02 N NaOH max.	

Note: In case of doubt regarding development of strength, the suitability of water for making concrete shall be ascertained by the compressive strength and initial setting time tests specified in 5.4.1.2 & 5.4.1.3 of IS : 456 - 2000.

TABLE - 22
Curing compound
ASTM C-156-1989 C-309-1989, D-1309-1988, D-1644-1988, E-1347-1990

Sample: 1 litre

Sr. No.	Particulars of Tests	Frequency	Equipments	Acceptance criteria	Purpose of testing
1	Water retention test ASTM C-156-1989	1lit.per 1000 lit. or as specified in the relevant specification	Mould, sprayer, balance, humidity chamber etc.	Water loss after 72 hrs.-not more than 0.55 kg/cm ²	To find out the ability to reduce moisture loss during the early hardening period
2	Reflectance test ASTM E-1347-1990	-do-	Tristimulus colorimeter	Shall exhibit a daylight reflectance not less than 60 %	To find out reflectance value of white pigment based curing compound
3	Drying time test ASTM C-309-1989	-do-	Mould, sprayer, humidity chamber	a) Dry to touch not more than 4 hrs. b) After 12 hrs. the compound shall not be tracky or track off the specimen	To know the drying time requirement
4	Long term settling ASTM D 1309-1988	-do-		Rating between 4 to 10	
5	Non volatile content ASTM D-1644-1988	-do-	Pipette, Oven, Balance, Desicator	-	To find out non volatile content of curing compound

TABLE - 23
PVC Water stops
IS: 8543-(Part 4)-1984 IS: 12200-1987, ASTM D 638-1991, D 412-1992, D 2240-1991,
Sample: 1.5m long – 3 pieces

Sr. No.	Particulars of Tests	Frequency	Equipments	Acceptance criteria	Purpose of testing
1.	Tensile Strength IS: 8543-(Part 4 / Sec.1) - 1984	Per lot of 45m or as per specified in specification	Tensile strength testing machine with accessories	Shall not be less than 116 kg/cm ²	To measure its strength
2.	Ultimate elongation IS: 8543-(Part 4 / Sec.1)- 1984	-do-	-do-	Shall not be less than 300 percent	To measure its elasticity
3.	Tear resistance	-do-		Shall not be less than 49 kg/cm ²	To disallow tearing
4.	Stiffness in flexure	-do-		Shall not be less than 24.60kg/cm ²	
5.	Accelerated Extraction i) tensile strength	-do-	Tensile strength testing machine with accessories	Shall not be less than 105 kg/cm ²	To measure strength
	ii) Ultimate elongation	-do-	-do-	Shall not be less than 250 percent	To measure its elasticity, Durability
6.	Effect of alkali at 7 days a) Change in weight % b) Hardness change	-do- -do-		± 0.10 percent max. ± 5.0 point	To measure strength
7.	Effect of alkali after 28 days a) Weight increase b) Weight decrease c) Change in dimension			0.40 percent max. 0.3 percent max. ± 1 percent	
8.	Durometer Hardness			± 1 percent shore "D"	

TABLE - 24
Admixture for Concrete
IS: 9103-1979

Sr.No.	Particulars of test	Frequency	Equipment	Acceptance criteria				Sample : 1 Litre Purpose of Testing
				Accelerating Admixture	Retarding Admixture	Water reducing Admixture	Air entrain Admixture	
1.	Water content of control sample	1/1000 lit.	Oven with Thermometer	-	-	95	-	To evaluate % of water
2.	Setting time allowable deviation from control sample in hrs.							
	Initial		Vicat Apparatus with initial & final needle	-3 max. -1 min.	+3 max. +1 min.	± 1 max.	-	To know the suitability in concrete/ mortar in setting time
	Final			-2 max. -1 min.	+3 max.	± 1 max.	-	
3.	Compressive Strength Allowable from control mix (%)	Days 3 7 28	C.T.M machine	125 min. 100 min. 100 min.	90 min. 90 min. 90 min.	110 min. 110 min. 110 min.	90 min. 90 min. 90 min.	To know the suitability in concrete/mortar in strength
4.	Flexural strength Allowable from control mix (%)	Days 3 7 28	Flexural Testing machine	110 min. 100 min. 90 min.	90 min. 90 min. 90 min.	100 min. 100 min. 100 min.	90 min. 90 min. 90 min.	To know the suitability in concrete/mortar in strength
5.	Length change percent increase from control sample							To know the shrinkage in mortar / concrete
	28 Days		Length change comperater	0.010 max.	0.010 max.	0.010 max.	0.010 max.	
	6 Months			0.010 max.	0.010 max.	0.010 max.	0.010 max.	
	1 Year			0.010 max.	0.010 max.	0.010 max.	0.010 max.	

Sr.No.	Particulars of test	Frequency	Equipment	Accelerating Admixture	Acceptance criteria			Purpose of Testing
					Retarding Admixture	Water reducing Admixture	Air entrain Admixture	
6.	Bleeding percent increase over control sample		Pipette, Temping Bar, Cylinder	5 max.	5 max.	5 max.	2 max.	To determine relative quantity of mixing water that will bleed from a sample.

O.K. CARD FOR CEMENT CONCRETE MIX (AT BATCHING PLANT)

Location of plant :

Grade of concrete : M-

Date :

Proportion as per mix design.

Location of placing concrete :

- | | | |
|-----|--|-----------------|
| 1. | Coarse aggregate : Natural or crushed | ----- |
| 2. | Whether gradation, Size and quality of coarse aggregates are as per specifications and mix design ?
Give % oversize and under size. | Yes/No
----- |
| 3. | Is the coarse aggregate free from excessive silt ? Specify actual % of silt | ----- |
| 4. | F. M. of Sand | ----- |
| 5. | Is the sand free from excessive silt ? Specify actual % of silt | Yes/No
----- |
| 6. | Type and brand of cement : PPC/OPC | ----- |
| | A.E.A. | ----- |
| | Water | ----- |
| 7. | a. Start of pour | ----- |
| | b. End of pour | ----- |
| 8. | a. Total m ³ . batched | ----- |
| | b. Total m ³ . placed | ----- |
| | c. Total m ³ . wasted | ----- |
| 9. | Ambient temperature at Start : at Finish : ... | ----- |
| 10. | Mixing time specified | ----- |
| 11. | W/C ratio | ----- |
| 12. | Slump specified | ----- |
| 13. | a. Slump at batchmix plant | ----- |
| | at placement site | ----- |
| | b. Air content | ----- |

Sign. of Contractor

Sign. of AE/AAE

Deputy Exe. Engineer

DEE/AE/AAE
Quality Control Sub. Dn.
Name of Divison :

Sign. of Inspecting Officer.

Name of Sub-Division :

Name of Dn. :
Name of Sub Dn. :

O.K.CARD FOR CONCRETING AT THE STRUCTURE UNDER CONSTRUCTION :

Name of Work :
Name of Structure :
Location :
Type of Con. :
Proportion :
as per mix desing
Details of component :
Date of Start : Time :
Date of Completion : Time :
Embient Temp. :
Enbient Temp. :

A. SURFACE PREPARATION :

1. Whether the cleaning of foundation is done as specified? Yes/No
2. Dewatering arrangement whether adequate? Yes/No
3. Whether foundation mapping is done? Yes/No
4. Whether the surface to receive the concrete is prepared as specified? Yes/No

B. REINFORCEMENT :

5. Whether placing of reinforcement is as per design and drawings? Yes/No
6. Whether cleaning and checking of reinforcement is done? Yes/No
7. Whether checking of reinforcement done for adequacy of cover maintaining spacing uniformity and rigidity. Yes/No

C. FORMWORK AND WATER STOPS AND STEEL ITEMS :

8. Whether the erection of form work, placement of water stop and joints are as per the requirement. Yes/No
9. Whether geometry of form work and adequacy of supporting system is checked. Yes/No
10. Whether form work joints are properly sealed Yes/No
11. Whether the Oiling of forms is done adequately. Yes/No
12. Whether the concrete mixes, their location and sequence of placement satisfactory. Yes/No
13. Whether the transporting units, placement units and vibrators are sufficient and adequate. Yes/No
14. Whether Curing arrangements are adequate ? Yes/No
15. Slump =
16. No. of cubes cast

Signature of Contractor

Sign. of A.E./AAE

Deputy Ex. Engr.

D.E.E./ A.E./A.A.E.

Sign. of inspecting Officer

Name of Dn. :

Name of Sub Dn. :

O.K. CARD FOR C.C. LINING

Location:

Chainage from to

Distance from Centre line :

Date :

1. Whether sub grade is Okay from geometric angle? Yes/No
2. whether sub grade is prewetted sufficiently before placing the concrete? Yes/No
3. Density and moisture content of sub grade
4. Date and time of approval of sub grade
5. Date and time of starting C.C. Lining.
6. Whether Paver machine is Okay and it's alignments set? Yes/No
7. Whether the levels of rails are checked? Yes/No
8. Whether placing arrangement of concrete is proper (i.e. sufficiency of lining equipments and transit mixers) Yes/No
9. Workability of concrete at placement/B.M. Plant slump M.M. _____
10. Whether No. of labourers, masons etc. are adequate? Yes/No
11. Are curing arrangements adequate and satisfactory? Yes/No
- 12.A Whether PVC strips to be inserted is checked W.R.T. quality and quantity Yes/No
- B Whether PVC strip insertion is made?
- C Whether proper cutting of joints has been done?
13. Whether log book of paver machine is maintained? Yes/No
- 14.A Whether curing compound to be used is tested?
- B Specify results with coverage.
15. No. of cube cast
16. Date and time of completion of lining
17. Remarks :

Sign. of Contractor

Sign. of AE/AAE

Deputy Exe. Engineer

D.E.E./A.E./A.A.E.
Quality Control Su b-Dn.

Sign. of Inspecting Officer

Name of Division :
Name of sub-Division :
Name of canal :

O.K. CARD FOR SUB GRADE OF C.C. LINING

Location: Chainage From to

Distance from Central Line : Date :

1. Whether proud has been removed before commencement of C.C. lining as per specifications? Yes/No
2. Whether final levels after proud removal are within the tolerance limits? Yes/No
3. Over excavation, if any, may be specifically indicated.
4. Whether final levels have been recorded Yes/No
5. Whether mapping of rock/soil is done Yes/No
6. Whether filling in over excavation is carried out? Yes/No
7. Whether sub grade has been properly watered compacted as per design? Yes/No
8. Depth of moisture in the sub grade after watering.
9. Whether designed under drainage arrangements are provided? (e. g. P.R.V., longitudinal & cross drains) Yes/No
10. Whether necessary approval of sub grade is taken? Yes/No
Result of test, % compaction & % of FMC
11. Instruction of inspecting officer if any.

Sign. of Contractor

Sign. of AE/AEE

Deputy Exec. Engineer

D.E.E./A.E./A.A.E.
Quality Control Sub-Dn. No.

Sign. of Inspecting Officer.

Name of Dn. :
Name of sub-Division :

O.K. CARD FOR SUB GRADE OF BRICK LINING

LOCATION	CHAINAGE Date :-	from	to
(A) SUB-GRADE			
1. Whether proud has been removed just before placing the leveling course 10 mm thick in C.M. 1:6 (or as specified)			Yes/No
2. Whether Template at an interval of 3m to 5m are prepared showing the layers of cement mortar and final profile of cross-section with brick lining ?			Yes/No
3. Whether the levels after proud removal are within the tolerance limit ?			Yes/No
4. In case of over excavation, whether earth filling is carried out Watered and Compacted ?			Yes/No
5. Whether Sub-Grade has been properly watered upto the required depth ?			Yes/No
6. Whether necessary tests for approval of sub-grade are taken? Results of tests			Yes/No
	% age of compaction		-
	% age of FMC		-
7. Whether sub grade is okay from geometrical angle and necessary templates are provided ?			
8. Remarks			

Sign. of Contractor

Sign. of A.E/A.A.E

Deputy Executive Engineer
Sub-Dn

D.E.E/A.E./A.A.E.
Quality Control Sub-Dn

Sign. of Inspecting Officer

Name of Division :
 Name of sub-Division :
 Name of canal :

O.K. CARD FOR BRICK LINING

LOCATION	Chainage Date :-	from	to
(A) SUB GRADE AND CONSTRUCTION MATERIAL.			
1. Whether subgrade is approved ?			Yes/No
2. Whether sub grade is okay from Geometrical angle and necessary Templates are Provided.			Yes/No
3. Date and time of approval of sub-grade		-	
4. Whether Bricks to be used are tested and test results are available?			Yes/No
5. Whether proper arrangement has been made for soaking of bricks before use ?			Yes/No
6. Whether over burnt/under brick/pilla bricks/Rejected bricks stacked seperately?			Yes/No
7. Whether sand to be used is of the approved quality and free from deleterious materials, well screened and of requisite F.M ?			Yes/No
8. Whether cement to be used is fres h, not older than 90 days? Brand of cement, Grade, and Batch No.			Yes/No
9. Whether cement Account Book and consumption register maintained upto date and kept available on site?			Yes/No
10. Whether Mixer Machine & Weigh batcher have been tested? Corrected batch weight is provided considering the free moisture in sand?			Yes/No
11. Board indicating proportion of cement mortar is displayed.			Yes/No
12. Whether proper handling arrangement for mortar is done and impervious platform is provided for motar ? Whether mortar tank is being used.			Yes/No
13. Total time taken for the use of particular batch of cement mortar (not more than 30 minutes.)			-
14. Whether the W/C ratio for the required consistancy is maintained properly.			Yes/No

15. Proper arrangement for measurement of water is provided? Yes/No
- (B) **MORTAR LAYERS**
16. Whether wooden L patties for uniformity in thickness of mortar are used in plaster layer? Yes/No
17. Whether strings and threads are kept on site to be used extensively for ensuring thickness and geometry of plaster? Whether wooden templates are used for curved portion ? Yes/No
18. Date and time of starting levelling course i.e. 1st layer of 10mm thick or as specified in cm 1:6 or as specified. -
19. Whether adequate arrangement for curing is done ? (e.g.covered with wet gunny bags etc.) Yes/No
20. Whether 1st layer is moistened, cleaned and scrubbed with broom Yes/No
21. before the 2nd layer of plaster ?
Date and Time of starting the 2nd layer i.e. impervious layer of specified thickness in C.M. 1:3 proportion/or as specified.
22. Whether the 2nd plaster layer is scrubbed as per requirement with wire brush ? Yes/No
23. Whether the 2nd plaster layer is cured ? Yes/No
24. Are curing arrangements adequate ? Yes/No
- (C) **BRICK LINING**
25. Date and time of starting the brick lining
26. Whether the bricks are soaked sufficiently Yes/No
27. Whether proper care for putting the bed plaster and filling of frog/joints with mortar taken ? Squeezing out of mortar between the joint space checked ? Yes/No
28. Whether the masonry is broomed with wire brushes at the end of day ? Yes/No
29. Whether the joints have been checked with joint tester and log book is maintained for joint testing ? Yes/No
30. Whether adequate curing arrangement for curing in bed like water ponds and slopes to be covered with mats soaked in water, or hose pipe for sprinkling of water on slopes or perforated pipes on top of lining or pucca gutter on top of lining is provided ? Yes/No
Specify curing register maintained or not

Sign. Of contractor

Sign. Of AE/AEE

Deputy Ex. Engineer

D.E./A.E./A.A.E.
Quality Control Sub-Dn

Sign. of Inspecting Officer

LIST OF INDIAN STANDARDS

Sr.No.	Standard No.	TITLE			
			1.6.13	IS:4031 (Part-13):1988	-do-Determination of measurement of water retentivity of masonry cement. (First revision)
1.00	CEMENT :				
1.1	IS : 269:1989	Specification for 33 grade ordinary portland cement (Fourth) Revision)	1.6.14	4031 (Part-14) : 1989	-do- Determination of False test.
1.2	IS : 455:1989	Portland blast furnace slag cement. (Fourth revision) Amed-3.	1.6.15	IS:4031 (Part-15):1991	-d0- Determination of fineness by wet sieving.
1.3	IS : 1489: 1991	Specification for Portland Pozzolona Cement (Third revision) Flyash based.	1.7	IS:4032:1986	Methods of chemical analysis for hydraulic cement (First revision)
1.4	IS : 3466:1988	Specification for masonry cement (Second revision)	1.8	IS:4905:1968	Methods for random sampling Amed – 1, Reaff – 1991.
1.5	IS : 3535:1986	Methods of Sampling hydraulic cement (First revision)	1.10	IS:6909:1990	Specification for super sulphated cement Amed –2.
1.6	IS : 4031(part-I)-1988	Methods of physical tests for hydraulic cement - Determination of fineness by dry sieving. (First revision)	1.11	IS:8041:1990	Rapid hardning cement.
1.6.2	(Part-2) : 1988	--do – Determination of fineness by specific surface by blaine air permeability (First revision)	1.12	IS:8042:1989	White Portland cement.
1.6.3	(Part-3) : 1988	-- do --Determination of soundness (First revision)	1.13	IS:8112:1989	43 Grade Ordinary Portland Cement Specification Amed – 3.
1.6.4	(Part-4) : 1988	-- do -- Determination of consistency of sand and cement paste (First revision)	1.14	IS:12269 – 1987	Specification for 53 grade ordinary Portland cement. Amed-3.
1.6.5	(Part-5) : 1988	-do-Determination of initial and final setting time (First revision)	1.15	IS:12330-1988	Specification for sulphate resisting Portland cement Amed-3.
1.6.6	(Part-6) : 1988	-- do --Determination of comp. strength of hydraulic cement other than masonry cement (First revision)	2.00	POZZOLANA :	
1.6.7	(Part-7) : 1988	-- do -- Determination of Comp. strength of masonry cement (First revision)	2.1	IS : 1344 : 1981	Specification for calcined clay pozzolana Second revision)Amed–1.
1.6.8	(Part-8) : 1988	-- do -- Determination of transverse and Comp. stren. of plastic mortar using prism (First revision)	2.2	IS : 1727 : 1967	Method of test for Pozzolanic materials (First revision) Amed-1, Reaff – 1990.
1.6.9	(Part-9) : 1988	-- do -- Determination of heat of hydraytion. (First revision)	2.3	IS : 3812 : 1981	Specification for fly ash for use as pozzolana and admixture (First revision) Reaff-1992.
1.6.10	(Part-10) : 1988	-- do -- Determination of drying shrinkage (First revision)	2.4	IS:6491:1981	Method of Sampling of Flyash.
1.6.11	(Part-11) : 1988	-- do -- Determination of density (First revision)	2.5	IS : 10153 :1982	Guidelines for utilisation and disposal for Flyash.
1.6.12	(Part-12) : 1988	-- do -- Determination of air content of hydraulic cement mortar. (First revision)	3.00	BUILDING LIME :	
			3.1	IS:712:1984	Specification for building limes.(Third revision)Amed (Reaff-1995)
			3.2	IS:1128:1974	Specification for limestone. (Slab & tiles) (First revision) Reaff-1993.
			3.3	IS : 1624 : 1986	Method of field testing of building lime (First revision) Amed-1, Reaff – 1993.
			3.4	IS : 3115 :1992	Lime based blocks. (Second revision)
			3.5	IS : 4095 : 1983	Lime pozzolana mixture. (First revision) Amed – 2, reaff – 1989.

3.6	IS : 6508 : 1988	Glossary of terms relating to building lime (first revision) Reaff-1993.	4.4	IS:1599:1985	2, Reaff-1995. Method for bend test (supersiding IS:1962-1974. IS:3260-1960 and IS:4598:1965) Reaff-1991.
3.7	IS : 6932 : 1973	Methods of test for building limes.			
3.7.1	IS : 6932(Part – I):1973	Determination of insoluble Residue, loss on ignition, butyric and aluminium oxide calcium oxide and magnesium oxide Reaff-1995.	4.5	IS:1608:1995.	Method for tensile testing of steel product (Second revision)
3.7.2	IS : 6932(Part – 2):1973	-- do --Determination of Carbon dioxide content Reaff – 1990.	4.6	IS:1785(Part-I):1983	Specification for plain hard drawn steel wire for pre-stressed conc. to part-I cold drawn stress relieved wire (Second revision) Amed-1, Reaff-1995.
3.7.3	IS : 6932(Part-3) : 1973	-- do --Determination of Residue on Slaking of quick lime. Reaff-1995.	4.7	IS:1785(Part-II):1983	Specification for plain hard drawn steel wire for pre stressed concrete Part-2 a cold drawn wire (First revision) Amed-1, Reaff-1995.
3.7.4	IS : 6932(Part-4) : 1973	-- do --Determination of fineness of Hydraulic lime. Reaff-1995.	4.8	IS:1786:1985	Specification for high strength deformed steel bars and wires for concrete reinforcement (Third revision) Amed-1, Reaff-1990.
3.7.5	IS : 6932(Part-5):1973	-- do --Determination of unhydrated oxide. Reaff-1995.	4.9	IS:1977:1966	Low tensile structural steel (Third revision)
3.7.6	IS:6932(Part-6):1973	-- do --Determination of volume-yield of quick lime Reaff-1995.	4.10	IS:2062:1992	Steel for general structural purposes (Fourth revision) Amed-1.
3.7.7	IS:6932(Part-7):1973	-- do --Determination of compressive and transverse strength. Reaff-1995.	4.11	IS:2090:1983	High tensile steel bars for concrete reinforcement. (Third revision, Reaffirmed – 1990.
3.7.8	IS:6932:(Part-8):1973.	-- do -- Determination of workability Reaff-1995.	4.12	IS:8500:1991	Structural steel medium & high strength qualities(first revision Amed-2.
3.7.9	IS:6932(Part-9):1973	-- do --Determination of soundness. Reaff – 1995.	4.13	IS:6003-1983	Indented wire for prestressed concrete (first revision)
3.7.10	IS:6932 (Part-10):1973:.	-do-Determination of poping and pitting of hydrated lime.Reaff-1995.	4.14	IS:6006-1983	Specification for uncoated stress relived strend for prestressed concrete (first revision)
3.7.11	IS:6932 (Part-11):1984:.	-- do -- Determination of setting time of hydrated lime. Reaff-1990.	4.15	IS:13620-1993	Fusion bonded epoxy coated reinforcing bars (amend - 1)
4.00	STRUCTURAL STEEL:		5.0	BUILDING STONE :	
4.1	IS:432(Part-I):1982	Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement Part-I Mild steel. (Third revision Reaff. 1995)	5.1.1	IS:1121(Part-I):1974	Method of test for determination of
4.2	IS:432(Part-II):1982	Specification for mild steel and Medium tensile steel bars and hard drawn steel wire for concrete reinforcement Part-2 hard drawn steel wire (Third revision) Reaff-1995.			
4.3	IS:1566:1982	Hard drawn steel wire fabric for concrete reinforcement (Secomd revision) Amed-			

5.1.2	IS:1121(Part-2):1974	strength properties of natured building stones. Compressive strength (First revision) Amed-1, Reaff-1993. -do- Transverse strength. (First revision) Reaff-1993.	6.4..2	IS:2386(Part-2):1963.	-- do --Estimation of deleterious material and organic impurities. Amed-1, Reaff-1990.
5.1.3	IS:1121(Part-3):1974	-do Tensile strength (First revision) Reaff-1993.	6.4..3	IS:2386(Part-3):1963.	-do- Specific gravity density voids, absorption and bulking. Reaff-1990.
5.1.4	IS:1121(Part-4):1974	-do Shear strength (First revision) Reaff-1993.	6.4..4	IS:2386(Part-4):1963.	-- do --Mechanical properties. Amed-5, Reaff-1990.
5.2	IS:1122:1974	Method of test for determination of true specific gravity of natural building stones (First revision) Reaff-1993.	6.4..5	IS:2386(Part-5):1963.	-- do --Soundness, Reaff-1990.
5.3	IS:1123;1975	Identification of Petrographic examination of natural building stone. First revision Reaff. 1990.	6.4..6	IS:2386(Part-6):1963.	-- do -- : Measuring mortar making properties of fine aggregate. Amed – 2, Reaff-1990.
5.4	IS:1124:1974	Method of test for determination of water absorption apparent sp. gr. and porosity of natural building stone(First revision) Reaff-1990.	6.4..7	IS:2386(Part-7):1963	-- do --Alkali aggregate reactivity, Reaff-1990.
5.5	IS:1125:1974	Method of test for determination of weathering of natural building stone(First revision) Reaff-1990.	6.5	IS:2430:1969	Method for sampling of aggregate for concrete.
5.6	IS:1126:1974	Method of test for determination of durability of natural building stone (First revision) Amed-1, Reaff-1990.	6.6	IS:5640:1970	Method of test for determining aggregate impact value of soft coarse aggregates. Amed-1. Reaff – 1990.
6.00	AGGREGATE :		7.00	BRICKS :	
6.1	IS:383:1970	Specification for coarse and fine aggregate material (Second revision) Reaff-1990.	7.1	IS:654:1992	Specification for clay roofing roofing tiles mangalore pattern (Third revision)
6.2	IS:1542:1992	Sand for plasters (Second revision)	7.2	IS:1077:1992	Specification for common burnt clay building bricks (Fifth revision)
6.3	IS:2116:1980	Sand for masonry mortars (First revision) Reaff-1992	7.3	IS:2117:1991	Guide for manufacture of hand made burnt clay building bricks (Third revision)
6.4.1	IS:2386(Part-I):1963.	Method of test for aggregate for concrete, Particle size and Shape,	7.4	IS:2248:1992	Glossary of terms relating to structural clay products for building (First revision)

7.5	IS:3495:1992(Part-I to 4) -1992	Method of test for burnt clay building bricks Part-1 to 4 (Third revision)	10.1.2	IS:1708(Part-2):1986	-do- Determine of specific gravity (Second revision)
7.6	IS:4860:1968	Specification for acid resistant bricks Reaff-1991.	10.1.3	IS:1708(Part-3):1986.	-do- Determination of volumetric Shrinkage.(Second revision)
7.7	IS:5454:1978	Method of sampling of clay building bricks (First revision) Reaff-1995.	10.1.4	IS:1708(Part-4):1986.	-do- Determination of radial and tangential shrinkage and fibre saturation point. (Second revision)
7.8	IS:6165:1992	Dimensions for special shapes of clay bricks (First revision)	10.1.5	IS:1708(Part-5):1986.	-do- Determination of static bending strength under two points loading. (Second revision)
8.00	TILES :		10.1.6	IS:1108(Part-6):1986.	-do- Determination of static bending strength under 2 point loading. (Second revision)
8.1	IS:1237:1980	Specification for cement flooring tiles (First revision) Reaff-1990.	10.1.7	IS:1708(Part-7):1986.	-do- Determination of impact bending strength (Second revision)
8.2	IS:1464:1992	Clay ridge and ceiling tiles specification (Second revision)	10.1.8	IS:1708(Part-8):1986.	-do- Determination of compressive strength parallel to grain (Second revision)
8.3	IS:2690(Part-1&2):1992	Burnt clay flat terracing tiles (Second revision)	10.1.9	IS:1708(Part-9):1986.	-do- Comp. strength perpendicular to grain. (Second revision)
8.4	IS:4457:1982	Specification for ceramic unglazed vitreous acid resisting tile (First revision) Reaff-1990.	10.1.10	IS:1708(Part-10):1986.	-do- Determination of hardness under static identification (Second revision)
9.00	LDPE FILM:		10.1.11	IS:1708(Part-11):1982	-do- Determination of sheer strength parallel to grain (Second revision)
9.1	IS:2508:1984	Low density polythelene films (Second revision) Amed-1, Reaff-1990.	10.1.12	IS:1708(Part-12):1986	-do- Determination of tensile strength parallel top grains. (Second revision)
10.00	TIMBER :		10.1.13	IS:1708(Part-13):1986.	-do- Determination of tensile strength perpendicular to grain (Second revision)
10.1.1	IS:1708(Part-1):1986	Method of testing of small clear specimen of timber Determination of moisture content. (Second revision) Reaff -1991.	10.1.14	IS:1708(Part-14):1986.	-do- Determination of clear age strength parallel to grain. (Second revision)

10.1.15	IS:1708(Part-15):1986.	-do- Determination of Nail screw holding power (Second revision)	12.3	IS:458:1988	Concrete pipes. (Third revision) Amed-2. Method test for strength of concrete. Amed-2, Reaff -1991.
			12.4	IS:516:1959	
10.1.16	IS:1708(Part-16):1986.	-do- Determination of brittleness by Izod impact (Second revision)	12.5	IS:1199:1959	Methods of sampling and analysis of concrete. Reaff - 1991.
10.1.17	IS:1708(Part-17):1986.	-do- Determination of brittleness of carphy impact. (Second revision)			
10.1.18	IS:1708(Part-18):1986.	-do- Determination of torsional strength (Second revision)	12.6	IS:1791:1985	
10.2	IS:2202(Part-1):1991.	Specification for flush door shutters solid core type) (Fifth revision(Amed – 3.	12.7	IS:1834:1984	Hot applied sealing compounds for joints in concrete(First rev.)
10.3	IS:2408;1963	Methods of static tests of timber in structural sizes. Amedment-1, Reaff1990.	12.8	1838(Part1.2)1983/1984	Preformed fillers for expansion tests in concrete pavement and structures (non extruding & resitient type)
10.4	IS:4970:1973	Key for identification of commercial timber (First revision)	12.9.1	IS:2185(Part-1):1979.	Specification for concrete for masonry units part-1. Hollow and solid concrete (Second revision) Amed-1, Reaff-1992.
11.00	ADMIXTURE :		12.9.2	IS:2185(Part-2):1983	Specification for concrete masonry units, Part-2 Hollow and solid light weight concrete blocks (first revision) Reaff-1995.
11.1	IS:2645:1975	Specification for integral cement water proofing compound. (First revision) Amed-1, Reaff-1992.	12.9.3	IS:2185(Part-3):1984	Specification for concrete masonry units part-3, Autoclave cellular aerated concrete blocks (First revision) Reaff-1990.
11.2	IS:9103:1979	Specification for Admixture for concrete (first revision) Reaff-1990.	12.10	IS:3085:1965	Methods of tests for permeability of cement mortar and concrete. Reaff-1990.
12.00	CONCRETE :		12.11	IS:3597:1985	Method of testing for concrete pipes. (first revision) Reaff 1990.
12.1	IS:456:2000	Code of practice for plain and reinforced concrete (Third revision) Amed-2, Reaff.1991.	12.12	IS:3860:1966	Precast cement concrete slabs for canal linings.
12.2	IS:457:1957	code of practice for general construction of plain and reinforced concrete for dams and other massive structure. Reaff-1991.	12.13	IS:3873;1978	Code of practice for laying insitu cement concrete lining on canals (First revision.)
			12.14	IS:4926;1976	Ready mixed concrete (First revision.)

12.15	IS:4969:1968	Method of test for determining flexural strength of precast cement concrete slabs for canal lining.			
12.16	IS:9012;1978.	Recommended practice for shotcreting (Reaff - 1987)			
12.17	IS:10262:1982	Recommended guideline for concrete mix design. Reaff-1989.			
13.00	MASONARY MORTAR :				
13.1	IS:2116:1980	Specification of sand for masonry mortars (First revision) Reaff-1992.	16.1	ASTM-C-309-1989	Specificatin for liquid membrane forming compounds for curing concrete.
13.2	IS:2250:1981	Code of practice for preparation and use of masonry mortars. (First revision) Reaff-1990.	16.2	C-156-1989	Test method for water retention by concrete curing material
14.0	Sealing Compound		16.3	D- 869 –1985	Method for evaluating degree of settling of paint.
14.1	IS:5256:1968	Code of practice for sealing joints in concrete lining on canals.	16.4	D-1309-1988	Test method for settling properties of traffic paint.
14.2	IS:13143;1991	Joints in concrete lining of canals-sealing compound – specifications.	16.5	D-1644-1988	Test methods for non volatile content of varnish
15.0	WATER (For construction)		16.6	E-1347-1990	Test methode for color anf color difference measurements by Tristimulus (filter) Colorimetry.
15.1	IS:456:2000	Code of practice for plain and reinforced concrete. (Third revision) Amed – 2, Reaff-1991	17.00	PVC Water Stops	
15.2	IS:3025;Part 1,3,9 to 12,14, to 19,21 to 26,32)	Methods of sampling and test (physical and chemical for water and waste water.)	17.1	IS:8543(Part-4)-1984	Method of testing plastics.
16.00	CURING		17.2	IS:12200-1987	Code of practice for provision of water stops at transverse contraction joints in masonry & concrete dams.
			17.3	ASTM:D:638:1991	Test for tensile properties of plastics
			17.4	ASTM:D:412:1992	Test for rubber properties in tension
			17.5	ASTM:D:2240:1990	Test for rubber property Durometer hardness