1.0 GENERAL

1.1 This standard specification shall be applicable for the work covered by the contract and without prejudice to the provisions of various international codes of practice, standard specifications etc. It is understood that the CONTRACTOR shall carry out the work in all respects with the best quality of materials and workmanship and in accordance with the best engineering practice and instructions of Engineer-In-Charge in consultation with SMMS.

1.2 This specification covers the requirement for protective coating for new construction.

2.0 SCOPE

2.1 Scope of work covered in the specification shall include, without being limited to, the following:

This specification defines the requirements for surface preparation, selection and application of primers and coatings on external surfaces of items mentioned in clause 2.2 of this specification and quality control, inspection & testing of the coating systems. The items listed in clause 2.2 and the heading of tables of paint systems are non-exhaustive. However, the CONTRACTOR is fully responsible for carrying out all the necessary painting, coating and lining job on external and internal surfaces as per the contract requirement.

2.2 Extent of work covered in this standard

2.2.1 The following surfaces and materials shall require shop, pre-erection and field painting, as applicable:

a. All Carbon Steel structures.

b. All Carbon Steel and Alloy steel piping, equipment, valves, fittings & stacks.

c. All Carbon Steel and Alloy steel tanks.

d. Tanks internal as per applicable datasheets & contract requirements.

e. All insulated CS pipes, equipment, valves, fittings & stacks.

f. All insulated SS pipes, equipment, valves, fittings, vessels & stacks.

g. All structural steel supports, walkways, handrails, ladders, platforms etc.

h. Flare lines, external surfaces of steel chimney with or without refractory lining and internal surfaces of steel chimney without refractory lining.

2.2.2 Marking and Identification of painted items:

a. Identification of color bands on all piping, as required, including aluminum cladding over insulation, galvanized, SS and nonferrous piping.

b. Identification lettering/ numbering on all painted surfaces of equipment/piping, aluminum cladding over insulation, galvanized, SS and non-ferrous piping.

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c. Marking / identification signs on painted surfaces of equipment and piping including hazardous service.

2.2.3 Supply and prequalification testing of all primers, paints and all other materials required for painting (other than OWNER supplied materials)

2.2.4 Application of pre-erection/fabrication and shop primer.

2.2.5 Repair work of damaged pre-erection/ fabrication and shop primer and weld joints in the field/site before and after erection.

2.2.6 Quality control, testing and inspection during all stages of work (surface preparation, application of coating and testing of applied coating).

2.2.7 Exclusions:

All metallic surfaces do require painting except for following materials. These materials are not painted unless specified by the contractual provisions and the same shall be painted as per the relevant specifications:

a. Un-insulated stainless steel.
b. Plastic and/or plastic-coated materials.
c. Galvanized Iron.
d. Aluminum.
e. Ni-Alloys.
f. Glass.
g. Ceramics.
h. Machined surfaces.
i. Label and names plates.

Note: Galvanized steel doesn't require painting for corrosion protection. However, if painting is mandated due to OWNERs instructions/contractual provision/ for colour coding requirement mentioned in this standard or by OWNER, then the coating system in Table 4.0 shall be followed.

3.0 REFERENCE CODES & STANDARDS

3.1 Latest editions of the following codes and standards are applicable for the work covered by this standard:

Steel Structures Painting Council (SSPC)

SSPC SP-1	Solvent cleaning
SSPC Painting manual Vol.1	Good Painting practices
SSPC Painting manual Vol.2	Systems & specification
SSPC VIS 1	Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning
SSPC AB1	Mineral and Slag Abrasives
SSPC PA 2	Measurement of Dry Paint Thickness with Magnetic Gauges

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American Society for Testing and Materials (ASTM):

ASTM Volume 6.01	Paint - Tests for Chemical, Physical, and Optical Properties; Appearance
ASTM Volume 6.03	Paint -- Pigments, Polymers, Resins, Naval Stores, Cellulosic Esters, and Ink Vehicles
ASTM D6677	Standard Test Method for Evaluating Adhesion by Knife
ASTM D5894	Standard Practice for Cyclic Salt Fog/UV Exposure of Painted Metal, (Alternating Exposures in a Fog/Dry Cabinet and a UV/Condensation Cabinet)
ASTM D870	Standard Practice for Testing Water Resistance of Coatings Using Water Immersion
ASTM D2485	Standard Test Methods for Evaluating Coatings for High Temperature Service
ASTM D2247	Standard Practice for Testing Water Resistance of Coatings in 100 % Relative Humidity
ASTM D4417	Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel
ASTM D4541	Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers
ASTM D4060	Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser
ASTM D4752	Standard Practice for Measuring MEK Resistance of Ethyl Silicate (Inorganic) Zinc-Rich Primers by Solvent Rub
ASTM D638	Standard Test Method for Tensile Properties of Plastics
ASTM D4940	Standard Test Method for Conductimetric Analysis of Water Soluble Ionic Contamination of Blast Cleaning Abrasives
ASTM D4285	Standard Test Method for Indicating Oil or Water in Compressed Air
ASTM D543	Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents
ASTM C868	Standard Test Method for Chemical Resistance of Protective Linings
ASTM G42	Standard Test Method for Cathodic Disbonding of Pipeline Coatings Subjected to Elevated Temperatures
ASTM B117	Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM D1475	Standard Test Method for Density of Liquid Coatings, Inks, and Related Products
ASTM D823	Standard Practices for Producing Films of Uniform Thickness of Paint, Coatings and Related Products on Test Panel
ASTM D2369	Standard Test Method for Volatile Content of Coatings
ASTM D1640/D1640M-14	Standard Test Methods for Drying, Curing, or Film Formation of Organic Coatings
ASTM D522/D522M	Standard Test Methods for Drying, Curing, or Film Formation of Organic Coatings
ASTM D968	Standard Test Methods for Abrasion Resistance of Organic Coatings by Falling Abrasive
ASTM D1044	Standard Test Method for Resistance of Transparent Plastics to Surface Abrasion

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ASTM D1849	Standard Test Method for Package Stability of Paint
ASTM D2247	Standard Practice for Testing Water Resistance of Coatings in 100 % Relative Humidity
ASTM D5146	Standard Guide to Testing Solvent-Borne Architectural Coatings

National Association for Corrosion Engineer (NACE):

NACE RP 0287	Field Measurement of Surface Profile of Abrasive Blast-Cleaned Steel Surfaces Using a Replica Tape
NACE SP 0198	Control of Corrosion under Thermal Insulation and Fireproofing Materials
NACE SP 0188	Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates

International Organization for Standardization (ISO):

ISO 12944	Corrosion Protection of steel Structures by Protective Paint System
ISO 1461	Hot dip galvanized coatings on fabricated iron and steel articles-Specifications and test methods.
ISO 8501-1/ SIS-05 59 00	Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness— Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings
ISO 8502-3	Preparation of steel substrates before application of paints and related products -Tests for the assessment of surface cleanliness - Part 3: Assessment of dust on steel surfaces prepared for painting (pressure-sensitive tape method)
ISO 8502-9	Preparation of steel substrates before application of paints and related products — Tests for the assessment of surface cleanliness—Part 9: Field method for the conductometric determination of water-soluble salts
ISO 2808	Paints and varnishes - Determination of film thickness
ISO 2811	Paints and varnishes — Determination of density

Other Standards

NORSOK M-501	Surface preparation and protective coating
RAL CLASSIC	Color matching system

4.0 SURFACE PREPARATION

4.1 General

Adhesion of the paint film to the surface depends largely on the degree of cleanliness of the metal surface and proper surface preparation have large contribution to the success of the paint protective system. Following method shall be employed for surface preparation:

a. Abrasive blast cleaning: Applicable in all cases.

b. Mechanical or power tool cleaning: Shall be used for repair & touch up, and any other area due to practical constraints with prior permission from EIL Engineer-in charge.

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4.2 Applicable Standards:

Latest editions of the following codes and standards are applicable for the surface preparation work:

TABLE-1: SURFACE PREPARATION STANDARDS

Sl. No.	GRADE OF SURFACE CLEANLINESS	VARIOUS INTERNATIONAL STANDARDS (EQUIVALENT)		
		ISO 8501-1/ SIS-05 59 00	SSPC, USA	NACE, USA
1.	Solvent cleaning	-	SSPC-SP-1	-
2.	Manual or hand tool cleaning	St 2	SSPC-SP-2	-
3.	Mechanical or power tool cleaning	St 3	SSPC-SP-3	-
4.	White metal	Sa 3	SSPC-SP-5	NACE No.1
5.	Near white metal	Sa 2½	SSPC-SP-10	NACE No.2
6.	Commercial Blast	Sa 2	SSPC-SP-6	NACE No.3
7.	Brush-off Blast for SS, galvanized steel and non-ferrous metals	-	SSPC-SP-16	-
8.	Surface Preparation of Concrete	-	SSPC-SP-13	NACE No.6

4.3 Sequence of surface preparation:

4.3.1 Solvent Cleaning

Mill scale, rust, rust scale and foreign matter shall be removed fully to ensure that a clean and dry surface is obtained. Unless otherwise specified, surface preparation shall be done as per provisions of relevant tables given elsewhere in this specification. Before surface preparation by blast cleaning, the surface shall be cleaned to remove all grease, oil etc. as per SSPC-SP-1.

4.3.2 Blast cleaning with abrasives

The surfaces shall be blast cleaned using one of the abrasives listed below and at an appropriate distance & angle depending on nozzle size maintaining constant velocity and pressure.

a. The quality of abrasives shall be free from contaminants and impurities and shall meet the requirements of SSPC AB1.

b. The compressed air shall be free from moisture and oil.

c. On completion of blasting operation, the blasted surface shall be clean and free from any scale or rust. Blast cleaning shall not be done outdoors in bad weather without adequate protection. If there is dew on the metal surface, it shall be cleaned. If possible, a vacuum collector shall be installed to collect and recycle the abrasives.

d. Surface roughness profile: The surface roughness profile for carbon steel and low alloy steels to be coated shall be in accordance with the written recommendations of the paint Manufacturer and shall be measured as per ASTM D4417, method B. When roughness profile is not specified by the paint Manufacturer, then surface roughness profile as specified below in this specification shall be followed.

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- The surface roughness profile shall be between 40 µm and 70 µm for coatings up to thickness 500 µm and between 70 µm and 125 µm for coating systems over 500 µm thickness. In all cases, the surface roughness shall have a sharp angular profile.

- If stainless steel, hot dip galvanised or non-ferrous metal surfaces are to be painted then blast cleaning shall be carried out as per SSPC-SP-16, using a fine non-iron containing abrasive.

- On galvanised surfaces, the zinc layer shall not be damaged; a smooth uniform surface roughness shall be achieved. No defects such as break through or crisping of the zinc layer shall occur. The surface roughness shall be in the range of 20 µm to 30 µm or as agreed with the paint Manufacturer.

e. Abrasives: Abrasive for use in blast cleaning steels shall be in accordance with ISO 8504-2. Steel or iron grit is commonly used as recyclable abrasives. When steel shot is used, it shall be used together with steel grit. The shot content of such a mix shall not exceed 67 %.For blasting stainless steel, non-(free) iron containing abrasive shall be used, e.g. Garnet or aluminium oxide. Abrasives used for blast cleaning shall be free from oil, grease, moisture, chloride contamination etc. and shall have crystalline silica not more than 1%.

Test methods for abrasives shall be in accordance with the tests specified in the ISO 11125 and ISO 11127 series for metallic and non-metallic abrasives respectively. Each batch of abrasive should be tested to check that the abrasive meets the requirements as specified in the relevant ISO standard. The conductivity of non-metallic abrasives to be used for stainless steels shall be maximum 15 mS/m. For all other non-metallic abrasives, the conductivity shall not exceed 25 mS/m. OWNER/PMC shall approve the use of alternative abrasive materials. Abrasive used shall be as per following specification:

Type	Generic Name	Standard
Metallic	Iron grit	ISO 11124-2
	Steel grit	ISO 11124-3
Natural mineral	Staurolite	ISO 11126-9
	Garnet	ISO 11126-10
Synthetic mineral	Copper slag	ISO 11126-3
	Aluminium oxide	ISO 11126-7

4.3.3 Mechanical or power tool cleaning

Power tool cleaning shall be done by mechanical striking tools, chipping hammers, grinding wheels or rotating steel wire- brushes. Excessive burnish of the surface shall be avoided as it can reduce paint adhesion. On completion of cleaning, the detached rust, mill scale etc. shall be removed by clean rags and /or washed by water/steam and thoroughly dried with compressed air jet before application of paint.

4.4 General Notes for surface preparation/blasting:

a. Surface shall not be coated in rain, wind or in an environment where injurious airborne elements exist.
b. Surface shall not be coated when the steel surface temperature is less than 3 ^{0}C above dew point.

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c. Surface shall not be coated, when the relative humidity is greater than 85%.

d. Surface shall not be coated when the temperature is below 10°C and the ambient/substrate temperature is below the paint manufacturers recommended temperature of application and curing.

e. The paint application shall not be done when the wind speed exceeds 20 km per hour.

f. The illuminance during coating and inspection shall be at least 1000 Lux.

4.5 Use of Dehumidifier

In case of internal coating of storage tanks, dehumidifier shall be used to control humidity level below 60%. Dehumidifier should depress the dew point of air in the enclosed space, sufficient enough so as to maintain it more than 3°C below the metal substrate temperature during entire period of blasting and coating application. During the interval time between application of primer coat and subsequent intermediate and top coats or between blast cleaning completion and start of application of primer coat, dehumidifier unit should be in continuous operation to ensure that no condensation occurs on the substrate.
The Engineer in-Charge shall have the right to disallow usage of dehumidifier if the performance is not meeting the specified requirements. Under such circumstances, the CONTRACTOR shall remove the equipment and replace the same with another equipment to provide satisfactory results without any additional cost to the OWNER.

4.6 Surface preparation of concrete:

The external surface of RCC to be painted shall be dry and clean. Any loose particle of sand, cement, aggregate etc. shall be removed and surface shall be prepared as per SSPC-SP-13.

5.0 COATING APPLICATION

5.1 Blast cleaned surface shall be coated with complete application of primer as soon as practicable but in no case later than 4 hours the same day. However, at times of unfavorable weather conditions, the Engineer-In-Charge shall have the liberty to control the time period, at his sole discretion and/or to insist on re-cleaning before primer application is taken up. In general, during unfavorable weather conditions, blasting and painting shall be avoided as far as practicable.

5.2 To the maximum extent practicable, each coat of paint shall be applied as a continuous film with uniform thickness and free of probes. Any spots or areas missed in application shall be re-coated and permitted to dry before the next coat is applied.

5.3 Each coat shall be in proper state of cure or dryness before the application of succeeding coat. Material shall be considered dry for re-coating when an additional coat can be applied without the development of any detrimental film irregularities such as lifting or loss of adhesion of the under coat. Manufacturer's instructions shall be followed for inter-coat interval.

5.4 When the successive coat of the same colour have been specified, alternate coat shall be tinted, when practical, sufficiently to produce enough contrast to indicate the complete coverage of the surface. The tinting material shall be compatible with the material underneath and shall not be detrimental to its service life and shall be recommended by the original paint manufacturer.

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5.5 Airless spray application shall be in accordance with steel structure paint manual Vol.1 & Vol.2 by SSPC, USA

5.6 Brush application of paint shall be in accordance with the following:

a. Brushes shall be of a style and quality that will enable proper application of paint.

b. Round or oval brushes are most suitable for rivets, bolts, irregular surfaces, and rough/ pitted steel. Wide flat brushes are suitable for large flat areas but they shall not have width over 5 inches.

c. Paint shall be applied into all corners.

d. Any runs or sags shall be brushed out.

e. There shall be a minimum of brush marks left in the applied paint.

f. Surfaces not accessible to brushes shall be painted by spray, daubers, or sheepskin.

5.7 Applied paint should have the desired wet film thickness specified by manufacturer. For each coat, the painter should know the WFT corresponding to the specified DFT and standardize the paint application technique to achieve the desired WFT. This has to be ensured in the qualification trial.

5.8 Irregular surfaces such as sharp edges, welds, small brackets, and interstices may stripe coated to ensure specified DFT is achieved. Paint manufacturer recommendation should be followed before deciding for brush application.

5.9 Unless otherwise instructed, final coating (i.e. application of field primer, intermediate and top coats) on pre-erection/ shop primed equipment shall be applied at site, only after all welding & testing like NDT are completed as well as after completion of steam blowing.

5.10 Drying of coated surfaces

a. No coat shall be applied until the preceding coat has dried. The material shall be considered dry for re-coating when another coat can be applied without the development of any film irregularities such as lifting or loss of adhesion of undercoats. Drying time of the applied coat should not exceed maximum specified for it as a first coat. If this exceeds, the paint material has possibly deteriorated or mixing is faulty.

b. No paint shall be force dried under conditions which will cause chalking, wrinkling, blistering formation of pores, or detrimentally affect the conditions of the paint.

c. No drier shall be added to paint on the job unless specifically called for in the manufacturers' specification for the paint.

d. Paint shall be protected from rain, condensation, contamination, snow and freezing until dried to the fullest extent practicable.

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5.11 Spot repair of damaged primer

a. Where pre-erection/shop primer has been damaged at isolated localized spots during handling and transportation or after erection / welding, its repair shall be done as given below and as per the Table-3 of this specification.

b. Surface preparation: Quickly remove the primer from damaged area by mechanical scraping and emery paper conforming to SSPC-SP-3 to expose the white metal. Blast clean the surface, if possible. Feather the primed surface, over the intact adjacent surface surrounding the damaged area, by emery paper.

Primer coating: One coat of F-8/F-9/F-16 shall be applied (as per the applicable design temperature and in conjunction with Table-3) wherever damage was observed on pre-erection / pre fabrication or shop primer.

c. If damaged areas are found to be extensive and spread over large areas (as required by Engineer-in charge), then entire pre-erection/pre-fabrication/shop primer shall be removed by blasting to achieve SSPC-SP-10 and entire blasted surface shall be primed again with F-8/ F-9 or F-16, as applicable, for the intended design temperature. (See note of Table-3). If the prepared surface lies adjacent to a sound coated surface, the surface preparation shall overlap the coated surface by at least 50mm. The remainder of existing coated surface shall be properly protected with shields or screens to prevent any possible damage to the coating.

5.12 Equipment:

a. All tools, brushes, rollers, spray guns, blast material, hand power tools for cleaning, all equipment, scaffolding materials, shot & grit blasting equipment , air compressors etc. required shall be suitable for the work and shall be arranged by the CONTRACTOR in sufficient quantity at the site. The manufacturers test certificates / data sheets for all the above mentioned items shall be reviewed by Engineer-In-Charge at site before start of the work.

b. All paint spraying equipment, including mixers, shall be thoroughly cleaned before mixing of new materials. All coating materials shall be mixed and thoroughly stirred in accordance with the instructions of the paint Manufacturer. Sufficient agitation to maintain good mixing shall be applied until the product is used. If air is entrapped in the product during mixing/stirring, sufficient time should be allowed for the air bubbles to escape before application. Only thinners specified by the paint Manufacturer shall be used.

5.13 Shop coating

a. Shop coated equipment (coated with primer & finishing coat) should not be repainted unless paint is damaged. Repair of primer shall be carried out as per Table-3 of paint systems depending upon the compatibility of paint. Intermediate and final coats over repaired primer shall be as per applicable tables mentioned in this specification.

c. Shop primed equipment and surfaces will only be 'spot cleaned' in damaged areas by means of power tool brush cleaning or hand tool cleaning and then spot primed before applying one coat of field primer, unless otherwise specified. If shop primer is not compatible with field primer, then shop coated primer should be completely removed before application of selected paint system for a particular environment.

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d. For package units/Items/ OEM equipment, shop primer & coating system should be as per the paint system given in this specification. However, manufacturers' standard may be followed after review by EIL but shall adhere to the minimum DFT specified in ISO-12944-5; C5 (Very high durability). For system under insulation, minimum guidelines as per NACE RP 0198 shall be followed.

In this case, guarantee of the coating system lies with package supplier/OEM. EIL's decision in this regard is final and binding on Supplier/Contractor/manufacturer

5.12 Guidelines for Documentation / records

a. A written quality plan with procedure for qualification trials and for the actual work including test and inspection plan & procedure for approval before start of work.

b. Daily progress report with details of weather conditions, particular of applications, no. of coats and type of materials applied, anomalies, progress of work versus program.

c. Results of measurement of temperatures, relative humidity, surface profile, film thickness, holiday detection, adhesion tests with signature of appropriate authority.

d. Particulars of surface preparation and paint application during trials and during the work.

e. Details of non-compliance, rejects and repairs.

f. Type of testing equipment and calibration.

g. Code and batch numbers of paint materials used.

Note: The coating applicator must maintain a job record consisting of all the information as per 5.12.b. to 5.12.g above as well as the approved procedure of work (5.12.a. above). The job record consisting of information in accordance to 5.12.b. to 5.12.g shall be entered on daily basis and should be daily signed by Engineer-in-charge.

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6.0 PAINT MATERIALS

Typical characteristics and codes of various paint materials used in this specification are as follows.

TABLE-2: PAINT MATERIALS
(Refer to *general notes* at the end of this table)

DESCRIPTION	P-6	P-7	P-4
Technical name	Epoxy Zinc Phosphate Primer	Cold Galvanizing product	Etch Primer/Wash Primer
Type and composition	Two component polyamine cured epoxy resin medium, pigmented with zinc phosphate.	One pack synthetic resin-based zinc galvanizing containing min 92% of electrolytic zinc dust of 99.95% purity.	Two pack polyvinyl butyral resin medium cured with phosphoric acid solution pigmented with zinc tetroxy chromate.
Volume solids % Minimum	49	37	9
DFT per coat, µ	40-50	40-50	8-10
Theoretical covering capacity in m^2/coat/ litre	9.8-12.2	3.4-4.4 m^2/kg	9.0-11.2
Weight per liter in Kg/litre (min.)	1.4±0.05	2.67 kg at 15°C	1.2±0.05
Touch dry at 30°C (max.)	30 min.	10 min.	2 hrs.
Hard dry at 30°C (max.),Hrs.	8	24	24
Over-coating interval, hrs.	Min. 8	Min. 4	Min. 4-6
Pot life at 30°C for two Component paints, hrs.	6 - 8	NA	NA
Adhesion (ASTM D 4541)	>7	NA	NA
Temperature resistance (min) ° C (ASTM D 2485) *Note 8	80 (Method A)	50 (Method A)	NA

TABLE- 2: PAINT MATERIALS (Contd.)

DESCRIPTION	F-2	F-3	F-6A/B	F-6C
Technical name	Acrylic Polyurethane finish paint	Chlorinated rubber-based finish paint	Epoxy-High Build coating	Solvent less epoxy coating
Type and composition	Two-pack aliphatic isocynate cured acrylic finish	Single pack Plasticized chlorinated rubber based	F-6A Two-Pack Aromatic polyamine cured epoxy resin	Two pack, cured with Amine Adduct; catalyzed epoxy

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	paint (free of alkyd/polyester resins).	medium with chemical and weather resistant pigments.	medium suitably pigmented. F-6B: polyamide cured epoxy resin medium suitably pigmented with MIO.	resin suitably pigmented
Volume Solids % (min.)	40	36	57	98
DFT per coat, µ	30-40	30-40	100-125	300-450
Theoretical covering capacity in m^2/coat/litre	10-13.3	9-12	4.6-5.7	2-3.9
Weight per liter in Kg/litre (min.)	1.15	1.15	1.42	1.40
Touch dry at 30°C (max)	30 min.	30 min.	3 hrs.	3 hrs.
Hard dry at 30°C (max.).	8 hrs.	8 hrs.	16 hrs.	16 hrs.
Full cure at 30°C (for immersion/ high temperature service)	NA	NA	5 days	5 days
Over-coating Interval, hrs	Min.12.	Min. Overnight	Min. Overnight Max. 5 days	Min. 8. Max. 48
Pot life (approx.) at 30°C for two component paints, hrs	5-8	NA	3-6	0.5
Adhesion (ASTM D 4541)	>5	>4	>7	>8
Abrasion Resistance (ASTM D4060) For 1000 g load	<300 mg /1000 cycles/CS17 or <100 mg /1000 cycles/CS10	NA	NA	NA
Temperature resistance (min.) °C (ASTM D 2485) *Note 8	80 (Method A)	60 (Method A)	80 (Method A)	120 (Method A)

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TABLE- 2: PAINT MATERIALS (Contd.)

DESCRIPTION	F-7	F-8	F-9	F-11	F-12
Technical name	High build coal tar epoxy coating.	Self-priming type surface tolerant high build epoxy coating (complete rust control Coating)	Inorganic zinc silicate Coating containing zinc content min. 80%. Shall pass MEK rub test as per ASTM D4752 with resistance rating >4	Heat resistant synthetic medium based two pack Aluminum Paint suitable up to 250°C dry temp.	Heat resistant silicone Aluminum Paint suitable up to 540°C dry temp.
Volume Solids % Minimum.	62	75	57	35	18
DFT per coat in μ	100-125	100-125	65-75	15-20	15-20
Theoretical covering capacity in M^2/coat/ litre	5-6.2	6-7.5	7.6-8.8	17.5-23.3	9-12
Weight per liter in Kg/litre (min.)	1.40	1.41	2.3	0.95	1.00
Touch dry at 30°C (maximum)	4 hrs.	3 hrs.	0.5 hrs.	3 hrs.	0.5 hrs.
Hard dry at 30°C (maximum),	48 hrs.	24 hrs.	12 hrs.	12 hrs	24 hrs.
Full cure 30°C (for immersion /high Temperature sev.)	5 days	5 days	NA	NA	NA
Over-coating interval, hrs	Min. 24 hrs Max.5days	Min. 10	Min. 12 hrs at 20°C & 50% RH	Min. 24	Min. 24
Pot life at 30°C for two component Paints, hrs	4-6	1.5	4-6	NA	NA
Adhesion MPa (ASTM D 4541)	>5	>5	>5	NA	NA
Temperature resistance (min.) ° C (ASTM D 2485) *Note 8	80 (Method A)	80 (Method A)	400 (Method B)	250 (Method A)	540 (Method B)

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TABLE- 2: PAINT MATERIALS (Contd.)

DESCRIPTION	F-14	F-15	F-16	F-17	F-20
Technical name	Polyamine cured coal tar epoxy	Two-component Epoxy phenolic coating cured with Polyamine adduct hardener	Inert polymeric matrix coating suitable for under insulation for CS and SS.	Novolac epoxy phenolic coating cured with Polyamine adduct hardener	Glass flake reinforced vinyl ester coating.
Type & composition	Specially formulated polyamine cured coal tar epoxy suitable for application under insulation	Two pack ambient temperature curing epoxy phenolic coating system suitable for application under insulation	Suitable for high temperature service and under insulation coating for CS, alloy steel and SS	Novolac epoxy phenolic coating cured with Polyamine adduct hardener	Two component glass flake filled vinyl ester lining for under immersion services up to 90 deg. C.
Volume Solids % Minimum.	67	67	50	98	98
DFT per coat in microns	100-125	75-100	100-125	300-450	500-600
Theoretical covering capacity in M^2/coat/ litre	5.4-6.7	6.7-8.9	4-5	2.2-3.3	1.6-2
Weight per liter in Kg/litre (min.)	1.45	1.65	>1.3	1.7	>1.2
Touch dry at 30°C (max)	4 hrs.	3 hrs.	1 hrs.	2 hrs.	2 hrs.
Hard dry at 30°C (max).	24 hrs.	24 hrs.	16 hrs.	24 hrs.	4 hrs.
Full cure 30°C (for immersion / high temp service)	168 hrs (7 days)	168 hrs (7 days)	NA	168 hrs (7 days)	96 hrs (4 days)
Over-coating interval	Min. 6 hrs Max.5 days	Min. 36 hrs Max.21 days	Min.6 hrs Max. Not applicable	Min. 16 hrs Max.21 days	Min. 4 hrs Max.3 days

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Pot life at 30°C, hrs (for two component paints)	4	4-6	1	1	50 min-1 hr.
Adhesion, MPa (ASTM D 4541)	>6	>7	NA	>8	>7, Tensile strength >20N/mm2 (ASTM D 638)
Temperature resistance (min.) ° C (ASTM D 2485) *Note 8 & 9	125 (Method A)	150 (Method A)	650 (Method B)	200 (Method A)	90 (Method A)

General notes for TABLE-2:

1. Covering capacity and DFT achieved per coat depends on method of application. Covering capacity specified above is theoretical. For estimation of actual quantity of paints required, include the losses during application. Minimum specified DFT should be maintained in any case.

2. All primers and finish coats should be ambient temperature curing and air drying unless otherwise specified.

3. All paints shall be applied in accordance with manufacturer's instructions for surface preparation, intervals, curing and application. Wherever a deviation is noticed from the specification in manufacturer data sheet, more stringent one between the data sheet and the specification shall prevail e.g. if this specification recommends Sa 2 ½ and the manufacturer data sheet requires Sa3, the surface preparation shall be done as per Sa 3. However, in another case if this specification requires the surface preparation of Sa 2 ½ and the manufacturer data sheet recommends only Sa 2 as minimum, the surface preparation shall be done as per Sa 2 ½.

4. Technical data sheets for all paints shall be supplied at the time of submission of quotations.

5. Internationally recognized & acceptable testing method shall be used for lab testing wherever testing standards are not mentioned.

6. Touch dry, hard dry, pot life, full cure period, & over coating interval shall be as per manufacturer's data sheets and no testing is required. Slight variation in the values of these parameters along with weight per liter may be permissible with the discretion of engineer-in-charge in consultation with SMMS.

7. Temperature resistance tests (ASTM D2485) shall be carried out for minimum required temperature resistance indicated.
8. Wherever ASTM D 2485 method B is applicable, test results of the panels subjected to salt spray (ASTM B 117) after muffle furnace exposure shall be submitted for pre-qualification purpose.

9. F6-C shall be suitable for drinking water service and should have certification from competent authority.

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7.0 SELECTION OF COATING SYSTEMS

The external coating system for EIL projects should be selected based on the C5 environment (very high durability) as per ISO12944-2, design temperature, involved services of the steel substrate and plant location.

The paint system to be applied for a specific job shall be arrived at sequentially as given below:

a. Identify the environment from area classification details and choose the appropriate table.
b. Identify the design temperature from the technical documents.
c. Identify the specific field paint system and surface preparation requirement from the above identified table and temperature range.
d. Identify the shop priming requirement from based on compatibility of the above paint system.
e. Identify the need of repair of shop primer and execute as per Table-3.

7.1 Classification based on plant location:

a) Plant located in inland area (more than 50 km from coast).

- For offsite areas and utilities: Table-5 to be followed.
- For process units, DM plant, CPP and Cooling towers: Table-6 to be followed.

b) Plant located on sea coast or within 50 km from sea coast.

- For process units, DM plant, CPP, Cooling tower, offsite & utilities etc.: Table-6 to be followed.

c) For external surface of above ground tanks, Table-8 to be followed for all locations (inland or coastal)

TABLE-3: REPAIR OF PRE-ERECTION/PRE-FABRICATION OR SHOP PRIMER AFTER ERECTION/WELDING
(For all un-insulated CS, LTCS & alloy steel items in all environments)

Sl. No.	Design Temp. in °C	Surface Preparation	Coating System	Total DFT in Microns (min.)	Remarks
3.1	-45 to 80	SSPC-SP-3	1 coat of F-8 @ 125 µ DFT/coat	125	See Note-1 below and clause 5.11
3.2	81 to 400	SSPC-SP-3	1 coat of F-9 @ 65-75 µ DFT/coat	65-75	
3.3	401 to 550	SSPC-SP-3	1 coat of F-16 @ 125 µ DFT/coat	125	

Note for Table-3:

1. The application and repair of pre-erection/pre-fabrication and shop primer given in above tables shall be done for all the items to be painted. In case the damages of primer are severe and spread over large area, entire primer shall be removed by blasting to achieve SSPC-SP-10 and surfaces to be primed again with F-8/ F-9/F-16, as applicable. After the repairs of the primer,

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suitable intermediate and final coats shall be applied as per applicable coating systems mentioned in Table 5.0 to Table 13.0.

TABLE-4: COATING SYSTEM FOR GALVANIZED ITEMS (Refer clause 2.2.7)

Sl. No.	Design Temp. in °C	Coating System	Total DFT in Microns (min.)	Remarks
4.1	Up to 60	Hot Dip Galvanizing with thickness as per ISO 1461, Surface preparation over galvanization as per SSPC SP 16 & ISO 12944-4; 1 coat of F-6B @ 100µ DFT/coat + 1 coat of F-2 @ 40 microns DFT/coat	140µ of finish coat (excluding the thickness of galvanizing)	Special primers like etch primer may also be considered for coating on galvanized surfaces

Notes for Table-4:

1. F-6B shall be modified type and suitable for coating over galvanization.
2. Repair of the damaged areas of galvanized coatings due to welding during erection shall be carried out as per recommended practice ISO 1461, using cold galvanizing spray process. Organic paint systems are not acceptable for the repair.
3. After repair of damaged galvanized coating by cold galvanization (P-7), the repaired area shall be top coated with paint system as given in table-4 above (i.e. 1 coat of F-6B @ 100µ DFT/coat + 1 coat of F-2 @ 40µ DFT/coat).
4. Galvanized gratings don't require painting in general until otherwise specified elsewhere or as per the requirement of the OWNER. Galvanized items may require painting to meet the colour coding requirement of the OWNER. Contractor has to ensure the applicable colour coding prior to application of coating as per this clause.

TABLE-5: COATING SYSTEM FOR INLAND PLANTS (OFFSITES & UTLITIES)

(For all un-insulated above ground CS, LTCS & Alloy steel piping, equipment, structures, valves, Vessels & columns, stacks etc.)

Sl. No.	Design Temp. in °C	Surface Preparation & Pre-erection/Shop Primer	Coating System		Total Final DFT in Microns (min.)	Remarks
			Primer	Finish Coat		
5.1	-45 to -15	SSPC-SP-10; 1coat of F-9 @ 65-75µ DFT/coat	-	-	65-75	a. No over-coating shall be done on F-9. b. Surface profile for F-9
5.2	-16 to 80	SSPC-SP-10; 1coat of F-9 @ 65-75µ DFT/coat	1 coat of P-6 @ 40 µ DFT/coat	1coat of F-6B @ 100 µ DFT/coat+ 1 coat of F-2 @ 40µ DFT/coat	245-255	

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5.3	81 to 250	SSPC-SP-10; 1coat of F-9 @ 65-75µ DFT/coat	-	2 coats of F-11 @ 20µ DFT/coat (2x20=40)	105-115	shall be 30-40 µm c. F-12 shall be ambient temperature curing type
5.4	251 to 400	SSPC-SP-10; 1coat of F-9 @ 65-75µ DFT/coat	-	2 coats of F-12 @ 20µ DFT/coat (2x20=40)	105-115	
5.5	401-650	SSPC-SP-10; 1 coat of F-16 @ 125 µ	-	1 coat of F-16 @ 125 µ	250-300	-

TABLE-6: COATING SYSTEM FOR CORROSIVE AREAS (PROCESS UNITS, COOLING TOWER, DM AND CPP etc.)

(For all un-insulated above ground CS, LTCS & Alloy steel piping, equipment, structures, valves, vessels & columns, furnace stacks etc.)

Sl. No.	Design Temp. °C	Surface Preparation & Pre-erection/Shop Primer	Coating System		Total DFT in Microns (min.)	Remarks
			Primer	Finish Coat		
6.1	-45 to -15	SSPC-SP-10; 1coat of F-9 @ 65-75µ DFT/	-	-	65-75	a)No over coating on F-9 is allowed b) F-12 shall be ambient temperature curing type c) Surface profile for F-9 shall be 30-40 µm
6.2	-16 to 80	SSPC-SP-10; 1coat of F-9 @ 65-75µ DFT/ coat	1 coat of P-6 @ 40 µ DFT/ coat	2 coats of F-6B @ 100 µ DFT/coat + 1 coat of F-2 @ 40µ DFT/coat (2x100 + 40= 240)	345-355	
6.3	81 to 400	SSPC-SP-10; 1coat of F-9 @ 65-75µ DFT/ coat	-	2 coats of F-12 @ 20µ DFT/coat 2x20=40	105-115	
6.4	401-650	SSPC-SP-10; 1 coat of F-16 @ 125 µ	-	1 coat of F-16 @ 125 µ	250-300	-

NOTES for TABLE-5 & TABLE-6:

1. The list of items given in the heading of the above table is not exhaustive. There may be more items for a particular contract where these specifications are used. The CONTRACTOR is fully responsible for completing painting including prefabrication primer for all the items supplied and fabricated as per contract document and scope of work.

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2. If the application of pre-erection/pre-fabrication/shop primer has already been completed, the same shall not be repeated in the field. In case the damages to the primer coat are severe and spread over large areas, the Engineer-In-Charge may decide & advise re-blasting and re-application of the primer coat. Repair of pre-fabrication/pre-erection primer, if required, shall be done as per Table-3.

3. Flare line within unit or offsite areas shall be coated as per clause 6.3 of Table-6.

4. For external surface of RCC Chimney, 2 coats of F-6 B@ 100µ DFT/coat to obtain a total DFT of 200 µ shall be applied after proper surface preparation as per guidelines in clause 4.6.

TABLE-7: COATING SYSTEMS FOR EFFLUENT TREATMENT PLANT (ETP)

Sl. No.	Design Temp. in °C	Surface Preparation	Coating system		Total DFT in Microns (min.)	Remarks
			Primer	Finish Coat		
7.1	For external surfaces of steel items: screens, walk way bridges, clarifier/thickener scrapping mechanism, baffles, Media filters/vessels (PSF, DMF, MMF, & ACF etc.), vertical pumps, CS/MS tanks/ vessels and structures.					
	-14 to 80	SSPS-SP-10	1 coat of F-9 @ 65-75µ DFT/coat	2 coats of F-6B @100µ DFT/coat + 1 coat of F-2 @ 40µ DFT/coat (2x100+40= 240)	305	-
7.2	For internal surfaces of steel items: all effluent handling units such as TPI, DAF, tube settlers, clarifiers, tanks, sludge tanks and sewage tank, wet slop oil tanks etc., scrapping mechanism in clarifier etc.					
	-14 to 80	SSPS-SP-10	1 coat of F-15 @ 80µ DFT/coat.	2 coats of F-15 @180µ DFT/coat (2x80=160)	240	-
7.3	All R.C.C./concrete surfaces exposed to effluent water / liquid such as tanks, structures, drains etc., all effluent handling units such as API, TPI, DAF, tube settlers, clarifiers, tanks, sumps, sludge sumps/tanks and sewage sumps/tank, wet slop oil sump/tanks etc.					
	-14 to 80	As per clause 4.6 of this specification	Epoxy screed lining		3000	Note 1
7.4	Internal surface of equipment like Media filters/vessels (PSF, DMF, MMF, & ACF etc.), activated carbon filters, alkaline, acids & other high corrosive service					
	Up to 90	SSPC-SP-10	1 coat of clear two component solvent free vinyl ester primer @ 100µ DFT/ Coat + 2 coats of F-20 @ 500µ DFT/ Coat		1100	Note-2

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NOTES for TABLE-7:

1. Contractor shall follow manufacturer recommendations to develop epoxy screed lining procedure for EIL review and approval.
2. This coating system is applicable in conjunction with relevant PDS of the equipment.

TABLE-8: EXTERNAL COATING SYSTEMS FOR CARBON STEEL AND LOW ALLOY STEEL STORAGE TANKS

Sl. No.	Design Temp. in °C	Surface Preparation	Coating system (Note-1)		Total DFT in Microns (min.)	Remarks
			Primer	Finish Coat		
8.1	All external surfaces of shell, wind girders, appurtenances, roof tops of all above ground tank including top side of external and internal floating roof and associated external structural works.					
8.1.1	-14 to 80	SSPC-SP-10	1coat of F-9 @ 65-75µ DFT/coat + 1coat of P-6 @ 40µ DFT/ coat	2 coats of F-6B @ 100µ DFT /coat + 1 coat of F-2 @ 40µ DFT/ coat	345-355	-
8.1.2	81 to 450	SSPC-SP-10	1coat of F-9 @ 65-75µ DFT/coat	1 coat of F-16 @ 125 µ DFT / coat	190-200	
8.2	External surfaces of bottom plate (in contact with soil) for all storage tanks.					
8.2.1	-14 to 80	SSPC-SP-10	1 coat of F-9 @ 65-75µ DFT/ coat	3 coats of F-7@ 150µ DFT/coat (3x150=450)	515-525	-
8.2.2	81 to 200	SSPC-SP-10	1 coat of F-17 primer @ 400µ DFT/ coat	1 coat of F-17 finish coat @ 400µ DFT/ coat	800-825	Note-4
8.3	For underside of the bottom plate (not in contact with soil)(in case tank is not lifted during PWHT) (Note- 2)					
8.3.1	-29 to 400	SSPC SP-10	1 coat of F-16 @ 125 µ	1 coat of F-16 @ 125 µ	250-300	Note-3

Notes for TABLE-8:

1. All paint coating application including primer for tanks shall be carried out at field after erection and completion of entire welding.

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2. For underside of bottom plate as per clause no.8.3.1:

   a) Painting shall be carried out before laying the bottom plate for tanks with non-Post Weld Heat Treatment (PWHT).

   b) For tanks with PWHT, painting shall be carried out after PWHT.

   c) In case tank is not lifted during PWHT then painting shall be applied before laying the bottom plate.

3. This coating system is also applicable for temperature ranges not covered in 8.2 above.

4. This coating system is also applicable for bottom plates having MOC as Stainless Steel.

TABLE-9: INTERNAL COATING SYSTEMS FOR CARBON STEEL AND ALLOY STORAGE TANKS

Sl. No.	Design Temp. in °C	Surface Preparation	Coating system		Total DFT in Microns (min.)	Remarks
			Primer	Finish Coat		
9.1	Internal side of bottom plate and first shell course of Crude oil tanks					
9.1.1	-14 to 90	SSPC-SP-10	1 Coat of F-6A @ 100 µ DFT/coat	1 Coat of F-6C @ 400 µ DFT/coat	500	-
9.2	Underside of floating roof, internal surfaces of shell for full height above first course, oil side surfaces of deck plates, oil side surfaces of pontoons, support structures, roof legs, drain pipes and ladders etc. of crude oil tanks					
9.2.1	-14 to 90	SSPC-SP-10	1 coat of F-15 primer @ 80µ DFT/ coat	1 coat of F-15 intermediate coat @ 80µ DFT/coat + 1 coat of F-15 finish coat @ 80µ DFT/ coat	240	-
9.3	All internal surfaces of hydrocarbon, slops, amine solutions, sour water and other hydrocarbon-water solutions tanks but not limited to: Underside of floating roofs, internal surface of cone roof, inside of bottom plate, internal surfaces of shell for full height, underside of floating roof, oil side surfaces of deck plates, oil side surfaces of pontoons, support structures, roof legs, drain pipes and ladders etc.					
9.3.1	-14 to 45	SSPC-SP-10	1 coat of F-9 @ 65-75 µ DFT/coat	-	65-75	-

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9.3.2	46 to 90	SSPC-SP-10	1 coat of F-15 primer @ 80µ DFT/ coat	1 coat of F-15 intermediate coat @ 80µ DFT/coat + 1 coat of F-15 finish coat @ 80µ DFT/ coat	240	-
9.3.3	91 to 200	SSPC-SP-10	-	1 coat of F-17 @ 400µ DFT/coat	400	-
9.4	Potable, Raw & Fire water, De-mineralized (DM) water & Condensates etc. All internal surfaces but not limited to internal surfaces of shell for full height, bottom plate, accessories, roof and roof structures of cone and dome roof tanks etc.					
9.4.1	-14 to 60	SSPC-SP-10	1 Coat of F-6A @ 100µ DFT/coat	1 coat of F-6C @ 300-350 µ DFT/ coat	400-450	-
9.4.2	61 to150	SSPC-SP-10	1 coat of F-15 primer @ 80µ DFT/ coat	1 coat of F-15 intermediate coat @ 80µ DFT/coat + 1 coat of F-15 finish coat @ 80µ DFT/ coat (80+80=160)	240	-
9.5	Hydrochloric acid (HCl) 10 %: All internal surfaces but not limited to internal surfaces of shell for full height, bottom plate, accessories, roof and roof structures of cone and dome roof tanks etc.					
9.5.1	-14 to 60	SSPC-SP-10	1 Coat of clear two component solvent free vinyl ester primer @ 100µ DFT/ Coat	2 Coats of F-20 @ 500µ DFT/ Coat	1100	-
9.6	Aggressive solvents like hexane, hexene, benzene, xylene and toluene etc.: All internal surfaces but not limited to internal surfaces of shell for full height, bottom plate, accessories, roof and roof structures of cone and dome roof tanks etc.					
9.6.1	-14 to 65	SSPC-SP-10	1 coat of F-9 @ 65-75µ DFT/ coat	-	65-75	-
9.7	Ethylene glycol tanks: All internal surfaces but not limited to internal surfaces of shell for full height, bottom plate, accessories, roof and roof structures of cone and dome roof tanks etc.					
9.7.1	All	SSPC-SP-10	-	3 coats of vinyl chloride co-polymer @ 75µ /Coat; (3x75=225)	225	-
9.8	Inside pontoon and inside of double deck of all floating roofs					
9.8.1	-14 to 80	SSPC-SP-3	1 coat of F-8 @ 100µ DFT/coat	1 coat of F-8 @ 100µ DFT/coat	200	-

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9.8.2	81 to150	SSPC-SP-10	1 coat of F-15 primer @ 80µ DFT/ coat	1 coat of F-15 intermediate coat @ 80µ DFT/coat + 1 coat of F-15 finish coat @ 80µ DFT/ coat (80+80=160)	240	-
9.8.3	151 to 200	SSPC-SP-10	-	1 coat of F-17 @ 400µ DFT/coat	400	-
9.9	Alkalis up to 50 % concentration: All internal surfaces but not limited to internal surfaces of shell for full height, bottom plate, accessories, roof and roof structures of cone and dome roof tanks etc.					
9.9.1	Up to 60°C	SSPC-SP-10	1 coat of F-15 primer @ 80µ DFT/ coat	2 Coats of F-6 A @ 100µ DFT/coat (2x100=200)	280	-

General Note for Table-9: The list of surfaces to be painted are not exhaustive. All internal surfaces of all type of tanks including structural items shall be coated as per the above table. No CS surface shall be kept un-painted.

TABLE-10: COATING SYSTEMS FOR EXTERNAL SIDE OF UNDERGROUND CARBON STEEL PLANT PIPING AND VESSELS

Sl. No.	Design Temp. in °C	Surface Preparation & Shop Primer	Coating system		Total DFT in Microns (min.)	Remarks
			Surface Preparation & Primer	Finish Coat		
10.1	Underground carbon steel plant piping.					
10.1.1	25 to 65	-	SSPC-SP-10; 1 coat of synthetic fast drying primer 25 @µ DFT/ coat	1 layer of coal tar tape coating @ 2mm +1 coat of synthetic fast drying primer @25 µ DFT/ coat + 1 layer of coal tar tape coating @ 2mm /layer as per 6-79-0011 Latest revision	4 mm	The primer DFT is not measurable. Re-conciliation primer shall be done by coverage of maximum 10 sq.m/litre
10.1.2	61 to 200	-	SSPC-SP-10; 1 coat of F-17 primer @400 µ DFT/ coat	1 coat of F-17 @ 400 DFT/coat	800	-

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10.2	External side of underground storage vessels					
10.2.1	-45 to 80	SSPC-SP -10; 1 coat of F-9 @ 65-75µ DFT/ coat	-	3 coats of F-7 @ 100µ DFT/coat	365-375	-
10.2.2	81 to 200	SSPC-SP -10	1 coat of F-17 primer @400 µ DFT/ coat	1 coat of F-17 @400µ DFT/ coat	800	-

TABLE-11: COATING SYSTEMS FOR UNDER INSULATION (ALL UNIT AREAS & OFFSITES)
(For insulated piping, equipment, storage vessels, tanks, columns etc. of CS, LTCS, Alloy steel, SS, DSS and SDSS in all environments.)

Sl. No.	Design Temp. °C	Surface Preparation & Pre-erection/Shop Primer	Coating system		Total DFT Microns (min.)	Remarks
			Primer	Finish paint		
11.1	Carbon steel, LTCS and Alloy steel Piping, Storage tanks, Vessels, Equipment etc.					
11.1.1	-45 to 125	SSPC-SP-10; 1coat of F-15 @ 75µ DFT/coat	None	2 coats of F-15 @75µ DFT/coat	225	Note 1
11.1.2	126 to 450	SSPC-SP-10; 1 coat of F-16 @ 125µ DFT/coat	None	1 coat F-16 @ 125µ DFT/coat	250	
11.2	Stainless Steel, Duplex Stainless steel, Super Duplex stainless steel & Piping, Tanks, Vessels & Equipment etc.					
11.2.1	-45 to 125	SSPC-SP-16; (15-25µ surface profile) 1 coat of F-15 @75 µ DFT/coat	None	2 coats of F-15 @75µ DFT/coat	225	Note 1
11.2.2	126 to 650	SSPC-SP-16; (15-25µ surface profile) 1 coat of F-16 @125µ DFT/coat	None	1 coat of F-16 @125µ DFT/coat	250	

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11.3	Cyclic service of CS, LTCS, SS, DSS, SDSS & Alloy Steels (Note-1)					
11.3.1	-45 to 150 (Note-1)	SSPC-SP-10 For CS, LTCS & Alloy steel. SSPC-SP-16 for SS; (15-25µ surface profile) 1 coat of F-15 @75 µ DFT/coat	None	2 coats of F-15 @75µ DFT/coat	225	Note-2&3
11.3.2	-180 to 650	SSPC-SP-10 for CS, LTCS & Alloy steel. SSPC-SP-16 for SS (15-25µ surface profile) 1 coat of F-16 @ 125µ DFT/coat	None	1 coat of F-16 @ 125µ DFT/coat	250	-

Notes

1. Coating system for any other design temperature range not covered in Sr. No. 11.1 & Sr. No. 11.2 shall be as per Sr. No. 11.3.2.
2. In case of overlapping of cyclic temperature ranges as mentioned in 11.3.1 and 11.3.2 then clause 11.3.1 shall be followed.
3. Alternatively, for this temperature range, 1 coat of F-17 @ 400 µ is also acceptable.

General notes for TABLE-11:

1. "Cyclic Service" is characterized by rapid or periodical temperature fluctuation or temperature cycles or as defined in the process datasheet.
2. The blasting abrasives for SS and alloy steels shall be aluminum oxide or garnet only.
3. The coating system applicable for any other temperature range shall be reviewed if it is encountered.

TABLE-12: INTERNAL COATING SYSTEMS FOR WATER SIDE COMPONENTS OF CS, SS, DSS & NON-FERROUS HEAT EXCHANGERS

Sl. No.	Design Temp. in °C	Surface Preparation & Pre-erection/Shop Primer	Coating System		Total Final DFT in Microns (min.)	Remarks
			Primer	Finish paint		
12.1	Up to 80	SSPC-SP-10 for CS and SSPC-SP-16 for SS	1 coat of F-15 @ 80 µ DFT/coat	2 coats of F-15 @ 80 80 µ DFT/coat	240	-

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12.2	81 to 200	SSPC-SP-10 for CS and SSPC-SP-16 for SS	-	2 coats of F-17@ 400µ/coat	800	-

Note for Table-12:

1. Coating systems are applicable as per requirement specified in the data sheets of the respective exchangers or equipment.

GENERAL NOTES FOR TABLE: 5 TO 12

1. For uninsulated or insulated items, scope of surface preparation, application of primers to finish coat including repair shall be as per applicable contractual documents like SOR, MR, and PR etc. The list of items are not exhaustive.

8.0 GUIDELINES FOR STORAGE & HANDLING

8.1 All paints and painting materials shall be stored in rooms only which are to be arranged by CONTRACTOR and approved by Engineer-In-Charge for the purpose. All necessary precautions shall be taken to prevent fire. The storage building shall preferably be separate from adjacent building. A signboard bearing the word "PAINT STORAGE- NO NAKED LIGHT-HIGHLY INFLAMMABLE" shall be clearly displayed outside. Manufacturers' recommendation /Materials safety datasheet shall be followed for storage and handling of paint materials.

Note: This standard doesn't address all the safety concerns if any, associated with its use. It is responsibility of the user of this standard to establish appropriate safety and health practice and determine the applicability of regulatory limitations prior to use.

9.0 COLOUR CODE

The colour coding system as per Annexure-1 of this specification shall be followed. However, OWNER's colour code prevails, if available. It is the CONTRACTOR's responsibility to obtain the same.

9.1 Identification

The system of colour coding consists of a ground colour and secondary colour bands superimposed over the ground colour. The ground colour identifies the basic nature of the service and secondary colour band over the ground colour distinguishes the particular service. The ground colour shall be applied over the entire length of the un-insulated pipes. For insulated lines, ground colour shall be provided as per specified length and interval to identify the basic nature of service and secondary colour bands to be painted on these specified length to identify the particular service. Above colour code is applicable for both unit and offsite pipelines.

9.2 Ground colour

On un-insulated pipes, the entire pipe has to be painted in ground colour. On metal cladded insulated lines, minimum 2 m long portion should be painted.

9.3 Colour bands

9.3.1. Location of colour bands:

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a. At battery limits.
b. Intersection points & change of direction points in piping.
c. Midway of piping section, near valves, across culverts.
d. At 50 m interval on long stretch pipes.
e. At starting and termination points.

9.3.2. Minimum width:

NB	Width
3" and below	75 mm
Above 3" to 6"	NB X 25 mm
Above 6" to 12"	NB X 18 mm
Above 12"	NB X 15 mm

For insulated pipes, NB indicates OD of the insulation.

Sequence: Colour bands shall be arranged in sequence as shown above and the sequence follows the direction of flow. The width of the 1st Band to 2nd band is 4:1.
Wherever deemed required by process department or safety, pipes handling hazardous substances will be given hazard marking of 30 mm wide diagonal stripes of black and golden yellow.

9.4 Identification markings on equipment/piping

Equipment tag numbers shall be stenciled/neatly painted using normal 'Arial' lettering style on all equipment and piping (both insulated & un-insulated) after completion of all paint works. Lettering colour shall be either black or white, depending upon the background, so as to obtain good contrast.

Operations group shall specify the location of the marking.

Size of the making shall be as follows:

Columns, vessels, heaters	: 150 mm
Pumps and other machinery	: 50 mm
Piping	: OD / 2 with maximum 100 mm
Storage tanks	: (as per drawings)

9.5 Colour coding for control valve

a) Carbon steel body : Signal grey (RAL7004)
Alloy steel body : Golden yellow (RAL1004)
Stainless steel body : Natural

b) The actuator of the control valve shall be painted as:

Direct action (open on-air failure) valves : Traffic Green (RAL 6024)
Reverse acting (close on-air failure) valves: Traffic Red (RAL 3020)

The painting status shall be comprehensively updated every 6 months for compliance.

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10.0 IDENTIFICATION OF VESSELS, PIPING ETC.

10.1 Equipment number shall be stenciled in black or white on each vessel, column, equipment & machinery (insulated or un-insulated) after painting. Line number in black or white shall be stenciled on all the piping of more than one location as directed by Engineer-In-Charge. Size of letter printed shall be as below:

Column & vessels	:	150 mm (high)
Pump, compressor & other machinery:		50 mm (high)
Piping	:	40-150 mm

10.2 Identification of storage tanks

The storage tanks shall be marked as detailed in the drawing.

11.0 PAINTING FOR CIVIL DEFENCE REQUIREMENTS

Painting for civil defense is a specific requirement and should be applicable as per instructions of OWNER and competent government authorities.

11.1 The following items shall be painted for camouflaging, if required by the client:

a. All columns
b. All tanks in offsite
c. Large vessels
d. Spheres

11.2 Two coats of selected finishing paint as per defense requirement shall be applied in a particular pattern as per clause 11.3 and as per the instructions of Engineer-In-Charge.

11.3 Method of camouflaging

a. Disruptive painting for camouflaging shall be done in three colours in the ratio of 5:3:2 (all matte finish).

Dark Green		Light Green		Dark Medium Brown
5	:	3	:	2

b. The patches should be asymmetrical and irregular.
c. The patches should be inclined at 30° to 60° to the horizontal.
d. The patches should be continuous where two surfaces meet at an angle.
e. The patches should not coincide with the corners.
f. Slits and holes shall be painted in dark shades.
g. Width of patches should be 1 to 2 m.

12.0 QUALITY CONTROL, INSPECTION AND TESTING

12.1 All painting materials including primers and thinners brought to site by CONTRACTOR for application shall be procured directly from manufactures as per specifications and shall be accompanied by manufacturers' test certificates. Paint formulations without certificates are not acceptable (see section 14.0 & 15.0).

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12.2 The CONTRACTOR must produce test certificate from pre-qualified paint manufacturer for various tests as detailed out in section 15.0 of this document. The Engineer-In-Charge, in consultation with SMMS, shall have the right to test wet samples of paint at random for verifying quality of paint supplied. CONTRACTOR shall arrange to have such tests, as instructed, performed at his cost at any one of the NABL accredited laboratories under a TPI agency.

Samples for the test will be drawn at random in presence Engineer-In-Charge or his representations. Following tests to be carried out if called:

a. Specific Gravity
b. % solids by weight (% zinc content in case of inorganic or organic zinc primer)
c. Drying time (touch dry & full curing)
d. Adhesion test on a test panel prepared at the site (ASTM D 6677).

Test methods for above tests shall be as per relevant ASTM or ISO Standard.

12.3 The painting work shall be subject to inspection by Engineer-In-Charge at all times. In particular, following stage-wise inspection will be performed and CONTRACTOR shall offer the work for inspection and approval of every stage before proceeding with the next stage. The record of inspection shall be maintained in the registers. Stages of inspection are as follows:

a. Surface preparation
b. Primer application
c. Each coat of paint

12.3.1 Following tests are to be carried out during surface preparation:

a. Test for presence of oil/grease and contamination

The steel substrate after degreasing as per SSPC-SP-1 shall be tested as per following procedure to validate absence of oil and grease contamination:

- Visual inspection - continue degreasing until all visible signs of contamination are removed.
- Conduct a solvent evaporation test by applying several drops or a small splash of residue-free tri-chloromethane on the suspect area especially pitting, crevice corrosion areas or depressed areas. An evaporation ring formation is indicative of oil and grease contamination. Continue degreasing and inspection till test is passed.

b. **Tests for surface finish of blasted surface** shall be done by visual inspection using SSPC-VIS1. Clear cellophane tape test as per ISO 8502-3 shall be used to confirm absence of dust on blasted surface. Checks shall be done on each component at least once per 200 m^2 of blasted surface and a minimum of 3 checks per shift.

c. **Test for presence of soluble salt** as per method ISO 8502-9. Maximum allowable salt content shall be considered 20 mg/m^2.Checks shall be done on each component at least once per 200 m^2 of blasted surface and minimum of 3 checks per shift. In case salt exceeds specified limit, the contaminated surface shall be cleaned by method as per Annexure-C of ISO 12944-4 (water cleaning). After cleaning, surface shall be retested for salt after drying.

d. **Blast Profile Measurement**: (In-Process testing during actual production before application coating). The angular profile depth measurement shall be done by profile tape as per method

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ASTM D 4417 method B (Profile depth gauge micrometer)/ calibrated Digital gauge meter. Spot measurement shall be carried out every 15m^2 of blasted surface. At each spot three measurements shall be taken over an area of 10 cm^2 and average of measurements to be recorded and reported. If profile is less than specified range, blasting shall continue till greater specified depth profile is achieved.

e. **Tests for blasting media:** Blasting Media (For every fresh batch of media and one random test during blasting). Blasting Media shall be visually inspected for absence of contamination and debris using 10 X magnification.

- Inspection for the absence of oil contamination shall be conducted using following procedure :
  - Fill a small clean 200 ml bottle half full of abrasive.
  - Fill the bottle with potable water, cap and shake the bottle.
  - Inspect water for oil film/slick. If present, the blasting media is not to be used.

- Soluble salt contamination if suspected shall be verified by method ASTM D 4940. If present, media to be replaced.

- Clean blasting equipment, especially pot and hoses, and then replace blasting media and retest.

f. **Test for Blasting Air** (Once Daily before start of blasting and once at random during Blasting). The air for blasting shall be free from moisture and oil. The compressor air shall be checked for oil and water contamination per ASTM D 4285.

In addition to above, record should include type of shop primer already applied on equipment e.g. zinc silicate or zinc rich epoxy or zinc phosphate. Any defect noticed during the various stages of inspection shall be rectified by the CONTRACTOR to the entire satisfaction of Engineer-In-Charge before proceeding further. Irrespective of the inspection, repair and approval at intermediate stages of work, CONTRACTOR shall be responsible for rectifying any defects found during final inspection/guarantee period/defect liability period as defined in general conditions of the contract. Dry film thickness (DFT) shall be checked and recorded after application of each coat and extra coat of paint should be applied to make-up the DFT specified without any extra cost to OWNER, the extra coat should have prior approval of Engineer-in-charge.

12.4 Final inspection of finished coating shall consist of the following:

a. **Coating DFT & WFT check:** DFT measurement shall be as per ISO 2808. Type-II electronic gauge shall be used as described in ASTM D7091. DFT gauge calibration, adjustment of gauge coating thickness, frequency and number of coating thickness measurement shall be as per ASTM D7091 and SSPC-PA2. Measured DFT shall have a tolerance as per SSPC-PA-2 level-3 of the dry film thickness, specified in this specification. Once in every layer of coating application, spot checks of WFT shall be carried out during the coating application according to ISO 2808, Method No. 1A- comb gauge. This is to ensure that film thickness is being achieved as per the specification.

b. **Adhesion testing:** Adhesion of the primer to the steel substrate and inter-coat adhesion of the subsequent coat(s) after curing for at least a week after application of the topcoat shall be examined by a knife test in accordance with ASTM D6677. For the knife test, if the rating is better than 8, the adhesion is considered acceptable. The adhesion is destructive and tested areas shall be repaired afterward using the spot repair procedure. Alternatively, the applicator may perform

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the adhesion test on a steel panel coated using the same surface preparation and coating application procedure as the work piece. Adhesion testing shall be carried out for each component at least once per 200 m^2 of coated surface.

c. **Holiday detection check:** Holiday testing of non-conductive coatings shall be carried out in accordance with NACE SP0188. For immersion, buried & under insulation services, 100% of coated area shall be inspected for holidays. For atmospheric exposure, 10% of coated area which must include weld seams, corners and edges to be holiday tested. Voltage at which test is to be carried out will depend upon DFT of coating being tested and shall be as per NACE SP0188. Any holiday is unacceptable and should be marked and repaired immediately.

The CONTRACTOR shall arrange for spot checking of paint materials for specific gravity, glow time (ford cup) and spreading rate.

13.0 PAINT MATERIAL GUARANTEE CERTIFICATE

The CONTRACTOR shall guarantee that the chemical and physical properties of paint materials used are in accordance with the specifications contained herein/to be provided during execution of work and shall submit necessary certificate of the paint material.

14.0 QUALIFICATION CRITERIA OF PAINTING CONTRACTOR/SUB-CONTRACTOR

Painting CONTRACTOR who is awarded any job for EIL, Projects under this standard must have necessary equipment, machinery, tools and tackles for surface preparation, paint application and inspection. The CONTRACTOR must have qualified, trained and experienced surface preparator, paint applicator, inspector and supervisors. The CONTRACTOR supervisor, inspector, surface preparator and paint applicator must be conversant with the standards referred in this specification.

15.0 PRE-QUALIFICATION/ACCEPTANCE CRITERIA FOR PAINT COATING SYSTEM

15.1 Pre-qualification of paint coating manufacturer and their products

Paint manufacturer meeting the following requirements shall be considered by the CONTRACTOR for supply of the paint products.

a) Manufacturer should have been in continuous business of paint coating formulation and manufacturer for at least past 5 years.

b) Manufacturer should possess past experience of supplying his products to hydrocarbon, petrochemical, fertilizer. Chemical processing industry or offshore platforms in the past 5 years.

c) Coating manufacturer should have supplied at least 10000 litre of an individual product to hydrocarbon, petrochemical, fertilizer. Chemical processing industry or offshore platforms.

d) The manufacturer's manufacturing procedure & QA/QC system shall meet ISO 9001 requirements and preferably should possess ISO 14000 certificate.

e) The Quality control set up should be manned by qualified paint technologists whose biodata should be sent along with quality control organization chart.

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The Past Track record of the manufacturers as mentioned above shall be substantiated by providing relevant documents to EIL-SMMS for their review and acceptance. This shall include Work Orders, Purchase orders and ISO 9001 certification covering all the requirements mentioned from bullets a) to e) above.

CONTRACTOR shall procure the paint materials from the qualified manufacturer meeting above requirements and after obtaining prequalification testing approval as per requirements mentioned in clause 15.2 below.

15.2 Pre-Qualification Testing procedure:

The paint manufacturer engaged by the mechanical contractor shall carry out the tests in NABL accredited government laboratories or in suggested list of laboratories below, as a part of qualification. Paint manufacturer shall provide the paint samples to laboratory for testing of the parameters mentioned in Table-2 (typical characteristics) and Table-13 (tests on coating systems) of this specification. The testing laboratory will confirm the compliance of the paint material with respect to the acceptance criteria mentioned in the respective tables. Colored photographs of coated test panels should be taken before and after the test and should be enclosed along with test report. Contractor shall furnish these test certificates along with all necessary supporting documents/information to EIL-SMMS for approval/ acceptance. The paint manufacturer will be qualified and approved by EIL-SMMS for supply of paints after review/assessment of the submissions made by the contractor. Test certificates which are more than 3 years old will not be considered. Paint manufacturers are advised to carryout pre-qualification testing accordingly for paints supply to EIL projects.

List of suggested laboratories:

1. National Test house – Kolkata
2. National Test house-Mumbai
3. HBTU- Kanpur
4. GIRDA (Gujarat Industrial Research & Development Agency)- Vadodara
5. Indian institute of chemical technology – Hyderabad
6. RITES – Kolkata
7. ICT- Mumbai

TABLE-13: PRE-QUALIFICATION TESTING

SYSTEM No.	COATING SYSTEM	REFERENCE CLAUSE (from table-3 to 12)	TOTAL DFT µ (min)
1.	F-9+P6+F6B+F2	6.2	345
2.	F9+F12+F12	6.3	105
3.	F15+F15+F15	9.2.1	240
4.	F16+F16	8.3.1	250
5.	F17	9.3.3	400
6.	F8	3.1	125
7.	F20+F20	9.3.1	1100
8.	F6A+F6C	9.1.1	500
9.	F9+F7+F7+F7	10.2.1	365
10.	F15+F6A+F6A	9.9.1	280

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S. No.	TEST	FOR SYSTEM NUMBER	DURATION	ACCEPTANCE CRITERIA
1.	Cyclic Test Salt Spray : 72 hrs. Drying in air: 16 hrs. UV-A340 nm weather meter: 80 hrs. One cycle: 168 hrs. (25 cycles at 168 hrs. each cycle) (ASTM D5894)	1	4200 hrs.	Shall pass. No chalking, cracking, flaking, blistering or peeling shall be observed.
2.	Chemical Resistance Test (ASTM D543)			
2a.	10% & 40% NaOH	3, 5, 7, 9 & 10	1000 hrs.	Shall pass. No cracking, discoloration, blistering, peeling or softening of film shall be observed.
2b.	5% H2SO4		168 hrs.	
2c.	Xylene		4 weeks	
2d.	Acetone		4 weeks	
2e.	Ethanol		4 weeks	
2f.	Kerosene		4 weeks	
2g.	Sea water		2000 hrs.	
3.	Immersion in DM/DI water @90^0 (ASTM C868)	3, 5, 7, 9 & 10	30 days	No softening, blistering or film damage.
4.	Resistance to DM water using water immersion. (ASTM D870)	8	2000 hrs.	Shall pass. No chalking, cracking, flaking, blistering or peeling.
5.	100% Humidity Test (ASTM D2247)	1 to 10 (except system-2)	1440 hrs.	Shall pass
6.	Thermal Shock Resistance Test; 5 cycles @ 30 minutes in furnace at 120 ° C and 15 minutes in water after quenching in water for each cycle. (ASTM D2485 method A)	2, 3, 4, & 10 (For system-2, testing to be done after heating the panels at 400°C for 2 hrs.)	-	Shall pass

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7.	Cathodic Disbondment Test (ASTM G42 @80°C)	3, 5, 9, & 10	-	Diameter of cathodic Disbondment < 10 mm with 6 mm diameter artificial holiday.
8.	Assessment of Adhesion and artificial ageing as per ISO 19277	3, 4, 5, 9 & 10	-	Shall Pass

Each coating product to be qualified shall be identified by the Specific gravity of base and curing agent (ISO 2811). The identification shall be carried out on the batch, which is used for the pre-qualification testing.

15.3 Information to be furnished during delivery of paint materials:

CONTRACTOR along with delivery of paint material has to furnish following information from paint manufacturer to EIL for acceptance/approval of products:

a) Batch test certificates:

Along with paint products delivery to site from the pre-qualified coating manufacturer, CONTRACTOR has to produce test certificate (from paint manufacturer) for each category of product for the following test items. All test results must mention clearly the batch no. and category of product tested. Tests to be conducted for following properties:

- Specific Gravity
- % solids by weight (% zinc content in case of inorganic or organic zinc primer) ~ ASTM D521.

b) Product information sheet/ technical data sheet for each category of product.
The contractor shall be fully responsible for the quality of the paints products as per prequalification testing. After the paint materials are supplied to site, the supplier shall organize random sampling and testing in a NABL laboratory as per discretion of the Engineer-in-charge in consultation with SMMS. Failing to meet the specified quality requirements may cause rejection of the paint products.

16.0 METHOD OF SAMPLING & DISPATCH FOR LABORATORY TESTING
(Pre-Qualification tests (sec. 15.2), Batch testing (sec. 15.3) and Inspection testing (sec. 12.0))

16.1 Samples of coating materials should be submitted to the laboratory in sealed containers with batch no. and test certificate on regular format of manufacturer's testing laboratory.

16.2 All test panels should be prepared by testing laboratory. Surface preparation for a system shall be done in accordance with this specification. For individual products testing, minimum shall be Sa 2.5. Colour photographs of test panels should be taken before and after the test and should be enclosed along with test report. Sample batch no. and manufacturer's test certificate should be enclosed along with the report. Test report must contain details of observation and rusting if any, as per the testing code.

16.3 Manufacturers should intimate EIL, details of sample submitted for testing, name of testing agency, date, and contact personnel of the testing agency.

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ANNEXURE-1: COLOUR CODE

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SR. No.	SERVICE	RECOMMENDED COLOUR FOR PAINT SYSTEM	RAL COLOUR CODE	
			BASE COLOUR	BAND COLOUR
	HYDROCARBON LINES (UNINSULATED)			
1	CRUDE SOUR	Basalt Grey with 1 deep orange band	7012	2011
2	CRUDE SWEET	Basalt Grey with 1 signal red band	7012	3001
3	LUBE OILS	Basalt Grey with 1 grass green band	7012	6010
4	FLARE LINES	White Aluminum	9006	
5	LPG	Deep Orange with 1 oxide red band	2011	3009
6	PROPYLENE	Deep Orange with 2 Cobalt blue bands	2011	5013
7	NAPTHA	Deep Orange with 1 grass green band	2011	6010
8	M.S.	Deep Orange with 1 Basalt Grey band	2011	7012
9	AV.GASOLINE (96 RON)	Deep Orange with 1 band each of grass green, white and signal red bands	2011 6010	9010 3001
10	GASOLINE (regular, leaded)	Deep Orange with 1 Jet black band	2011	9005
11	GASOLINE (premium, leaded)	Deep Orange with 1 Cobalt blue band	2011	5013
12	GASOLINE (white)	Deep Orange with 1 white band	2011	9010
13	GASOLINE (Aviation 100/130)	Deep Orange with 1 signal red band	2011	3001
14	GASOLINE (Aviation 115/145)	Deep Orange with 1 traffic purple band	2011	4006
15	N-PENTANE	Deep Orange with 2 Cobalt blue bands	2011	5013
16	DIESEL OIL (White)	Oxide red with 1 white band	3009	9010
17	DIESEL OIL (Black)	Oxide red with 1 traffic yellow band	3009	1023
18	KEROSENE	Oxide red with 1 grass green band	3009	6010
19	HY.KEROSENE	Oxide red with 2 grass green bands	3009	6010
20	DISUFIDE OIL (EX-MEROX)	Oxide red with 1 jet black band	3009	9005
21	M.T.O	Oxide red with 3 grass green bands	3009	6010
22	DHPPA	Oxide red with 2 white bands	3009	9010
23	FLUSHING OIL	Oxide red with 2 jet black bands	3009	9005
24	LAB FS	Oxide red with 2 Basalt Grey bands	3009	7012
25	LAB RS	Oxide red with 3 Basalt Grey bands	3009	7012

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26	LAB (Off. Spec)	Oxide red with 1 light grey band	3009	7035
27	N-PARAFFIN	Oxide red with 1 Cobalt blue band	3009	5013
28	HEAVY ALKYLATE	Oxide red with signal red band	3009	3001
29	BLOW DOWN, VAPOR LINE	Off white / Aluminum with 1-Brown band	9006	8004
30	BLOWDOWN	Off white / Aluminum with 2 copper brown bands	9006	8004
31	A.T.F.	Clay Brown with 1 white band	8003	9010
32	TOULENE	Clay Brown with 1 traffic yellow band	8003	1023
33	BENZENE	Clay Brown with 1 grass green band	8003	6010
34	LAB PRODUCT	Clay Brown with 1 Cobalt blue band	8003	5013
35	FUEL OIL	Jet Black with 1 traffic yellow band	9005	1023
36	FULE OIL (Aromatic rich)	Jet Black with 2 traffic yellow bands	9005	1023
37	ASPHALT	Jet Black with 1 white band	9005	9010
38	SLOP AND WASTE OILS	Jet Black with 1 deep orange band	9005	2011
39	SLOP AROMATICS	Jet Black with 2 deep orange bands	9005	2011
		CHEMICAL LINES		
40	TRI-SODIUM PHOSPHATE	Lemon Yellow with 1 violet blue band	1012	5000
41	CAUSTIC SODA	Lemon Yellow with 1 jet black band	1012	9005
42	SODIUM CHLORIDE	Lemon Yellow with 1 white band	1012	9010
43	AMMONIA	Lemon Yellow with 1 Cobalt blue band	1012	5013
44	CORROSION INHIBITOR	Lemon Yellow with 1 Aluminum band	1012	9006
45	HEXAMETA PHOSPHATE	Lemon Yellow with 2 jet black bands	1012	9005
46	ACID LINES	Golden Yellow with 1 signal red band	1004	3001
47	RICH AMINE	Lemon Yellow with 2 Cobalt blue bands	1012	5013
48	LEAN AMINE	Lemon Yellow with 3 Cobalt blue bands	1012	5013
49	SOLVENT	Lemon Yellow with 1 grass green band	1012	6010
50	LCS	Lemon Yellow with 1 Blue Grey	1012	7031
		WATER LINES		
51	RAW WATER	Sky blue with 1 jet black band	5015	9005
52	INDUSTRIAL WATER	Sky blue with 2 signal red band	5015	3001

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53	TREATED WATER	Sky blue with 1 oxide red band	5015	3009
54	DRINKING WATER	Sky blue with 1 grass green band	5015	6010
55	COOLING WATER	Sky blue with 1 light brown band	5015	1011
56	SERVICE WATER	Sky blue with 1 signal red brown	5015	3001
57	TEMPERED WATER	Sky blue with 2 grass green bands	5015	6010
58	DM WATER	Sky blue with 1 aluminum band	5015	9006
59	DM WATER ABOVE 150°F	Sky blue with 2 jet black bands	5015	9005
60	SOUR WATER	Sky blue with 2 traffic yellow bands	5015	1023
61	STRIPPED WATER	Sky blue with 2 Cobalt blue bands	5015	5013
62	ETP TREATED WATER	Sky blue with 2 oxide red bands	5015	3009
	FIRE PROTECTION SYSTEM (ABOVE GROUND)			
63	FIRE WATER FOAM & EXTINGUISHERS	Carmine Red	3002	
	AIR & OTHER GAS LINES (UNINSULATED)			
64	SERVICE AIR	Yellow green with 1 signal red band	6018	3001
65	INSTRUMENT AIR	Yellow green with 1 jet black band	6018	9005
66	NITROGEN	Yellow green with 1 deep orange band	6018	2011
67	FREON	Yellow green with 1 traffic yellow band	6018	1023
68	CHLORINE	Lemon Yellow with 1 oxide red band	1012	3009
69	SO_2	Lemon Yellow with 2 white bands	1012	9010
70	H_2S	Deep Orange with 2 oxide red bands	2011	3009
71	GAS (Fuel)	Deep Orange with 1 aluminum band	2011	9006
72	GAS (Sour)	Deep Orange with 2 aluminum bands	2011	9006
73	GAS (Sweet)	Deep Orange with 2 signal red band	2011	3001
74	HYDROGEN	Deep Orange with 1 Pale green band	2011	6021
	STEAM AND CONDENSATE LINES (UNINSULATED)			
75	HP STEAM	White Aluminum with 1 traffic yellow band	9006	1023
76	MP STEAM	White Aluminum with 1 signal red band	9006	3001
77	MLP STEAM	White Aluminum with 1 orange band	9006	2011

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78	LP STEAM	White Aluminum with 1 light green band	9006	6021
79	CONDENSATE	Sky blue with 1 white band	5015	9010
80	CONDENSATE ABOVE 150°F	Sky blue with 3 oxide red band	5015	3009
81	BFW	Sky blue with 2 signal red bands	5015	3001
Note: For all insulated steam lines, the colour coding shall be followed as given for un-insulated lines with the specified length of colour bands.				
INSULATED HYDROCARBON PIPING				
82	IFO SUPPLY	Jet Black ground colour with 1 traffic yellow band in centre	9005	1023
83	IFO RETURN	Jet Black ground colour with 1 grass green band in centre	9005	6010
84	HPS	Jet Black ground colour with 1 signal red band in centre	9005	3001
85	BITUMEN	Jet Black ground colour with 2 signal red bands in centre	9005	3001
86	CLO	Jet Black ground colour with 1 brown band in centre	9005	8004
87	VB TAR	Black ground colour with 2 copper brown bands in centre	9005	8004
88	VR AM (BITUMEN / VBU FEED)	Jet Black ground colour with 1 Cobalt blue band in centre	9005	5013
89	VR BH	Black ground colour with 2 Cobalt blue bands in centre	9005	5013
90	VAC. SLOP	Black ground colour with 1 white band in centre	9005	9010
91	SLOP	Black ground colour with 1 deep orange band in centre	9005	2011
92	CRUDE SWEET	Basalt Grey ground colour with 1 signal red band in centre	7012	3001
93	CRUDE OUR	Basalt Grey ground colour with 1 deep orange band in centre	7012	2011
94	VGO / HCU	Oxide red ground colour with 2 iron grey bands in centre	3009	7011
95	OHCU BOTOM / FCCU FEED	Oxide red ground colour with 2 iron grey bands in centre	3009	7011
UNINSULATED EQUIPMENT, TANKS AND STRUCTURES				
96	HEATER STRUCTURE	Iron grey	7011	
97	HEATER CASING	White Aluminum	9006	
98	VESSELS & COLUMNS	White Aluminum	9006	
99	HYDROGEN BULLETS	Antique Pink	3014	
100	LPG VESSELS	Oxide red	3009	

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101	SO_2 VESSEL	Lemon Yellow	1012	
102	HEAT EXCHANGER	White Aluminum	9006	
103	FO TANK AND HOT TANKS	Jet Black	9005	
104	ALL OTHER TANKS	White Aluminum	9006	
105	CAUSTIC / AMINE / ACID TANKS	Golden yellow	1004	
106	SOUR WATER	Sky Blue	5015	
107	OUTER SURFACE IN BOILER HOUSE	Aluminum	9006	
108	COMPRESSORS AND BLOWERS	Basalt Grey	7012	
109	PUMPS	Pigeon Blue	5014	
110	MOTORS & SWITCH GEAR	Pastel Blue	5024	
111	HAND RAILING	Signal red	3001	
112	STAIRCASE, LADDER AND WALKWAYS	Jet Black	9005	
113	LOAD LIFTING EQUIPMENT AND MONORAILS ETC	Clay Brown	8003	
114	GENERAL STRUCTURE	Jet Black	9005	
115	FLUE GAS STACK	Jet Black	9005	
	PIPES AND FITTINGS OF ALLOY STEEL AND SS MATERIAL IN STORE			
115	IBR	Signal red	3001	
116	9Cr-1Mo	Pale Green	6021	
117	5Cr-0.5Mo	Light Blue	5012	
118	$2_{1/4}$Cr-1 Mo	Luminous Yellow	1026	
119	$1_{1/4}$Cr-½ Mo	Traffic Yellow	1023	
120	SS-304	Grey Blue	5008	
121	SS-316	Blue Lilac	4005	
122	SS-321	Pigeon Blue	5014	
	SAFETY COLOUR SCHEMES			
123	DANGEROUS OBSTRUCTION	Jet Black and Bright Red Orange band	9005	2008
124	DANGEROUS OR EXPOSED PARTS OF MACHINERY	Bright Red Orange	2008	

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मानक विनिर्देशन
सिविल एवं संरचनात्मक कार्य

STANDARD SPECIFICATION
CIVIL & STRUCTURAL WORKS

सामग्री
MATERIALS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
7	13.03.25	UPDATED & REISSUED	MI	AJS	ANURAG SINHA	M. NANDI
6	25.02.21	UPDATED & REISSUED	TK	AJS	AS	S.MAZUMDAR
5	16.05.16	UPDATED & REISSUED	MK	AJS	RS	R.NANDA
4	21.08.14	UPDATED & REISSUED	ASR	AS	PKM	S.CHANDA
3	19.06.09	REAFFIRMED & REISSUED	AS	SCH	VINAY KUMAR	N. DUARI
2	18.02.00	UPDATED & REISSUED	DPN	SKP	SC JAIN	A. SONI

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Abbreviations:

API	:	American Petroleum Institute
ASTM	:	American Society for Testing & Materials
BIS	:	Bureau of Indian Standards
BS	:	British Standard
C&D Waste	:	Construction and Demolition Waste
DIN	:	Deutsches Institut' für Normung
EC	:	Emulsifiable Concentrate
IS	:	Indian Standards
PCC	:	Plain Cement Concrete
PVC	:	Poly Vinyl Chloride
RA	:	Recycled Aggregates
RCA	:	Recycled Concrete Aggregates
RCC	:	Reinforced Cement Concrete

Structural Standards Committee

Convenor: **Mr. Anurag Sinha**

Members:
Mr. Virender Goel
Mr. Deepak Agrawal
Ms. Alpana Srivastava
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1.0 SCOPE

1.1 This specification establishes and defines the requirements of various materials to be used in Civil and Structural works.

1.2 Whenever any reference to BIS Codes is made, the same shall be taken as the latest revision (with all amendments issued thereto) as on the date of submission of the bid.

1.3 Apart from the BIS Codes mentioned in particular in the various clauses of this specification, all other relevant codes related to specific job under consideration regarding quality, tests, testing and/ or inspection procedures shall be applicable. Reference to some of the Codes in the various clauses of this specification does not limit or restrict the scope of applicability of other referred or relevant codes.

1.4 In case of any variation/contradiction between the provision of BIS Codes and this specification, the provision given in this specification shall be followed.

1.5 All materials shall be of standard quality and shall be procured from renowned sources/ manufacturers approved by the Engineer-in-Charge. It shall be the responsibility of the Contractor, to get all materials/ manufacturers approved by the Engineer-in-Charge prior to procurement and placement of order.

1.6 Whenever called for by the Engineer-in-Charge all tests of the materials as specified by the relevant BIS Codes shall be carried out by the Contractor in an approved laboratory and test reports duly authenticated by the laboratory, shall be submitted to the Engineer-in-Charge for his approval. If so desired by the Engineer-in-Charge, tests shall be conducted in the presence of the Engineer-in-Charge or his authorized nominee.

1.7 Quality and acceptability of materials not covered under this specification shall be governed by the relevant BIS Codes. In case BIS code is not available for the particular material, other codes e.g. BS or DIN or API/ ASTM shall be considered. The decision of Engineer-in-Charge, in this regard, shall be final and binding on the Contractor.

1.8 Whenever asked for, the Contractor shall submit representative samples of materials to the Engineer-in-Charge for his inspection and approval. Approval of any sample does not necessarily exempt the Contractor from submitting necessary test reports for the approved material, as per the specification/relevant BIS Codes.

1.9 The Contractor shall submit manufacturer's test reports on quality and suitability of any material procured from them and their recommendation on storage, application, workmanship etc. for the intended use. Submission of manufacturer's test reports does not restrict the Engineer-in-Charge from asking fresh test results from an approved laboratory of the actual material supplied from an approved manufacturer/ source at any stage of execution of work.

1.10 All costs relating to or arising out of carrying out the tests and submission of test reports and or samples to the Engineer-in-Charge for his approval during the entire tenure of the work shall be borne by the contractor and included in the quoted rates.

1.11 Materials for approval shall be separately stored and marked, as directed by the Engineer-in-Charge and shall not be used in the works till these are approved.

1.12 All rejected materials shall be immediately removed from the site by the Contractor at his own cost.

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2.0 REFERENCES

As mentioned in the respective clauses.

3.0 WATER

3.1 Water used in construction for all civil & structural works shall be clean and free from injurious amount of oil, acids, alkalies, organic matters or other harmful substances which may be deleterious to concrete, masonry or steel. The pH value of water sample shall be not less than 6. Potable water shall be considered satisfactory. Underground water can also be used with the prior approval of Engineer-in-Charge, if it meets all the requirements of IS 456.

3.2 Tests on water samples shall be carried out in accordance with IS 3025 and they shall fulfill all the guidelines and requirements given in IS 456.

3.3 The Engineer-in-Charge may require the Contractor to prove, that the concrete prepared with water, proposed to be used, shall have average 28 days compressive strength not lower than 90% of the strength of concrete prepared with distilled water.

3.4 The Engineer-in-Charge may require the Contractor to get the water tested from an approved laboratory before starting the construction work and in case the water contains any oil/ organic matter or an excess of acid, alkalies or any injurious amount of salts etc., beyond the permissible maximum limits given in IS 456, the Engineer-in-Charge may refuse to permit its use. In case the water is supplied by the owner, contractor shall get himself satisfied regarding its quality before using the same in his works at his own expense. In case there is any change in source of water, water samples shall be tested again to meet the specified requirements.

3.5 Water shall be stored in tin barrels, steel tanks or water-tight reservoirs made with bricks / stone or reinforced concrete. Brick/ stone masonry reservoirs shall have RCC base slab and shall be plastered inside, with 1 part of cement and 4 parts of sand and finished with neat cement punning. These reservoirs shall be of sufficient capacity to meet the water requirement, at any stage of construction.

3.6 Water for curing shall be of the same quality as used for concreting and masonry works. Sea water shall not be used for preparation of cement mortar, concrete as well as for curing of plain/reinforced concrete and masonry works. Sea water shall not be used for hydrotesting and checking the leakage of liquid retaining structures also.

4.0 AGGREGATE

4.1 General

4.1.1 Coarse and fine aggregates for Civil and Structural Works shall conform in all respects to IS 383 (Specification for coarse and fine aggregate for concrete). Aggregates shall consist of naturally occurring (crushed or uncrushed) stones, gravel and sand or a combination thereof or manufactured aggregates produced from other than natural sources. These shall be chemically inert, hard, strong, dense durable, clear and free from veins, adherent coatings, injurious amount of disintegrated pieces, alkalies, free lime, vegetable matter and other deleterious substances such as iron pyrites, coal, lignite, mica, shale, sea shells etc. Naturally occurring aggregates shall be obtained from an approved source known to produce the same satisfactorily.

Manufactured aggregates shall consist of Iron and Steel slag aggregates, Copper slag aggregates or aggregates made from Construction & Demolition (C&D) waste such as Recycled Aggregates (RA) and Recycled Concrete Aggregates (RCA). RA shall comprise of waste from concrete, brick, tiles, stone, etc. and RCA shall be derived from concrete after requisite processing. Extent of utilization of manufactured aggregates in RCC and PCC works shall be as per Table-1 of IS 383.

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4.1.2 Source and type of aggregates shall be got approved by the Engineer-in-Charge prior to procurement. Change in source and type of aggregates, at later stage, shall not be generally permitted; but under specific circumstances, Engineer-in-Charge can allow a change in source and type of aggregate. Contractor shall produce necessary test certificates from approved laboratories regarding the quality and suitability of the proposed aggregates and submit fresh mix design for approval of the Engineer-in-Charge. Any such change, if permitted by the Engineer-in-Charge, shall be without any time and cost implication to the owner.

4.1.3 Aggregates which may chemically react with alkalies of cement or might cause corrosion of the reinforcement, shall not be used. If so desired by the Engineer-in-Charge, the Contractor shall carry out alkali reactivity tests and submit the results to him for approval.

4.1.4 The maximum quantities of deleterious materials in the aggregates as determined in accordance with IS 2386 - Part II (Methods of Test for aggregates for concrete), shall not exceed the limits defined in IS 383. No special test is required to prove the absence of such deleterious matters if the aggregates are from a known source with satisfactory prior data on the properties of concrete made with them. In case of newly developed quarry sites, the contractor shall submit necessary test results as per IS 383 and IS 2386 to the Engineer-in-Charge prior to his acceptance and approval. The method of Sampling shall be in accordance with the requirements given in IS 2430.

4.1.5 Coarse and fine aggregates shall be batched separately. All-in-aggregate shall be used only where specifically permitted by the Engineer-in-Charge.

Separate sieve analysis and grading curves shall be prepared by the Contractor for any/ all batches of coarse and fine aggregates, and submitted to the Engineer-in- Charge, whenever asked for, to ensure conformity with those submitted along with the mix design.

4.1.6 Whenever required by Engineer-in-Charge, the aggregates (coarse/ fine) shall be washed and/ or sieved by the contractor before use in the works to obtain clean and graded aggregate at no extra cost to the owner.

4.1.7 Aggregates not in conformity with the specifications shall be rejected and the Contractor shall immediately remove them from the site of work.

4.2 Coarse Aggregates

4.2.1 Coarse aggregates are the aggregates, which are retained on 4.75 mm BIS Sieve. It shall have a specific gravity not less than 2.6 (saturated surface dry basis).

The grading of the aggregates shall be as per IS 383 or as required by the mix design, to obtain densest possible concrete. For this purpose, the contractor shall submit to the Engineer-in-Charge at least three sets of mix design and test results, each with different gradings of coarse aggregates, proposed to be used. The Engineer-in-Charge may allow "All-in-aggregates" to be used provided they satisfy the requirements of IS 383.

4.2.2 Coarse aggregates may be obtained from

a) Uncrushed gravel or stone which results from natural disintegration of rock

b) Crushed gravel or stone which results from crushing of gravel or hard stone

c) Partially crushed gravel or stone which results from blending of (a) and (b) above

d) Manufactured from other than natural sources, by processing materials, using thermal or other processes such as separation, washing, crushing and scrubbing. Manufactured coarse

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aggregate may be RCA or RA processed from C&D waste and may be supplied as single sized or graded.

4.3 Fine Aggregates

4.3.1 Fine aggregates are the aggregates which pass through 4.75 mm BIS sieve but not more than ten percent (10%) pass through 150 micron BIS sieve. These shall comply with the requirements of grading zones I, II and III of IS 383. Fine aggregates conforming to grade zone IV shall not be used for reinforced concrete works.

Sand from sea shores, creeks or river banks affected by tides, shall not be used for filling or concrete works.

4.3.2 Fine aggregates shall consist of

a) Natural Sand : Fine aggregate resulting from natural disintegration of rock and which has been deposited by streams or glacial agencies. This may also be called as uncrushed sand.

b) Crushed Sand –
   i) Crushed Stone Sand : Fine aggregate produced by crushing hard stone
   ii) Crushed Gravel Sand : Fine aggregate produced by crushing natural gravel

c) Mixed Sand : Fine aggregate produced by blending natural sand and crushed stone sand or crushed gravel sand in suitable proportions.

d) Manufactured Fine Aggregate : Fine aggregate manufactured from other than natural sources, by processing materials, using thermal or other processes such as separation, washing, crushing and scrubbing. Manufactured fine aggregate may be RCA processed from C&D waste.

4.4 Sampling and Testing

The Contractor shall carry out all tests including mix designs of concrete, at his own expense, at the start of work as well as during any stage of construction as required by the Engineer-in-Charge. Test shall be carried out in accordance with IS 516 - Methods of test for strength of concrete and IS 2386 - Methods of test for aggregates for concrete. Testing shall be carried out from laboratories approved by the Engineer- in-Charge. The method of sampling shall be in accordance with the requirements given in IS 2430.

4.5 Storage of Aggregates

4.5.1 Storage of all types of aggregates at site of work shall be at contractor's expense and risk and shall be stored as specified in IS 4082. Aggregates shall in no case be stored near to the excavated earth or directly over ground surface.

4.5.2 The Contractor shall maintain sufficient quantities of aggregates, near to the place of work, required for the continuity of the work. Each type and grade of aggregate shall be stored separately on hard, firm surface having adequate slope for drainage of water.

4.5.3 Aggregates delivered at site in wet condition or becoming wet due to rain or any other means, shall not be used for atleast 24 hours. The Contractor shall obtain prior approval of the Engineer-in-charge for the use of such aggregates and shall adjust the water content in accordance with IS 2386 to achieve the desired mix. In the absence of test results, and to allow variation in mass of aggregates and water content on account of moisture content, the

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Contractor can make suitable adjustment in the masses as per IS 456, for preparation of nominal mix concrete only.

5.0 SAND

5.1 Sand for Masonry Mortars

5.1.1 The sand shall consist of natural sand, crushed stone sand or crushed gravel sand or a combination of any of these. The sand shall be hard, durable, clean and free from adherent coatings and organic matter and shall not contain the amount of clay, silt and fine dust more than specified in IS 2116.

5.1.2 The sand shall not contain any harmful impurities such as iron pyrites, alkalis, salts, coal or other organic impurities, mica, shale or similar laminated materials, soft fragments, sea shells in such form or in such quantities as to affect adversely the hardening, strength or durability of the mortar.

5.1.3 Unless found satisfactory as a result of further tests as may be specified by the Engineer-in-Charge, or unless evidence of such performance is offered which is satisfactory to him, the maximum quantities of clay, fine silt, fine dust and organic impurities in the sand, when tested in accordance with IS 2386, shall not be more than 5% by mass in natural sand, or crushed gravel sand or crushed stone sand. For organic impurities, when determined in accordance with IS 2386, colour of the liquid shall be lighter than that indicated by the standard solution specified in IS 2386.

5.1.4 **Grading of Sand**

The particle size grading of sand for use in mortars shall be within the limits as specified below:

GRADING OF SAND FOR USE IN MASONRY MORTARS

IS SIEVE DESIGNATION IS 460 (PART I)	PERCENTAGE PASSING BY MASS	REF. TO METHOD OF
4.75 mm	100	IS 2386 (Part I)
2.36 mm	90 to 100	
1.18 mm	70 to 100	
600 micron	40 to 100	
300 micron	5 to 70	
150 micron	0 to 15	

In case of a sand whose grading falls outside the specified limits due to excess or deficiency of coarse or fine particles, this shall be processed to comply with the standard by screening through a suitably sized sieve and/or blending with required quantities of suitable sizes of natural sand particles or crushed stone screenings which are by themselves unsuitable. Based on test results and in the light of practical experience with the use of local materials, deviation in grading of sand may be considered by the Engineer-in-Charge. The various sizes of particles of which the sand is composed shall be uniformly distributed throughout the mass.

5.1.5 **Sampling and Testing**

The method of sampling shall be in accordance with IS 2430. The amount of material required for each test shall be as specified in relevant parts of IS 2386. Any test which the engineer-in-charge may require in connection with this, shall be carried out in accordance with the relevant parts of IS 2386.

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If further confirmation as to the satisfactory nature of the material is required, compressive test on cement mortar cubes (1:6) may be made in accordance with IS 2250 using the supplied material in place of standard sand and the strength value so obtained shall be compared with that of another mortar made with a sand of acceptable and comparable quality.

5.2 Sand for Filling

Sand for filling shall meet the requirements of IS 383 and shall be natural sand, hard, strong, free from any organic and deleterious materials. Any sand proposed for filling, shall be used only after it is approved by the Engineer-in-Charge. Sand obtained from sea shores, creeks or river banks affected by tides, shall not be used for filling. Fine aggregates suitable for concreting works shall be suitable for filling also. No sand below grading zone-III as per IS 383 shall be allowed for filling.

6.0 CEMENT

Cement to be used for civil and structural works shall be one of the following. Specific requirement for the type of cement to be used shall be as shown in the drawings or as specified in the contract or as directed by the Engineer-in-Charge.

- Specification for 33/43/53 grade ordinary portland cement — IS 269
- Specification for portland slag cement — IS 455
- Specification for Portland pozzolana cement (fly ash based) — IS 1489 Pt.1
- Specification for Portland pozzolana cement (calcined clay based) — IS 1489 Pt.2
- Specification for Masonry Cement — IS 3466
- Specification for high alumina cement for structural use — IS 6452
- Specification for rapid hardening portland cement — IS 8041
- Specification for Sulphate Resisting Portland cement — IS 12330

6.1 Storage at Site

6.1.1 The storage of cement (lifted from the Owner's godown or procured by the Contractor himself) at the site of work shall be at contractor's expense and risk and shall meet the requirements of IS 4082. The cement shall be stored above ground in a suitable weather tight building or godown and in such a manner as to permit easy access for proper inspection and also to prevent deterioration due to moisture. In the event of any damage occurring to the quality of cement due to faulty storage or on account of negligence on the part of the contractor, such damages shall be borne by the contractor himself.

6.1.2 All approved cement shall be arranged in batches with type, brand and date of receipt flagged on them. A maximum of eight bags shall be stacked one over the other. Cement bags shall be used in the same order as received from the manufacturer/ owner. The contractor shall maintain a register, on day-to-day basis, giving the details of the receipt/ consumption, source of supply and type of cement etc. The register shall always be accessible to the Engineer-in-Charge for verification.

6.2 Tests after Delivery

Each consignment of cement supplied by Owner or contractor, shall, after delivery at site and at the discretion of the Engineer-in-Charge, be subjected to any or all of the tests and analyses, required by the relevant Indian Standard Codes. In case the cement is supplied by the owner, the contractor shall get himself satisfied regarding its quality before using the same in his works at his own expense. The contractor shall carry out and bear the cost of all tests and

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analyses required to ensure quality of cement before using in actual works, irrespective of the fact whether the cement is supplied by the Owner or procured by him.

6.3 Rejection

The Engineer-in-Charge may reject at his discretion any cement, notwithstanding the manufacturer's certificate or failing to meet the requirements of relevant BIS Codes for testing of cement. He may similarly reject any cement which has deteriorated owing to inadequate protection from moisture or due to intrusion of foreign matter or any other cause. Any cement which is considered defective, shall not be used and shall be promptly removed from the site by the contractor.

7.0 STEEL

7.1 General

All steel bars, sections, plates, and other miscellaneous steel materials, etc shall be free from loose mill scales, rust as well as oil, mud, paint or other coatings. The materials, construction specifications such as dimensions, shape, weight, tolerances, testing etc, for all materials covered under this section, shall conform to respective BIS Codes. Steel sections shall be conforming to IS 808 or IS 12778.

7.2 Reinforcement Bars

Reinforcement bars, to be used for civil and structural works shall be one of the following or in combination thereof.

- Mild Steel and Medium Tensile Steel Bars and Hard-Drawn Steel Wire for Concrete Reinforcement — IS 432
- Specification for hard drawn steel wire fabric for concrete reinforcement — IS 1566
- Specification for plain hard-drawn steel wire for prestressed concrete. — IS 1785
- Specification for High strength deformed steel bars and wires for concrete reinforcement. — IS 1786
- Specification for indented wire for prestressed concrete. — IS 6003
- Specification for fusion bonded epoxy coated reinforcing bars — IS 13620

7.3 Structural Steel

Structural steel to be used for general structural purposes shall be one of the following or in combination thereof.

Structural steel sections shall conform to following BIS Codes:

- Steel tubes for structural purposes. — IS 1161
- Mild Steel Tubes, tubulars and other wrought steel fittings. — IS 1239
- Steel for general structural purposes (Grade A/BR/B0). — IS 2062
- Hollow steel sections for structural use. — IS 4923

7.4 Miscellaneous Steel Materials

Miscellaneous steel materials shall be conforming to the following BIS Codes.

- Expanded Metal Steel Sheets for General purposes. — IS 412
- Mild steel bars of anchor bolts, rungs, metal inserts, grating etc.) — IS 2062
- Hexagonal head bolts, screws & nuts of product grade C. — IS 1363

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- Cold formed light gauge structural steel sections. IS 811
- Technical supply conditions for threaded steel fasteners. IS 1367
- Plain washers IS 2016
- Steel wire ropes for general engineering purposes IS 2266
- Thimbles for wire ropes. IS 2315
- Bulldog grips. IS 2361
- Mild Steel Tubes, tubulars and other wrought steel fillings. (For Hand rail tubular sections). IS 1239
- Drop forged sockets for wire ropes for general engineering purposes. IS 2485
- Steel chequered plates. IS 3502
- Hexagonal bolts and nuts (M42 to M150). IS 3138
- High Strength Structural Bolts IS 3757
- High Strength Bolts IS 4000

7.4.1 Anchor Bolts

Material for Anchor Bolts such as MS bars, washers, nuts, pipe sleeves and plates etc. shall be as per relevant BIS Codes mentioned above.

7.5 Storage

The storage of all materials at site of work shall be at the contractor's expense and risk and shall be done as per the requirements given in IS 4082. The contractor shall maintain the proper records of receipt/consumption. The records shall always be accessible to the Engineer-in-Charge for verification.

The reinforcement bars, structural steel sections and other miscellaneous steel materials etc, shall be stored in such a way as to avoid and prevent deterioration, corrosion, bending, twisting and wrapping. In case of any damage occurring to the material on account of faulty storage or negligence by the contractor, same shall be borne by the contractor himself.

7.6 Tests after Delivery

Materials supplied by the Owner or Contractor, shall, after delivery at site and at the discretion of Engineer-in-Charge, be subjected to any or all of the tests, required by the relevant BIS Codes. The Contractor shall carry out and bear the cost of such tests irrespective of the fact whether the material is procured by the Owner or the contractor. In case steel is supplied by the Owner, the Contractor shall get himself satisfied regarding its quality before using the same in his works at his own expense.

7.7 Rejection

The Engineer-in-charge may reject at his discretion any material, not withstanding the manufacturer's certificate or failing to meet the requirements of relevant BIS Codes for testing of materials. He may similarly reject any material, which has deteriorated or corroded etc., due to improper storage, handling or transport. Defective materials shall not be used and removed from the site by the contractor at his own expense.

8.0 BRICK

8.1 General

All Bricks used for masonry works shall conform to the requirements of following BIS Codes:

- Common Burnt Clay Bricks- Specifications IS 1077

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- Pulverized Fuel Ash Cement Bricks- Specifications IS 16720
- Pulverized Fuel Lime Ash Bricks- Specifications IS 12894
- Burnt Clay Fly Ash Bricks- Specifications IS 13757

8.1.1 Common Burnt Clay Bricks

Bricks for masonry works shall conform to IS 1077 - Specification for common burnt clay building bricks and shall be of class 5.0 (with minimum compressive strength of 5.0 N/mm^2). Specific requirement for any other class of bricks shall be as shown in drawings or as described in the contract for a particular site or type of work. Physical requirements, quality, dimensions, tolerances etc. of common burnt clay building bricks shall conform to the requirements of IS 1077.

Bricks shall be hand - moulded or machine moulded and shall be made from suitable soils. The bricks shall have smooth rectangular faces with sharp corners and shall be well burnt, sound, hard, tough and uniform in colour. These shall be free from cracks, chips, flaws, stone or humps of any kind.

8.1.2 Pulverized Fuel Ash Cement Bricks

Pulverized fuel ash-cement bricks shall conform to IS 16720. The bricks shall be sound, free from visible cracks and uniform in shape and colour. The brick shall have total pulverized fuel ash content not less than 35 percent of the mass of bricks. Pulverized fuel ash shall conform to IS 3812 (Part 1) or IS 3812 (Part 2).

8.1.3 Fly Ash Lime Bricks (FALG Bricks)

The Fly Ash Lime Bricks (FALG Bricks) shall conform to IS 12894. Visually the bricks shall be sound, compact and uniform in shape free from visible cracks, warpage, flaws and organic matter. Fly ash shall conform to IS 3812.

8.1.4 Burnt Clay Fly Ash Bricks

The burnt clay fly ash bricks shall conform to IS 13757. The bricks shall be sound, compact and uniform in shape and colour. Bricks shall have smooth rectangular faces with sharp and square corners. The bricks shall be free from visible cracks, flaws, warpage, nodules of free lime and organic matter, the bricks shall be hand or machine moulded. The bricks shall have frog of 100 mm in length 40 mm width and 10 to 20 mm deep on one of its flat sides. If made by extrusion process may not be provided with frogs. Fly Ash shall conform to grade I or grade II of IS 3812.

8.1.5 Mechanized Autoclave Fly Ash Lime Brick

These bricks shall be machine moulded and prepared in plant by appropriate proportion of fly ash and lime. The autoclave fly ash bricks shall conform to IS 12894. Visually, the bricks shall be sound, compact and uniform shape, free from visible cracks, warpage and organic matters. The brick shall be solid with or without frog, and of 100/80 mm in length, 40 mm width and 10 to 20 mm deep one of its flat side as per IS 12894. The brick shall have smooth rectangular faces with sharp corners and shall be uniform in shape and colour. Fly ash shall conform to IS 3812 and lime shall conform to class 'C' hydrated lime of IS 712.

8.2 Tests after Delivery

The Contractor shall take samples of each type of brick as directed by the Engineer-in-Charge as per the requirements of IS 5454 and tests shall be carried out as per IS 3495. The cost for carrying out any or all the tests, shall be borne by the Contractor. The bricks, when tested, as

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per IS 3495 shall have a minimum average compressive strength, as given in the Code, for a particular class of brick. Water absorption shall not be more than 20% by its dry weight, when soaked in cold water for 24 hours.

Brick samples so approved, shall be deposited with the Engineer-in-Charge. All subsequent deliveries shall be upto the standards of the approved samples.

8.3 Stacking of Bricks

Bricks shall be stored at site as per the requirements given in IS 4082 and shall not be dumped at site. They shall be unloaded from trucks to a place on a levelled surface near to the work site. They shall be stacked in regular tiers even as they are unloaded, to minimise breakages and defacement of bricks. The supply of bricks shall be so arranged that as far as possible, at least two days' requirements of bricks are available at site at any time. Bricks, of different class & types, shall be stacked separately.

8.4 Local Bricks/ Class 3.5 Bricks.

Where shown on drawings, locally available bricks of non modular size (230 mm x 110 mm x 70 mm) in place of bricks of modular size (190 mm x 90 mm x 90 mm) can be used in case the bricks satisfy the other requirements of respective BIS codes. Minimum compressive strength of these bricks shall not be less than 3.5 N/mm^2.

8.5 Concrete Block Masonry

Concrete Block Masonry shall be as per EIL Specification No. 6-68-0016.

9.0 STONE

9.1 General

All Stones used for masonry works shall conform to the requirements of following BIS Codes.

- Method of identification of natural building stones. IS 1123
- Recommendations for dimensions and workmanship of natural building stones for masonry work. IS 1127
- Recommendations for dressing of natural building stones. IS 1129

9.2 Quality of Stones

Stones shall be of approved quality, hard, dense, strong, sound, durable, clean and uniform in colour. They shall also be free from veins, adherent coatings, injurious amount of alkalies, vegetable matters and other deleterious substances such as iron pyrites, coal, lignite, mica, sea shells etc. Unless otherwise approved, stones from one single quarry shall be used for any one work. The strength of stones should be adequate to carry the imposed load and shall meet all the requirements of IS 1905, taking into account the appropriate crushing strength of stone and type of the mortar used. The percentage of water absorption, when tested in accordance with IS 1124, shall not exceed 5 percent.

Stones normally used, shall be small enough to be lifted and placed by hand. The length of the stone shall not exceed 3 times the height. Width of stone on base shall not be less than 150 mm and in no case exceed $3/4^{th}$ thickness of the wall. Height of the stone shall not be more than 300 mm.

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9.3 Unloading/Stacking

The stones shall be unloaded from the trucks to a site near to the place of work as defined in IS 4082 and shall be stacked on a firm ground having adequate stope for drainage. The supply of stones shall be so arranged that as far as possible, at least two days' requirements of stone are available at site at any time.

10.0 ADMIXTURES

10.1 General Requirements for Admixtures

10.1.1 All concrete admixtures shall in general comply with the following BIS Codes unless otherwise stipulated in this specification.

- Specification for integral cement water proofing compounds. IS 2645
- Specification for other admixtures for concrete. IS 9103

10.1.2 Generally, admixtures shall have ISI certification marks. However, even in case of BIS certified admixtures, Engineer-in-Charge may require the Contractor to carry out and submit any or all the tests (as specified in relevant BIS Codes), from BIS approved laboratories, over and above the manufacturer's test certificate, before giving his final approval.

In case, admixtures certified by BIS are not available, the contractor shall submit to the Engineer-in-Charge the type and/or proprietary brand of the admixture from only reputed manufacturers along with necessary test certificates from BIS recognized/ BIS approved laboratories or any other document directed by Engineer-in-Charge for the latter's final approval. In such cases, names of at least two manufacturers shall be submitted to the Engineer-in-Charge for his selection. In case, both the names are rejected, the contractor shall submit a fresh list of two manufacturers for approval by the Engineer-in-Charge.

The Engineer-in-Charge may direct the contractor to submit test results as required by IS 2645 or IS 9103 for any admixture proposed to be used in the concrete in any approved laboratory at his discretion at any stage of the work. The cost of any/all tests required to satisfy compliance with this specification shall be borne by the Contractor.

In case of non-availability of any BIS code for testing and acceptability criteria, relevant American, British or German Code shall be applicable.

10.1.3 Prior approval of the Engineer-in-Charge shall be obtained while using water reducing admixtures in the concrete (PCC/ RCC) or mortar. Other type of admixtures such as accelerating admixtures, retarding admixtures or air entraining admixtures, shall not be used unless specified on the design drawings or prior approval taken from the design approving authority. Once approved, utmost care shall be exercised at site by the Contractor to maintain the consistency in the quality of admixture and the concrete/ mortar so produced.

10.1.4 The suitability and effectiveness of any admixture shall be verified by trial with the designed concrete mixes using cement, aggregates together with any other materials to be actually used in the works as per the direction of Engineer-in-Charge. If two or more admixtures are to be used simultaneously in the same concrete mix, the Contractor must submit necessary test results from an approved laboratory to show their interaction and compatibility. Any/all tests specified in BIS Codes shall be carried out only with the type of material and mix design, to be actually used in the work site.

10.1.5 No admixture shall impair the durability of the concrete nor combine with the ingredients to form harmful compounds nor increase the risk of corrosion of reinforcement. Use of admixtures shall not reduce the dry density of concrete. Once the proportion of admixture has

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been established, strict check shall be maintained not to alter the proportions of ingredients and water-cement ratio of the Design Mix during execution.

10.1.6 The chloride contents in admixtures shall not exceed 2% by mass of the admixture or 0.03% by mass of the cement.

10.1.7 Admixtures which do not meet the requirements stipulated in this specification shall be rejected and shall not be used.

10.2 Water Proofing Compounds

10.2.1 Water proofing compounds shall be mixed with cement only.

10.2.2 The permeability of the specimen with the admixture shall be less than half of the permeability with similar specimen without the use of these compounds. These compounds shall be used in such proportion as recommended by manufacturer but in no case it shall exceed 3% by weight of cement.

10.2.3 The initial setting time of the cement with the use of these compounds shall not be less than 30 minutes and final setting time shall not be more than 10 hours. Test shall be carried out in accordance with IS 4031.

10.2.4 Compressive strength of specimen at 3 days shall not be less than 160 kg/sq.cm nor 80% of the 3 days compressive strength of mortar cubes prepared with same cement and sand only, whichever is higher. Similarly compressive strength at 7 days shall not be less than 220 kg/sq.cm nor less than 80% of the 7 days compressive strength prepared with the same cement and sand only, whichever is higher. The test to determine the compressive strength shall conform to IS 4031.

10.3 Concrete Penetrating Corrosion Inhibiting Admixture shall be as per EIL Specification No. 6-68-0017.

11.0 WATER BARS (WATER STOPS)

11.1 PVC water bars shall be used in reinforced concrete construction of liquid retaining structures or any other structure to safeguard them from hydrostatic pressure and water leakage and any relative movement between two parts of the structure due to thermal loading shrinkage or differential movement of foundations. Wherever desired or shown in the drawings, they shall be used at expansion/contraction/construction joints. These shall be pre-formed and shall provide a permanent water tight seal along the entire joint in the poured concrete structures. These shall also be flexible enough to withstand deflection/displacements at joints arising due to variation of temperatures or settlement of foundations. The minimum thickness of water bar shall be as shown on drawings or described in the schedule of rates and unless otherwise mentioned, these shall be able to withstand a water head of at least 12 meters.

11.2 Performance requirements of PVC water bars shall meet the requirements of IS 12200. These shall be of approved make and of ribbed/ serrated/ plane type with a bulb at the centre. The thickness and width of water bars shall be as per schedule of rates/ drawings but in no case the thickness shall be less than 5 mm and width less than 150 mm. The joining of the water bars shall be carried out by vulcanising strictly as per the manufacturer's specifications. Lapped joints shall not be allowed under any circumstances.

12.0 BITUMEN/BITUMINOUS MATERIALS

Bitumen to be used for various types of work shall meet all the requirements of relevant BIS Codes as given below:

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- Specification of Paving Bitumen IS 73
- Specification for bitumen mastic for flooring IS 1195
- Specification for Bitumen felts for water proofing and damp proofing IS 1322
- Specification for Bituminous compounds for water proofing and caulking purposes IS 1834
- Specification for preformed fillers for expansion joint in concrete pavements and structures IS 1838
- Specification for bitumen mastic for use in water proofing of roofs IS 3037
- Specification for bitumen primer for use in water proofing and damp proofing IS 3384
- Specification for Bitumen Mastic for Tanking and Damp proofing IS 5871
- Specification for Glass fibre base coal tar pitch & bitumen felts IS 7193
- Code of practice for damp proofing using bitumen mastic IS 7198
- Specification for bitumen Mastic, Anti-Static and electrically conducting grade IS 8374

The type and grade shall be as shown on the drawings or as indicated in schedule of quantities or as directed by Engineer-in-Charge. Tests and acceptable criteria shall be as per relevant BIS Codes.

13.0 PVC PIPES

PVC Pipes shall conform to the requirements of IS 4985.

14.0 WOOD/ TIMBER

14.1 Wood recommended for platforms of cold vessels or below cold vessels/ exchangers shall be hard and shall be of group A, grade I, and shall have safe permissible stress of 7 N/mm^2 in compression, perpendicular to grains on outside location as per IS 883. General characteristics like durability, treatability etc. shall conform to IS 883 and IS 3629.

14.2 Timber required to be used for formwork shall be fairly dry before use. It should maintain its shape during the use and even when it comes into contact with moisture from the concrete. Storage of Wood/Timber shall be as per the requirements of IS 4082.

For proper identification and selection of suitable timber for formwork, following codes shall be referred.

- Classification of commercial timbers and their zonal distribution IS 399
- Specification for ballies for general purposes. IS 3337
- Specification for Ply wood for concrete shuttering work. IS 4990

15.0 EPOXY COMPOUNDS

Refer EIL Specification No. 6-68-0056.

16.0 PAINT

16.1 Refer EIL Specification No. 6-79-0020 or the job specification whichever applicable.

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17.0 ANTITERMITE COMPOUNDS

17.1 Following chemicals as per IS 6313 (Part 2 & 3) shall be used for treatment of soil for protection of buildings against attack by subterranean termites:

S.No.	Chemical	Relevant Standard	Dosage* (Chemical Emulsion)
1	Chlorpyrifos 20% Emulsifiable Concentrate (EC)	IS 8944	250ml in 5 litre water 50ml in 1 litre water
2	Imidacloprid 30.5% Suspension Concentrate (SC)	IS 16131	10.5ml in 5 litre water 2.1ml in 1 litre water
3	Bifenthrin 2.5% Emulsifiable Concentrate (EC)	IS 15936	100ml in 5 litre water 20ml in 1 litre water

(*Dosage as specified above or as per Manufacturer's recommendation, whichever is stringent)

18.0 POLYSULPHIDE SEALANTS

Polysulphide Sealants shall conform to IS 12118 and be of approved make. Test conditions and requirements shall be as given in the above referred BIS code.

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मानक विनिर्देशन
सिविल एवं संरचनात्मक कार्य

STANDARD SPECIFICATION
CIVIL AND STRUCTURAL WORKS

प्रीकास्ट कंक्रीट
PRECAST CONCRETE

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
2	17.05.2024	REVISED & REISSUED AS STANDARD SPECIFICATION	DB	RM	AS	MN
1	10.03.2019	REAFFIRMED & ISSUED AS STANDARD SPECIFICATION	AVM	AJS	RS	RKT
0	26.07.2013	ISSUED AS STANDARD SPECIFICATION	AK	VG/RS	PKM	DM

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Abbreviations:

IS: Indian Standard

Structural Standards Committee

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Mr. Deepak Agrawal
Mr. VK Panwar
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1.0 GENERAL

This Specification defines the requirements for the manufacture of precast concrete units. Precast concrete units shall be designed and fabricated by an experienced and acceptable precast concrete manufacturer. The manufacturer shall have been regularly and continuously engaged in the manufacture of precast concrete units either RCC or PCC similar to that indicated in the project specifications or drawings for at least 7 years. The units to be precast shall take care of any special requirements specified in the "**Contract Specific Requirements**" or on the Drawings.

The precast units shall be manufactured in accordance with Specification No. 6-68-0004.

1.1 Reference Codes and Specifications

Apart from this specification, the construction of Precast concrete works shall be in accordance with the Indian Standard Code of Practice for "Building Design & Erection using Prefabricated Concrete" IS 15916 along with all amendments till date and other relevant codes mentioned therein.

2.0 QUALITY REQUIREMENTS

At a minimum, the Contractor's Quality Plan shall include the following documents, procedures and/or instructions:

(a) Lifting methods (where not shown on the Drawings).

(b) Erection methods including the erection sequence (where not shown on the Drawings).

(c) Minimum concrete strength requirements prior to lifting (where not shown on the Drawings).

(d) Where it is proposed to stack units, evidence to demonstrate the strength and stability of the stack.

(e) Procedure/format of records keeping for precast works. (Refer Annexure -I).

This documentation shall be submitted at least 28 days prior to the commencement of site work, if not submitted beforehand.

3.0 MANUFACTURE

Formwork shall be of rigid construction and concrete vibration shall be such that intense concrete compaction will be achieved. This may require the use of form vibrators or vibrating tables on some large and/or complex-shaped units.

Formwork and embedded items shall not restrain movements nor damage precast units within the formwork due to the effects of shrinkage or steam curing.

The casting of the precast units shall be carried out on specially prepared casting beds which will prevent any distortion or misalignment of the forms during and after concreting. Each precast unit shall be cast in one continuous operation with no construction joints.

If the batch volume is less than 2 cubic metres, the sampling rate shall be reduced as follows:

(a) Less than 2 cubic metres per batch : 50% rounded up

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(b) Less than 0.5 cubic metres per batch : 30% rounded up.

In any case a minimum of 1 test representing each member shall be undertaken. Test specimens, for the purpose of determination of adequate unit strength for lifting and handling, shall be subjected to the same curing regime as the unit they represent. The Contractor shall ensure that sufficient cubes are provided to enable the required testing to be undertaken.

4.0 CURING

Concrete shall be:

(a) moist cured in accordance with Specification No. 6-68-0004 or

(b) membrane cured in accordance with Specification No. 6-68-0004

5.0 MARKING

For the purposes of unit curing, testing, location and orientation within the final structure, each batch of units, or if continuous production methods are used, each day's production, shall be clearly identified and indelibly marked to show:

(a) Unit identification

(b) Date of manufacture.

(c) Marking of top and bottom surface to ensure correctness of the reinforcement.

Each unit shall be marked on a surface which is not visible in the final structure.

6.0 LIFTING, HANDLING, STORAGE AND ERECTION

Precast units shall not be lifted or handled before the concrete has attained a compressive strength of 10 MPa or strength required during lifting as per design requirement or as specified on the Drawings, whichever is greater.

The Contractor shall detail in the Quality Plan the measures to be taken to minimise handling stresses, in particular those due to de-moulding.

The Contractor shall carefully handle precast units by methods that will not damage them or their connections. Units shall be handled from the approved lifting points shown on the Drawings. Beams and slabs shall be lifted and supported with the top surfaces uppermost at all times, unless shown otherwise on the Drawings.

Units shall be stored clear of the ground and supported on non-staining timber bearers only at approved bearing points. The thickness and width of the bearers shall be compatible with the strength group of the timber used, the type of precast unit and the site. The bearers shall support the units over their full width at the specified lifting points. The ground or space between the bearers supporting the units shall be carefully cleared and leveled to prevent the unit from being supported at positions other than on the bearers. The bearers shall rest on a firm foundation and adequate precautions shall be taken to prevent subsidence.

If units are stacked in tiers, the bearers shall be placed directly over each other. The lowest unit shall not be overstressed.

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Temporary props, if required, shall be used to hold the precast elements joints till it attain the required strength. After attaining the required strength, props shall be removed.

7.0 TRANSPORTATION

Unless stated otherwise on the Drawings, units shall not be transported until the concrete has reached its 28 day characteristic compressive strength and is at least 7 days old.

No unit shall be removed from the casting yard until a lot conformance package has been completed.

Submission of the lot conformance package prior to removal from the yard shall be required.

Units shall be securely fixed to the transporter by ties fitted with suitable tensioners. Provision shall be made to protect the units from damage caused by these ties.

Precast concrete units shall be delivered to the site in accordance with the delivery schedule to avoid excessive build-up of units in storage at the site. Upon delivery to the jobsite all precast concrete units shall be inspected by the Engineer-in-charge for quality and final acceptance.

8.0 PAYMENT

8.1 Payment for precast concrete members shall be made on cubic meter basis of the volume of the finished member. The rate quoted shall include cost of formwork, preparation of casting yard, finishing as specified, curing, marking, lifting, handling, storage, transportation to site of work, fixing in position etc. Reinforcement and pipe sleeves shall be paid separately under relevant items. Lifting hooks shall be paid on the same basis as reinforcement. Metal inserts shall be paid as per relevant clauses of Specification No. 6-68-0008 (Miscellaneous Steel Works).

8.2 The quoted rate shall be inclusive of providing pockets, openings, recesses of all sizes, chamfers, fillets grooves, holes, curing (hot, cold or by using curing compounds). The rate shall be deemed to include complete cost of taking and testing concrete cubes and carrying out other tests including tests of various ingredients as per specification and as directed by the Engineer-in-Charge.

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ANNEXURE-I

Procedure/format of record keeping for precast works shall at least include the following:

I. PRE-POURING INSPECTION REPORT:

This shall include mould cleaning & oiling, inspection of shutter joins, reinforcement & cover check, prestressed strands check, inspection of lifting hooks, inserts, embedments, etc.

II. CONCRETE TESTING REPORT:

This shall include the strength attained by concrete at various stages i.e. de-shuttering, lifting transportation, erection, loading, with other structural components, grouting, etc.

III. POST POURING INSPECTION REPORT (PREDELIVERY / DISPATCH)

This shall include inspection of the size of precast element, honeycomb, cracks, exposed reinforcement, finishing works, etc.

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तटीय पाइपलाइनों के हाइड्रोस्टेटिक टेस्टिंग के लिए मानक विनिर्देश

STANDARD SPECIFICATION FOR HYDROSTATIC TESTING OF ONSHORE PIPELINES

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
5	18-07-23	REVISED & REISSUED AS STANDARD SPECIFICATION	AKS	RK	MSG	SM
4	06-04-18	REVISED & REISSUED AS STANDARD SPECIFICATION	SRG	MSG	VM	RN
3	11.04.12	REVISED & REISSUED AS STANDARD SPECIFICATION	RSB	SKJ	VM	DM
2	31.07.06	REVISED & REISSUED AS STANDARD SPECIFICATION	MKM	DD	AS	VC
1	15.10.98	REVISED & REISSUED AS STANDARD SPECIFICATION	KKS	RK	VC	AS

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Abbreviations:

API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
OISD	Oil Industry Safety Directorate (of India)
PNGRB	Petroleum & Natural Gas Regulatory Board
SMYS	Specified Minimum Yield Strength

Pipeline Engineering Standards Committee

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FIGURES

FIG. 1	WATER COMPRESSIBILITY FACTOR V /S. PRESSURE AND TEMPERATURE (2 °C – 20 °C)
FIG. 2	WATER COMPRESSIBILITY FACTOR V /S. PRESSURE AND TEMPERATURE (22 °C – 40 °C)

TABLES

TABLE 1	DIFFERENCE BETWEEN THE WATER THERMAL EXPANSION FACTOR AND THE STEEL THERMAL EXPANSION FACTOR

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1.0 SCOPE

1.1 This specification covers the minimum requirements of supply, work and operation to be performed by Contractor for hydrostatic testing of cross-country steel pipelines transporting hydrocarbons in liquid or gaseous phase under high pressure.

This specification does not cover the requirements of caliper pigging, drying/ pre-commissioning of the tested pipelines.

1.2 This specification shall be read in conjunction with the conditions of all specifications and documents included in the CONTRACT between Company and Contractor. Unless specified otherwise, all sections of this specification shall apply to all specifications referred in this specification.

2.0 REFERENCE CODES, STANDARDS AND SPECIFICATIONS

2.1 Reference has been made in this specification to the latest edition (edition enforce at the time of issue of enquiry) of the following codes, standards and specifications.

a)	ASME B31.4	:	Pipeline Transportation Systems for Liquids and Slurries.
b)	ASME B 31.8	:	Gas Transmission and Distribution Piping Systems.
c)	API RP 1110	:	Pressure Testing of Steel Pipelines for the Transportation of Gas, Petroleum Gas, Hazardous Liquids, Highly Volatile Liquids or Carbon Dioxide.
d)	ASME Sec. VIII Div. 1	:	Boiler and Pressure Vessel Code- Rules for Construction of Pressure Vessels.
e)	OISD STD 141	:	Design, Construction and Inspection Requirements for Cross Country Liquid Hydrocarbon Pipelines.
f)	OISD STD 214	:	Cross-Country LPG Pipelines.
g)	OISD STD 226	:	Natural Gas Transmission Pipelines and City Gas Distribution Networks.
h)	PNGRB PPPL T4S Regulations	:	PNGRB (Technical Standards and Specifications including Safety Standards for Petroleum and Petroleum Products Pipelines) Regulations, 2016.
i)	PNGRB NGPL T4S Regulations	:	PNGRB (Technical Standards and Specifications including Safety Standards for Natural Gas Pipelines) Regulations, 2009.

j) Company Standard Specifications

i)	6-71-0051	:	Standard Specification for Pipeline Construction (Onshore)
ii)	6-77-0006	:	Welding Specification for Onshore Pipeline for Transportation of Gas.
iii)	6-77-0007	:	Welding Specification for Onshore Pipelines for Transportation of Liquid Hydrocarbons

2.2 In case of conflict between the requirements of this specification and that of the above referred codes, standards, and specifications, the requirement of this specification shall govern.

2.3 For the purpose of this specification the following definitions shall hold:

- The words "Shall" and "Must" are mandatory.

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- The words "Should', "May" and "Will" are non-mandatory, advisory or recommended.

3.0 GENERAL

3.1 Hydrostatic test shall be performed on the entire length of the pipeline. Hydrostatic test shall be performed in accordance with approved Hydrostatic Test Diagrams clearly indicating the number of test sections and minimum and maximum test pressures in each test sections. The maximum length of each test section shall not exceed 50 km.

3.2 For pipeline sections which in Company's opinion, once installed would require an inordinate amount of effort for repair in case of a leak, a provisional pre-test shall be conducted. However, after installation, such pre-tested sections shall be tested again along with the entire pipeline.

3.3 Hydrostatic test shall commence only after mechanical and civil works completion, i.e., all welds have been accepted and the pipeline has been laid and backfilled. Hydrostatic test shall include those sections which have been previously tested viz. Rail/road crossings, major water crossings including test on banks and in place after installation, and scraper traps at the terminals. Contractor shall perform all works required for hydrostatic testing after obtaining prior written approval from the Company.

4.0 HYDROSTATIC TEST PROCEDURE MANUAL

Contractor shall prepare for Company's approval a hydrostatic test procedure manual. The procedure shall strictly comply with the requirements of this specification and shall be submitted to Company for approval well in advance. The procedure manual shall include all temporary materials and equipment, but not be limited to the following items:

a) A diagram for the system to be tested, indicating all fittings, vents, valves, temporary connection, relevant elevations and ratings. The diagram shall also indicate injection locations and intake and discharge lines.

b) Estimated amount of test water, water source, including required concentration of corrosion inhibitors and additives, procedure for inhibitor injection and control of concentration.

c) Filling and flushing procedures, including a complete description of all proposed equipment and instruments (including spares), their location and set-up.

d) The type and number of pigs to be used, gauging plate parameters, sequence of pigs to be launched during pig tracking system for cleaning and removal of air pockets. Pig inspection procedures, including procedure to be followed in case the caliper pig indicates damage to pipeline in excess of the values specified in governing codes.

e) Procedure for levelling and stabilization after filling and for pressurization and to allow for temperature stabilization.

f) Pressure testing procedure including a complete description of all proposed equipment and instruments (including spares), their location and set-up and proposed system for observation and recording of data during the pressure test.

g) Procedure for detection and location of leaks.

h) Procedure for dewatering the pipeline section(s) after testing, including a complete description of all proposed equipment and instruments (including spares), their

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location and set-up, the type and sequence of pigs and the pig tracking system along with the pig specification.

i) Forms for recording the test data.

5.0 TEST DURATION AND PRESSURE

5.1 The duration of hydrostatic test shall be minimum 24 hours after thermal stabilization.

5.2 Unless specified otherwise in the Contract, the hydrostatic test pressure shall be as follows:

For pipeline handling hydrocarbon in gaseous phase:

a) 1.25 times the design pressure for pipeline located in Class-1 and Class-2 locations as per ASME B 31.8.

b) 1.5 times the design pressure for pipeline located in Class-3 and Class-4 locations as per ASME B 31.8.

For pipeline handling hydrocarbon in liquid phase:

a) 1.25 times the design pressure for pipeline handling liquids including Liquefied Petroleum Gas (LPG).

The test pressure, as calculated above, shall be generated at the highest point in the section under test. At any point in the test section hoop-stress due to test pressure and static head shall not exceed 95% of the SMYS of pipe material.

6.0 EQUIPMENT AND INSTRUMENTATION

The Contractor shall furnish all necessary equipment for performing the work as stated in cleaning, flushing, filling, stabilising, testing and dewatering procedures.

This shall include, but not be limited to the following equipment and instruments:

a) Pigs for cleaning, filling and gauging

- Cleaning pigs with spring loaded steel wire brushes. For internally coated pipes, the pigs shall be provided with nylon/polyurethane brushes.
- Four cup batching pigs.
- Gauging pigs fitted with gauge plate.

The Contractor shall provide a sufficient number of pigs, including spares.

b) Fill pumps:

The Contractor shall determine the type and number of fill pumps in order to guarantee the following:

- Differential Head : 20% greater than the maximum required
- Flow Rate : Minimum 400 m^3/h; Maximum 1000 m^3/h

If a single pump is used, a standby unit must be available.

c) Variable speed positive displacement pumps equipped with a stroke counter to pressurize the pipeline. The pump shall be capable of exceeding the maximum test pressure by at least 20 bar. Contractor shall also ensure availability of standby pressurizing pump.

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d) Two positive displacement meters to measure the volume of water used for filling the line. These meters shall be provided with a calibration certificate not older than three months.

e) Portable tanks of sufficient size to provide a continuous supply of water to the pump during filling and pressurizing.

f) Bourdon pressure gauges of suitable pressure range and accuracy.

g) Dead weight testers with an accuracy of 0.01 bar measuring with least count of 0.05 bar provided with a calibration certificate not older than three months.

h) Two 24 hours recording pressure gauges complete with pressure recording charts and ink, duly tested with dead weight tester prior to use. These shall be installed at the test head.

i) Two temperature recorders for fill water.

j) Thermocouples duly calibrated for measuring the pipe wall temperature.

k) Two laboratory thermometers of range 0°C to 60°C and with accuracy of ±0.2° C to be used in thermowells.

l) Means to measure the volume of water necessary to drop the line pressure by 0.5 bar (container on scales or graduated cylinder)

m) Injection facilities to inject additives into the test medium in the required proportions.

n) Communication equipment suitable for a continuous connection between the beginning and the end of the test section and with the inspection team along the line, in accordance with the requirements of Local Authorities.

o) The temporary scraper traps shall be installed according to the test section fixed in the test procedure manual. Proper piping and valve arrangements shall be available to allow launching and receiving of each pig independently.

The test heads shall be sized in conformity with ASME specification Section VIII, Division 2.

p) Thermocouples for measuring the temperature of the pipe wall and soil shall be installed at the following locations:

- One pair of thermocouples at about 500 m distance from the pumping head.
- One pair of thermocouples every 2500 m of the pipe. The spacing may be increased to maximum 5000 m depending on the terrain and nature of sub soil along the alignment of test section.
- One pair of thermocouples at about 500 m distance from the terminal head.

Thermocouples shall be attached on the external surface of the pipe after removal of external coating and shall be adequately protected by padding with minimum 500 mm soil. After successful testing, the thermocouples shall be removed and damaged coating shall be repaired as per applicable coating repair procedure, approved by Company. For soil temperature measurements, the thermocouple shall be buried at pipe centerline depth at a distance of 500 mm from the pipe wall.

q) Digital pressure/ temperature monitoring and chart recording systems can be used in lieu of the components listed above provided that the individual pressure/

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temperature sensors included in the system have a level of accuracy and can be field calibrated in a manner similar to those instruments listed above. Instruments shall be portable and rugged in construction with minimum weatherproof rating of IP-66. They shall display pressure and temperature readings on the screen and shall have adequate memory for recording the same. The instrument shall have computer interface to export the stored data after completion of test.

7.0 PROCEDURES

7.1 Equipment and/or parts which need not or must not be subjected to the test pressures or which must not be tested with water, must be disconnected or separated from the pipeline to be tested.

7.2 If the difference of minimum and maximum atmospheric temperature should cause thermal instability on the pipe section directly exposed to atmospheric condition, the scraper traps and above ground pipeline shall be properly protected.

The pipeline test shall exclude long segments of line exposed to atmospheric conditions, viz. aerial lengths on piers, suspension bridges, etc. Such sections shall be tested separately.

7.3 The test medium shall be soft non-aggressive water furnished by the Contractor. The water to be used shall be filtered, shall not be contaminated and shall be free from sand or silt. Contractor shall submit laboratory test reports of water used for testing. The possible use of sea water shall be subject to its degree of cleanness, the possibility of obtaining a pre-determined salinity neutralisation and the use of corrosion inhibitors, this at the sole discretion of Company. Contractor shall provide Company approved corrosion inhibitors, oxygen scavengers and bactericides to be added to the test water. The Contractor shall furnish and install all temporary piping, which may be necessary to connect from source of water to its pump and manifolds/tankages.

The following products are acceptable for corrosion inhibition of the water used for hydro testing:

- REMIDOL 4000 of M/s Chemtreat India Ltd., Navi Mumbai.
- HIBITOL 2000 of M/s Renkal Chemical, Navi Mumbai.
- INDION 175 of M/s Ion Exchange India Ltd., Hyderabad.
- VISCO 3900 of M/s NALCO EXXON.

Indicative dosage for inhibitor is as follows:

- Upto 6 months : 500 mg/l
- Above 6 months : 750 mg/l

However the exact dosage rates shall be as per the hydro test water analysis and manufacturer recommendation.

Contractor shall note the following:

a. All chemicals for hydrotesting shall be procured from approved vendors. Chemicals older than three months shall not be used.

b. Company representative shall inspect the chemical containers and take random samples prior to its use. Contractor shall get the samples tested in an EIL nominated Govt./PSU/other competent laboratories. Testing shall be carried out for accelerated % corrosion inhibition efficiency, % SRB and TBC killing efficiency test. Company reserves the right to witness the testing. The test report shall be submitted to Company for approval prior to undertaking hydro testing works.

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c. Only those chemicals which have passed the above tests shall be used for hydrotesting.

d. Chemicals shall be injected by dosing pump only and mixing in open tank shall not be allowed

7.4 Before filling operation, the Contractor shall clean the pipeline by air driven pigs provided with spring loaded brushes and chisels to remove all mill scale, rust, sand, etc. from the inside of pipe section. For this purpose, temporary headers for air cleaning shall be attached to the pipeline. The number of pig runs depends upon the cleaning results and shall be determined by the Company at site.

7.5 After cleaning the pipeline by using air and acceptance by Company, gauging shall be carried out by using gauging pig. The gauge plate diameter shall be equal to 95% of inside diameter of the heaviest wall pipe in the test section. While computing the ID of heaviest wall pipe, pipe manufacturing tolerances shall not be considered. A 10 mm thick aluminium plate shall be used for making the gauge plate.

After receipt of gauging pig at the other end, the gauge plate shall be inspected in the presence of Company representative. A deformed, bent or severally nicked plate or damaged pig shall be evidence of gauging pig run failure and the same shall not be acceptable to COMPANY. In such cases the Contractor shall repair and rectify the line and repeat the gauging pig run to the satisfaction and approval of the Company Representative. Any obstruction and/or faults such as dents, buckles, flat spots, etc. analysed and noted during gauging pig run shall be located and any necessary repair work shall be performed to rectify the same to the satisfaction of the Company. A written approval shall be obtained from Company regarding successful completion of gauging pig run.

After acceptance of gauging operation, air header shall be cut and removed. Pre-tested test headers loaded with three numbers of four cup batching pigs shall be welded to test section.

The drawing of the test headers shall be submitted along with hydrotest procedure for approval. All fittings and flanges to be used in the test header fabrication shall be at least one ANSI rating higher than the line rating. The headers shall be pretested at line hydrotest pressure for duration of minimum 24 hours. The record shall be kept and shall be part of the final hydro test report.

Weld joints between test header and pipeline shall be radiographed. Un-inhibited water equal to 10% of the volume of test section shall be introduced in front of the first pig. The first pig shall be launched by introducing about 1.5 km un-inhibited water. Then the second pig shall be launched by pumping the inhibited water till the second pig is received at the other end. Subsequent to receipt of second pig, the pressurization and thermal stabilization operation can commence.

7.6 Thermal stabilization

After a check has been made to confirm if the pressure has attained at least 1 bar (g) on the highest section, the thermal stabilization can be started.

Thermal equilibrium between the pipeline and environment shall be checked through the thermocouples installed on the pipeline and in the soil.

Pipe and soil temperature readings shall be taken at 2 hours-intervals. Thermal stabilization shall be considered to have been achieved when a difference not higher than 1°C is attained between the average pipe temperature and average soil temperature. Thermal stabilization completion shall be approved by Company.

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7.7 Pressurisation

7.7.1 The pressurization shall be performed in the presence of Company at a moderate and constant rate not exceeding 2 bars/min. One pressure recording gauge shall be installed in parallel with the dead weight tester. Volume required to reach the test pressure shall be recorded periodically throughout the pressurization as follows:

a) Each 5 bar increments up to 80% of test pressure as recorded by the dead weight tester;
b) Each 2 bar increments between 80% to 90% of test pressure as recorded by the dead weight tester;
c) Each 0.5 bar increments between 90% of the test pressure to full test pressure as recorded by the dead weight tester.

7.7.2 The pressurisation shall be cycled according to the following sequence:

a) Pressurise to 50% of test pressure, hold pressure for 1 hour,
b) Drop pressure to static head of test section at test head,
c) Pressurise to 75% of test pressure, hold pressure for 1 hour
d) Drop pressure to static head of test section at the test head
e) Pressurise to 100% of test pressure, hold pressure for 1 hour
f) Drop pressure to static head of test section at the test head
g) Pressurise to test pressure.

During the pressurisation to each test pressure, three tests shall be carried out for the calculation of air volume in the pipeline under test at 50% 75% and 100% of test pressure.

In case, during the hold pressure periods indicated above, a decrease in pressure in observed, the above operations shall not be repeated more than twice, after which the line shall not be considered capable of test, until the Contractor has isolated and eliminated the cause for the lack of water tightness.

7.8 Air Volume Calculation.

In order to check the presence of air in the pipeline, two separate consecutive pressure lowering of 0.5 bar shall be carried out after pressurizing to test pressure.

For calculation of air in the pipeline the second pressure lowering shall be used, and the relevant drained water shall be accurately measured (V_I). This amount measured shall be compared to the theoretical amount (V_P) corresponding to the pressure lowering that has been carried out, by using the procedure outlined in clause 12.1 of this specification.

If no air is present in the length under test:

$$\frac{V_I}{V_P} = 1$$

In order that the above ratio is acceptable, it shall not differ from 1 by more than 6% (i.e. 1.06). If the air found in the pipeline is within the above established tolerance, then the pressurising can continue. If the ratio V_I/V_P exceeds 1.06, the hydrostatic testing cannot go on and additional pig passages shall be performed to remove the air pockets. V_I/V_P ratio less than 1 shall not be acceptable. In such a case all hydrotest calculations for V_P including pipe book lengths shall be rechecked.

The test shall be repeated as per the above procedure until above estimated tolerances are satisfied. The pressurising can then continue, to reach the value of the test pressure.

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7.9 Testing

After the section has been pressurised and the air volume test has given acceptable results the test pressure shall be held for a minimum of 24 hours after stabilisation. After temperature and pressure has stabilised, the injection pump shall be disconnected and all connections at the test heads shall be checked for leakage. The pressure recorders shall then be started with the charts in a real time orientation for continuous recording throughout the test.

During the testing period the following measurements shall be recorded/reported

- Every one hour pressure measurements from dead weight testers.
- Every two hour the ambient temperature and the pipe temperature at the thermocouples.

All data shall be recorded on appropriate forms attached to the hydrostatic test procedure manual. Care shall be taken that the maximum test pressures are not exceeded. Bleed-off water shall be accurately measured and recorded.

8.0 ACCEPTANCE

8.1 The hydrostatic test shall be considered as positive if pressure has kept a constant value throughout the test duration, except for change due to temperature effects. Such changes shall be evaluated as deseribed under clause 12.2 of this specification.

The pressure change value as a function of temperature change shall be algebraically added to the pressure value as read on the meters. The pressure value thus adjusted shall be compared with the initial value and the test shall be considered as acceptable if the difference is less than or equal to 0.3 bar. In case of doubt the testing period shall be extended by 24 hours.

8.2 If test section fails to maintain the specified test pressure after isolation, Contractor shall determine the location of leakage or failure by suitable means. All leaks and failures within the pipe wall or weld seams shall be repaired by replacement of entire joint or joints in which leakage or failure occurs. In those cases where leaks occur in circumferential welds the method of repair shall be determined by the Company. Contractor shall comply with instructions of the Company whether to replace a section of the line pipe that includes the line leak or whether to repair the circumferential weld. This repair should, however, meet the requirements of applicable welding specification enclosed with the Contract. Where failures occur in pipeline field bends, bends shall be replaced with same degree of bends. After completion of repairs, the hydrostatic test shall be repeated in full, as per this specification.

8.3 The cost of repairs or replacements, followed by refilling and repressurising the line, due to poor workmanship, shall be borne by the Contractor. In the event of leaks or failures resulting from faulty Company furnished materials, Contractor shall be reimbursed as per the provisions of Contract. All work of reinstalling line pipe, to replace failures, shall be done in accordance with the relevant specifications included in the CONTRACT.

8.4 Contractor shall haul and stockpile all damaged and defective pipes to storage location designated by the Company. All cracks and splits resulting from failure shall be coated with an application of grease to preserve the characteristics of failures from corrosion. Joint of failed pipes shall be marked with paint, with a tag indicating failure details, date and location of failure and pressure at which failure occurred. Failed pipes shall have pipe number and heat number clearly marked on the outside surface along with warning sign to prevent re-usage.

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9.0 TERMINATION

After the positive result of testing and completion of data gathering, the test shall be terminated upon written approval given by the Company. The pipeline shall be slowly depressurised at a moderate and constant rate as instructed by Company. Subsequent operations such as caliper pigging, swabbing, drying, purging/inertising and commissioning shall be carried out as per the applicable specifications enclosed with the Contract.

9.1 Contractor shall dewater the tested line as per the following requirement after test acceptance.

Dewatering shall be carried out by using four cup pigs and foam pigs driven by compressed air. The detailed dewatering procedure shall be deployed by the Contractor in such a way as to provide adequate control of pigs during dewatering. Pigs and equipment required for dewatering the line shall be furnished by Contractor and shall be approved in advance by the Company. Four cup pigs shall first be passed through the line to displace the water. Foam pigs shall then be passed in order to complete the line dewatering. Contractor shall use a number of foam pigs each in different colours/numbered for this purpose. The line shall be considered dewatered when a negligible amount of water is flushed out by the last foam pig and approval is given by the Company.

9.2 Before the start of dewatering and disposal of hydrotest water, a procedure for treatment of inhibited water to prevent pollution shall be submitted by Contractor to Company for review and approval. During dewatering, care shall be taken to properly dispose off the discharged water in order to avoid pollution, damages to fields under cultivation and/or existing structures and interference with traffic.

9.3 Upon completion of the testing and dewatering operation, any provisional traps for pigs and all other temporary installation relating to the test shall be removed. Subsequently, the individual sections of the line already tested shall be joined in accordance with the requirements of relevant specifications issued for the purpose.

10.0 TEST REPORT

A complete report signed by Contractor and the Company shall be submitted upon completion of the hydrostatic test for each test section.

This report shall contain as a minimum:

- The cleaning, flushing, filling and testing procedures used;
- Schematic layout of cleaning, filling and testing facilities;
- Instrument calibration certificates;
- A profile of the pipeline that shows the test sites, all instrument and injection connections;
- Pipe filling logs and records;
- Additive specification, required concentration and additive injection records;
- Pig specifications;
- Pig inspection records including photographs of the damages;
- Records of gauging pig survey and photographs;
- Pressurisation and stabilisation records;
- Pressure and temperature recording charts with appropriate information inscribed thereon;
- Temperature data along the pipeline;
- Dead weight tester logs and recordings;
- Air volume calculations;
- Pressure change due to temperature change calculations;
- Environmental data;

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- Depressurisation logs and records;
- Dewatering procedure and schematic layout of relevant facilities;
- Dewatering logs and records;
- Records and photographs of all leaks, if applicable.

11.0 MEASUREMENTS

11.1 Water Amount Measurements

The water volume added to the section to be tested shall be measured during the filling stage through a positive displacement meter (a turbine meter may also be used).

In the calculation, as per clause 12.1 of this specification, use shall be made of the geometrical volume of the section in question. The water amount that has been let into the section shall be measured during the pressurisation stages thorough positive displacement meters or turbine meters.

11.2 Pressure Measurement

Pressure shall be measured with a dead weight tester that shall permit readings with least count of 0.05 bar.

During the test, the pressure shall be recorded by means of a recording pressure gauge featuring the following specifications:

Accuracy	:	± 0.1% of the full-scale value
Recording	:	Continuous on tape or disk, graph width 100mm
Feed	:	20mm/h for tape diagrams, 15°/h for disk diagrams
Recording range	:	To be such as to record pressure between 50% and 90% of the diagram width.

The recording pressure gauge shall be checked by means of dead weight test at the beginning, and at the end of the hydrostatic test.

11.3 Temperature Measurements

a) Water temperature shall be taken at every 2 hours through the thermocouples that have been installed on the pipe wall along the section under test.

Further, the temperature measurement shall be taken:

- During the filling operation
- During the thermal stabilisation stage
- During the hydrostatic test

The thermocouples' sensitivity shall enable temperature readings with the accuracy of ±0.1°C.

b) Water temperature shall also be measured on the pump delivery by means of a recording thermometer throughout the filling stage.

The recording thermometer shall feature the following characteristics:

Accuracy	:	± 1% of the scale range
Scale	:	-10° to +40°C

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Recording	:	Continuous on tape or disk, diagram width 100mm
Feed	:	20mm/h for tape diagrams, 15°/h for disk diagram

c) Ground temperature shall be taken at every two hours though the thermocouples that have been installed in the soil along the section under test.

d) Environmental temperature shall be recorded from the beginning of pressurization to the end of the test by means of a recording thermometer featuring the following characteristics:

Accuracy	:	± 1% of the scale range
Scale	:	0° to +60°C
Recording	:	Continuous on tape or disk, diagram width 100mm
Feed	:	20mm/h for tape diagrams, 15°/h for disk diagrams.

12.0 CALCULATIONS

12.1 The theoretical water amount that is necessary for filling the section to be tested shall be obtained from the geometrical volume of the section considering the pipe tolerances.

The theoretical water amount that is necessary for pressurizing the section shall be calculated by means of the following formula:

$$V_P = (0.884 \frac{ri}{t} + A) \times 10^{-6} \times V_t \times \Delta P \times K$$

Where

V_P	=	computed water amount required to raise the pressure by ΔP in the section to be tested (m^3)
V_t	=	geometrical volume of the section (m^3)
ΔP	=	pressure rise (bar)
ri	=	nominal inner radius of the pipe (mm)
t	=	nominal pipe thickness (mm)
A	=	isothermal compressibility value of water at the pressurization temperature in the P range (bar^{-1}) x 10^6 (Refer water compressibility factor v/s pressure and temperature charts-Figures 1 & 2, For temperature above 40°C the values may be extrapolated.)
K	=	a dimensionless coefficient that is equal to a value of 1.02 for welded pipes.

12.2 The pressure change due to a water temperature change shall be calculated through the following formula:

$$\Delta P = \frac{B}{0.884 \frac{ri}{t} + A} \Delta T$$

where

ΔP	=	pressure change resulting from a temperature change (bar)
ΔT	=	algebrical difference between water temperature at the beginning of the test and water temperature as measured at the end of the test (°C).
B	=	Value of the difference between the thermal expansion of water at the pressure and temperature as measured at the end of the test and that of steel ($°C^{-1}$) x 10^6

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(Refer Table 1)

A = Isothermal compressibility value of water as estimated at the pressure and temperature values obtained at the end of test (bar^{-1}) x 10^6
(Refer Figures 1 & 2)

ri = nominal inner radius of the pipe (mm)
(in case of the test section having multiple wall thicknesses, "ri" shall correspond to the wall thicknesses, having the maximum total length in the given test section).

t = nominal pipe thickness (mm)

13.0 PRECAUTIONS DURING THE TEST

In addition to all that has been expressly described in the procedures for carrying out the tests, the following additional requirements shall be complied with:

13.1 Provision shall be made for the installation of no-admittance signs to unauthorised personnel from the roads to the R.O.U.

13.2 Signs stating 'PIPE UNDER TEST-KEEP OFF" with local language translation shall be placed where the pipeline is uncovered, and particularly where the provisional traps and stations are located. Such areas shall be suitably fenced in such a way as to prevent access of unauthorised personnel. No unauthorised personnel shall be closer than 40M to the pipeline or equipment under test.

13.3 Provisional scraper traps shall be installed in compliance with methods and suitable location so that their rupture cannot cause any injuries to the personnel or third parties.

13.4 The test station shall be placed in such a location as to prevent it from being affected by a catastrophic failure in the test head.

13.5 Once dewatering is over the sectionalising valves and other valve assemblies tested previously, shall be installed at locations shown in the drawings and in accordance with the procedures contained in the relevant specifications. All thermocouples installed in the pipeline shall be removed and damaged corrosion coating shall be repaired using Company approved materials and procedure.

14.0 PRESERVATION OF PIPELINE

When so stated in the CONTRACT, to preserve/conserve the pipeline for a specified duration, Contractor shall completely fill the pipeline with water, with sufficient quantity of corrosion inhibitors depending upon quality of water and the period of conservation, at a pressure to be agreed upon with the Company at a later stage. Contractor shall obtain necessary approval from the Company of the procedure, type and quality and quantity of inhibitors used before commencement of the works.

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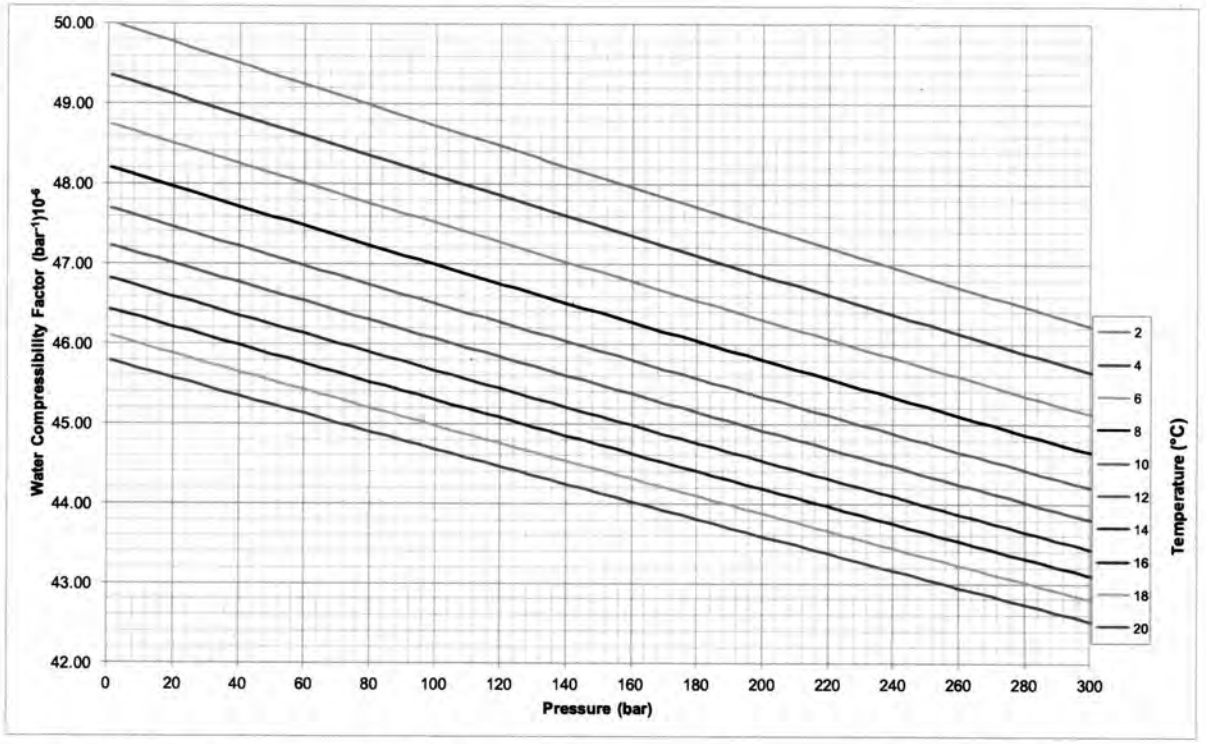

Fig. 1: Water Compressibility Factor v /s. Pressure and Temperature (2 °C – 20 °C)

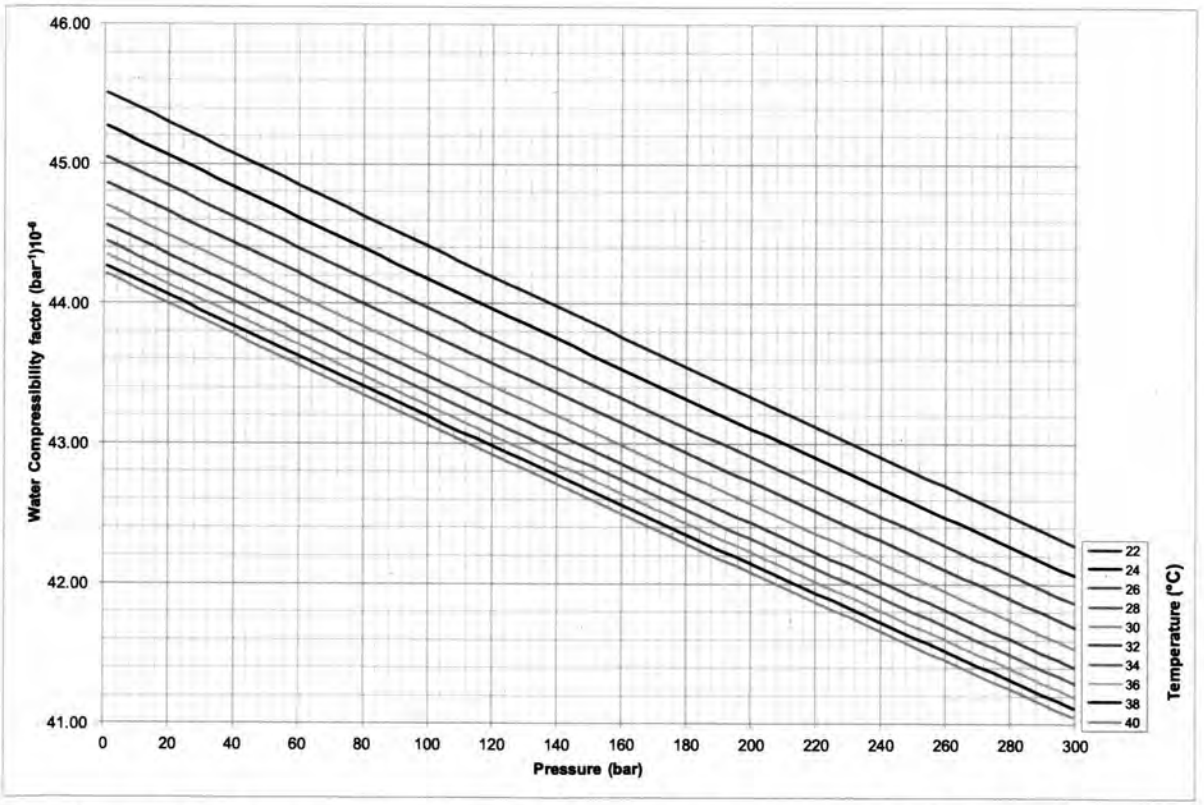

Fig. 2: Water Compressibility Factor v /s. Pressure and Temperature (22 °C – 40 °C)

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°C bar	1	2	3	4	5	6	7	8
.981	-87.24	-69.35	-51.98	-35.10	-18.70	-2.78	12.68	27.69
10	-84.30	-66.54	-49.28	-32.52	-16.23	-0.42	14.94	29.86
20	-81.05	-63.42	-46.29	-29.66	-13.49	2.20	17.45	32.26
30	-77.80	-60.30	-43.31	-26.79	-10.76	4.82	19.96	34.65
40	-74.54	-57.18	-40.32	-23.93	-8.02	7.45	22.46	37.05
50	-71.29	-54.07	-37.33	-21.07	-5.28	10.07	24.97	39.45
60	-68.04	-50.95	-34.34	-18.21	-2.54	12.69	27.48	41.85
70	-64.78	-47.83	-31.36	-15.35	0.20	15.31	29.99	44.24
80	-61.53	-44.71	-28.37	-12.49	2.94	17.93	32.49	46.64
90	-58.28	-41.60	-25.38	-9.63	5.68	20.55	35.00	49.04
100	-55.03	-38.48	-22.40	-6.77	8.42	23.17	37.51	51.44
110	-51.77	-35.36	-19.41	-3.91	11.16	25.79	40.02	53.84
120	-48.52	-32.24	-16.42	-1.04	13.90	28.42	42.52	56.23
130	-45.27	-29.12	-13.43	1.82	16.64	31.04	45.03	58.63
140	-42.01	-26.01	-10.45	4.68	19.38	33.66	47.54	61.03
150	-38.76	-22.89	-7.46	7.54	22.11	36.28	50.05	63.43
160	-35.51	-19.77	-4.47	10.40	24.85	38.90	52.56	65.83
170	-32.26	-16.65	-1.48	13.26	27.59	41.52	55.06	68.22
180	-29.00	-13.53	1.50	16.12	30.33	44.14	57.57	70.62
190	-25.75	-10.42	4.49	18.98	33.07	46.77	60.08	73.02
200	-22.50	-7.30	7.48	21.84	35.81	49.39	62.59	75.42
210	-19.25	-4.18	10.47	24.71	38.55	52.01	65.09	77.81
220	-15.99	-1.06	13.45	27.57	41.29	54.63	67.60	80.21
230	-12.74	2.05	16.44	30.43	44.03	57.25	70.11	82.61
240	-9.49	5.17	19.43	33.29	46.77	59.87	72.62	85.01
250	-6.23	8.29	22.41	36.15	49.51	62.49	75.12	87.41
260	-2.98	11.41	25.40	39.01	52.25	65.12	77.63	89.80
270	0.27	14.53	28.39	41.87	54.98	67.74	80.14	92.20
280	3.52	17.64	31.38	44.73	57.72	70.36	82.65	94.60
290	6.78	20.76	34.36	47.59	60.46	72.98	85.15	97.00
300	10.03	23.88	37.35	50.46	63.20	75.60	87.66	99.40

Table 1 : Difference between the water thermal expansion factor and the steel thermal expansion

FACTOR ($°C^{-1}$) 10^{-6}

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°C bar	9	10	11	12	13	14	15	
.981	42.28	56.44	70.19	83.55	96.53	109.14	121.39	
10	44.34	58.41	72.08	85.35	98.25	110.77	122.95	
20	46.64	60.60	74.17	87.35	100.15	112.59	124.68	
30	48.93	62.79	76.26	89.34	102.06	114.41	126.41	
40	51.22	64.98	78.35	91.34	103.96	116.22	128.14	
50	53.51	67.17	80.44	93.34	105.86	118.04	129.87	
60	55.80	69.36	82.53	95.33	107.77	119.86	131.60	
70	58.10	71.55	84.63	97.33	109.67	121.67	133.34	
80	60.39	73.74	86.72	99.33	111.58	123.49	135.07	
90	62.68	75.93	88.81	101.32	113.48	125.30	136.80	
100	64.97	78.12	90.90	103.32	115.39	127.12	138.53	
110	67.26	80.31	92.99	105.31	117.29	128.94	140.26	
120	69.56	82.50	95.08	107.31	119.20	130.75	141.99	
130	71.85	84.69	97.17	109.31	121.10	132.57	143.72	
140	74.14	86.88	99.26	111.30	123.01	134.39	145.45	
150	76.43	89.07	101.35	113.30	124.91	136.20	147.19	
160	78.72	91.26	103.45	115.29	126.81	138.02	148.92	
170	81.01	93.45	105.54	117.29	128.72	139.83	150.65	
180	83.31	95.64	107.63	119.29	130.62	141.65	152.38	
190	85.60	97.83	109.72	121.28	132.53	143.47	154.11	
200	87.89	100.02	111.81	123.28	134.43	145.28	155.84	
210	90.18	102.21	113.90	125.27	136.34	147.10	157.57	
220	92.47	104.40	115.99	127.27	138.24	148.92	159.30	
230	94.77	106.59	118.08	129.27	140.15	150.73	161.04	
240	97.06	108.78	120.17	131.26	142.05	152.55	162.77	
250	99.35	110.97	122.27	133.26	143.95	154.36	164.50	
260	101.64	113.16	124.36	135.25	145.86	156.18	166.23	
270	103.93	115.35	126.45	137.25	147.76	158.00	167.96	
280	106.23	117.54	128.54	139.25	149.67	159.81	169.69	
290	108.52	119.73	130.63	141.24	151.57	161.63	171.42	
300	110.81	121.91	132.72	143.24	153.48	163.45	173.15	

Table 1 : Difference between the water thermal expansion factor and the steel thermal expansion

FACTOR ($°C^{-1}$) 10^{-6}

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°C bar	16	17	18	19	20	21	22	23
.981	133.29	144.87	156.13	167.08	177.74	188.12	198.23	208.09
10	134.78	146.29	157.48	168.36	178.96	189.28	199.33	209.13
20	136.43	147.86	158.97	169.78	180.31	190.56	200.55	210.29
30	138.08	149.43	160.46	171.21	181.66	191.84	201.77	211.44
40	139.73	151.00	161.96	172.63	183.01	193.13	202.99	212.60
50	141.38	152.57	163.45	174.05	184.36	194.41	204.20	213.75
60	143.03	154.14	164.95	175.47	185.71	195.69	205.42	214.91
70	144.68	155.71	166.44	176.89	187.07	196.98	206.64	216.07
80	146.33	157.28	167.94	178.31	188.42	198.26	207.86	217.22
90	147.98	158.85	169.43	179.73	189.77	199.54	209.08	218.38
100	149.63	160.42	170.93	181.16	191.12	200.83	210.30	219.53
110	151.28	161.99	172.42	182.58	192.47	202.11	211.51	220.69
120	152.92	163.56	173.92	184.00	193.82	203.40	212.73	221.84
130	154.57	165.13	175.41	185.42	195.17	204.68	213.95	223.00
140	156.22	166.70	176.91	186.84	196.52	205.96	215.17	224.16
150	157.87	168.27	178.40	188.26	197.88	207.25	216.39	225.31
160	159.52	169.84	179.89	189.69	199.23	208.53	217.61	226.47
170	161.17	171.41	181.39	191.11	200.58	209.81	218.82	227.62
180	162.82	172.99	182.88	192.53	201.93	211.10	220.04	228.78
190	164.47	174.56	184.38	193.95	203.28	212.38	221.26	229.93
200	166.12	176.13	185.87	195.37	204.63	213.66	222.48	231.09
210	167.77	177.70	187.37	196.79	205.98	214.95	223.70	232.25
220	169.42	179.27	188.86	198.21	207.33	216.23	224.92	233.40
230	171.07	180.84	190.36	199.64	208.69	217.51	226.14	234.56
240	172.72	182.41	191.85	201.06	210.04	218.80	227.35	235.71
250	174.37	183.98	193.35	202.48	211.39	220.08	228.57	236.87
260	176.02	185.55	194.84	203.90	212.74	221.37	229.79	238.02
270	177.66	187.12	196.34	205.32	214.09	222.65	231.01	239.18
280	179.31	188.69	197.83	206.74	215.44	223.93	232.23	240.34
290	180.96	190.26	199.32	208.17	216.79	225.22	233.45	241.49
300	182.61	191.83	200.82	209.59	218.14	226.50	234.66	242.65

Table 1 : Difference between the water thermal expansion factor and the steel thermal expansion

FACTOR ($°C^{-1}$) 10^{-6}

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°C bar	24	25	26	27	28	29	30	
.981	217.71	227.09	236.27	245.24	254.02	262.62	271.05	
10	218.69	228.03	237.15	246.07	254.80	263.36	271.75	
20	219.79	229.07	238.13	247.00	255.68	264.19	272.53	
30	220.89	230.10	239.11	247.93	256.55	265.01	273.31	
40	221.98	231.14	240.10	248.85	257.43	265.83	274.08	
50	223.08	232.18	241.08	249.78	258.30	266.66	274.86	
60	224.17	233.22	242.06	250.71	259.18	267.48	275.64	
70	225.27	234.25	243.04	251.64	260.05	268.31	276.41	
80	226.36	235.29	244.02	252.56	260.93	269.13	277.19	
90	227.46	236.33	245.00	253.49	261.81	269.96	277.96	
100	228.55	237.36	245.98	254.42	262.68	270.78	278.74	
110	229.65	238.40	246.96	255.34	263.56	271.61	279.52	
120	230.74	239.44	247.94	256.27	264.43	272.43	280.29	
130	231.84	240.48	248.93	257.20	265.31	273.26	281.07	
140	232.93	241.51	249.91	258.13	266.18	274.08	281.85	
150	234.03	242.55	250.89	259.05	267.06	274.91	282.62	
160	235.12	243.59	251.87	259.98	267.93	275.73	283.40	
170	236.22	244.62	252.85	260.91	268.81	276.56	284.18	
180	237.31	245.66	253.83	261.83	269.68	277.38	284.95	
190	238.41	246.70	254.81	262.76	270.56	278.21	285.73	
200	239.51	247.74	255.79	263.69	271.43	279.03	286.50	
210	240.60	248.77	256.77	264.62	272.31	279.86	287.28	
220	241.70	249.81	257.76	265.54	273.18	280.68	288.06	
230	242.79	250.85	258.74	266.47	274.06	281.51	288.83	
240	243.89	251.88	259.72	267.40	274.93	282.33	289.61	
250	244.98	252.92	260.70	268.32	275.81	283.16	290.39	
260	246.08	253.96	261.68	269.25	276.68	283.98	291.16	
270	247.17	255.00	262.66	270.18	277.56	284.81	291.94	
280	248.27	256.03	263.64	271.11	278.43	285.63	292.72	
290	249.36	257.07	264.62	272.03	279.31	286.46	293.49	
300	250.46	258.11	265.60	272.96	280.18	287.28	294.27	

Table 1: Difference between the water thermal expansion factor and the steel thermal expansion

FACTOR ($°C^{-1}$) 10^{-6}

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°C bar	31	32	33	34	35	36	37	38
.981	279.34	287.48	295.50	303.41	311.21	318.93	326.57	334.15
10	280.00	288.10	296.08	303.95	311.72	319.40	327.00	334.55
20	280.73	288.78	296.72	304.55	312.27	319.91	327.48	334.99
30	281.45	289.47	297.36	305.14	312.83	320.43	327.96	335.43
40	282.18	290.15	298.00	305.74	313.38	320.95	328.43	335.86
50	282.91	290.84	298.64	306.34	313.94	321.46	328.91	336.30
60	283.64	291.52	299.28	306.94	314.50	321.98	329.39	336.74
70	284.37	292.21	299.92	307.53	315.05	322.49	329.86	337.18
80	285.10	292.89	300.56	308.13	315.61	323.01	330.34	337.62
90	285.83	293.57	301.20	308.73	316.17	323.53	330.82	338.06
100	286.56	294.26	301.84	309.33	316.72	324.04	331.30	338.50
110	287.29	294.94	302.48	309.92	317.28	324.56	331.77	338.94
120	288.02	295.63	303.12	310.52	317.84	325.07	332.25	339.37
130	288.75	296.31	303.76	311.12	318.39	325.59	332.73	339.81
140	289.48	297.00	304.40	311.72	318.95	326.11	333.20	340.25
150	290.21	297.68	305.04	312.32	319.50	326.62	333.68	340.69
160	290.94	298.36	305.68	312.91	320.06	327.14	334.16	341.13
170	291.67	299.05	306.32	313.51	320.62	327.65	334.63	341.57
180	292.40	299.73	306.97	314.11	321.17	328.17	335.11	342.01
190	293.13	300.42	307.61	314.71	321.73	328.69	335.59	342.44
200	293.86	301.10	308.25	315.30	322.29	329.20	336.06	342.88
210	294.59	301.78	308.89	315.90	322.84	329.72	336.54	343.32
220	295.32	302.47	309.53	316.50	323.40	330.24	337.02	343.76
230	296.05	303.15	310.17	317.10	323.96	330.75	337.50	344.20
240	296.77	303.84	310.81	317.69	324.51	331.27	337.97	344.64
250	297.50	304.52	311.45	318.29	325.07	331.78	338.45	345.08
260	298.23	305.21	312.09	318.89	325.62	332.30	338.93	345.51
270	298.96	305.89	312.73	319.49	326.18	332.82	339.40	345.95
280	299.69	306.57	313.37	320.09	326.74	333.33	339.88	346.39
290	300.42	307.26	314.01	320.68	327.29	333.85	340.36	346.83
300	301.15	307.94	314.65	321.28	327.85	334.36	340.83	347.27

Table 1 : Difference between the water thermal expansion factor and the steel thermal expansion

FACTOR ($°C^{-1}$) 10^{-6}

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°C bar	39	40	41	42	43	44	45	
.981	341.68	349.18	356.65	364.10	371.57	379.04	386.54	
10	342.05	349.51	356.94	364.37	371.80	379.24	386.71	
20	342.45	349.87	357.27	364.66	372.06	379.46	386.90	
30	342.85	350.23	357.60	364.95	372.31	379.69	387.09	
40	343.25	350.60	357.93	365.25	372.57	379.91	387.28	
50	343.65	350.96	358.26	365.54	372.83	380.13	387.46	
60	344.05	351.33	358.58	365.83	373.09	380.35	387.65	
70	344.45	351.69	358.91	366.13	373.34	380.58	387.84	
80	344.85	352.06	359.24	366.42	373.60	380.80	388.03	
90	345.25	352.42	359.57	366.71	373.86	381.02	388.22	
100	345.66	352.79	359.90	367.00	374.12	381.25	388.40	
110	346.06	353.15	360.23	367.30	374.37	381.47	388.59	
120	346.46	353.51	360.55	367.59	374.63	381.69	388.78	
130	346.86	353.88	360.88	367.88	374.89	381.91	388.97	
140	347.26	354.24	361.21	368.18	375.15	382.14	389.16	
150	347.66	354.61	361.54	368.47	375.40	382.36	389.35	
160	348.06	354.97	361.87	368.76	375.66	382.58	389.53	
170	348.46	355.34	362.20	369.05	375.92	382.81	389.72	
180	348.87	355.70	362.52	369.35	376.18	383.03	389.91	
190	349.27	356.07	362.85	369.64	376.43	383.25	390.10	
200	349.67	356.43	363.18	369.93	376.69	383.47	390.29	
210	350.07	356.80	363.51	370.22	376.95	383.70	390.47	
220	350.47	357.16	363.84	370.52	377.21	383.92	390.66	
230	350.87	357.52	364.17	370.81	377.47	384.14	390.85	
240	351.27	357.89	364.50	371.10	377.72	384.36	391.04	
250	351.67	358.25	364.82	371.40	377.98	384.59	391.23	
260	352.08	358.62	365.15	371.69	378.24	384.81	391.42	
270	352.48	358.98	365.48	371.98	378.50	385.03	391.60	
280	352.88	359.35	365.81	372.27	378.75	385.26	391.79	
290	353.28	359.71	366.14	372.57	379.01	385.48	391.98	
300	353.68	360.08	366.47	372.86	379.27	385.70	392.17	

Table 1: Difference between the water thermal expansion factor and the steel thermal expansion

FACTOR ($°C^{-1}$) 10^{-6}

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मानक विनिर्देशन
सिविल एवं संरचनात्मक कार्य

STANDARD SPECIFICATION
CIVIL & STRUCTURAL WORKS

सादा एवं प्रबलित सीमेंट कंक्रीट
PLAIN AND REINFORCED CEMENT CONCRETE

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
8	07 DEC 22	UPDATED & REVISED	DK	DA	AS	SM
7	29th JAN 16	UPDATED & REISSUED	AJS	AS	RS	SC
6	15th DEC 14	UPDATED & REISSUED	SP	AS	PKM	SC
5	28th DEC 12	UPDATED & REISSUED	CDS	AJS	PKM SC	DM
4	23rd NOV 07	UPDATED & REISSUED	YPC	PKM	VK	VC
3	APR,01	UPDATED & REISSUED	RPM7097	SCS	SCJ1151	MI

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Abbreviations:

ACI	:	American Concrete Institute
ASTM	:	American Society for Testing and Materials
BS	:	British Standards
GI	:	Galvanized Iron
IS	:	Indian Standard
ISO	:	International Organization for Standardization
PVC	:	PolyVinyl Chloride
RCC	:	Reinforced Cement Concrete
SCC	:	Self Compacting Concrete
SWG	:	Standard Wire Gauge

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1.0 SCOPE

This specification is applicable for Concrete Grade up to M60 and establishes the requirements of materials, mix proportioning, placing, curing, etc. of all types of cast-in-situ and precast concrete (ref. section 1.6) used in foundations, underground and above ground structures, floors, pavements etc. Any special requirements as shown or noted on the drawings shall supersede the provisions of this specification.

1.1 Reference Codes and Specifications

Apart from this specification, construction of plain and reinforced concrete works shall be in accordance with the Indian Standard Code of Practice for "Plain and Reinforced Concrete" IS 456 along with all amendments till date and other relevant codes mentioned therein.

1.2 For Liquid Retaining Structures, EIL Specification No. 6-68-0005 shall be applicable.

1.3 For Structural Steel works, EIL Specification No. 6-68-0006 & 0008 shall be applicable.

1.4 For Bipolar Concrete Penetrating Corrosion Inhibiting Admixture, EIL Specification No. 6-68-0017 shall be applicable.

1.5 For Self Compacting Concrete, EIL Specification No. 6-68-0019 shall be applicable.

1.6 For precast concrete manufacturing refer EIL Specification No. 6-68-0014.

1.7 In case of conflict between the clauses mentioned in this specification and those in the Bureau of Indian Standards (BIS), this specification shall govern.

2.0 MATERIALS

2.1 Materials for concrete viz cement, Pozzolanas, Fly Ash, Ground Granulated Blast Furnace Slag, Sand, Coarse aggregate, Water, etc. shall be as described in EIL Specification No.6-68-0002.

2.2 Materials for all reinforcements, embedment, inserts, water bars etc. shall conform to EIL Specification 6-68-0002.

2.3 Materials to be used as additive to concrete shall conform to EIL specification 6-68-0002 & 6-68-0017.

3.0 GRADES OF CONCRETE

Characteristic Compressive strength for different grades of concrete shall be as per Table-1.

TABLE – 1
GRADES OF CONCRETE

Group	Grade Designation	Specified Characteristic Compressive Strength of 150 mm cube at 28 days (N/mm^2)
Ordinary Concrete	M10 M 15 M 20	10 15 20

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TABLE – 1 (CONT.)
GRADES OF CONCRETE

Group	Grade Designation	Specified Characteristic Compressive Strength of 150 mm cube at 28 days (N/mm^2)
Standard Concrete	M 25	25
	M 30	30
	M 35	35
	M 40	40
	M 45	45
	M 50	50
	M 55	55
High Strength Concrete	M 60	60

Note: The characteristic strength is defined as the strength of material below which not more than five (5) percent of the test results are expected to fall.

4.0 TYPE OF CONCRETE MIX

4.1 Unless otherwise noted on drawings, all lean/plain concrete shall be of Nominal Mix type and reinforced concrete shall be of Design Mix type.

4.2 Nominal Mix Concrete

This concrete shall be made (without preliminary tests) by adopting nominal concrete mix with proportions of materials as specified in Table 9 of IS 456.

4.3 Design Mix Concrete

The mix shall be designed as per IS: 10262 in an approved laboratory to produce the grade of concrete having the required workability and characteristic strength not less than appropriate values given in Table-1. The target mean strength of concrete mix shall be equal to the characteristic strength plus 1.65 times the standard deviation.

As long as the quality of materials does not change, a mix design done earlier but not prior to one year may be considered adequate for later work. However, in case the source & quality of materials changes or there is a break in the continuity of construction, the Engineer-In-Charge shall ask for a new design mix.

Irrespective of the grade of concrete required to be produced as per characteristic strength criteria, the minimum cement content and maximum water cement ratio in the design concrete shall be strictly maintained as stipulated in Table 5 of IS 456.

5.0 CONCRETE MIX PROPORTIONING

Proportioning, as used in this specification, shall mean the process of determining the proportions of the various ingredients to be used to produce concrete of the required workability when fresh/green and strength, durability & surface finish, when hardened. The following information shall be collected prior to design of the concrete mix:

a) Grade designation.
b) Type of cement.
c) Maximum nominal size of aggregate.
d) Minimum cement content.
e) Maximum water cement ratio
f) Workability requirements.

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g) Exposure condition as per Table 3 & Table 4 of IS 456
h) Maximum temperature of concrete at the time of placing.
i) Method of Placing.

The Engineer-in-Charge shall verify the strength of the concrete mix, before giving his sanction of its use. However, this does not absolve the Contractor of his responsibility as regards achieving the prescribed strength of the mix. If during the execution of the work, cube tests show lower strengths than required, the Engineer-in-Charge shall order fresh trial mixes to be made by the Contractor. No claim to alter the rates of concrete work shall be entertained due to such changes in mix variations. Any variation in cement consumption shall be taken into consideration for material reconciliation. Preliminary mix designs shall be established well ahead of start of work.

5.1 Maximum Density

Suitable proportions of sand and the different sizes of coarse aggregates for each grade of concrete shall be selected to give as nearly as practicable the maximum density as per clause 10.2.3 of IS 456. This shall be determined by mathematical means, laboratory tests, field trials and suitable changes in aggregate gradation. The contractor shall ensure the same to the satisfaction of Engineer-in-Charge.

5.2 Consistency

The concrete shall have a consistency such that it shall be workable in the required position and when properly vibrated it flows around reinforcing steel, all embedded fixtures, etc.

5.3 Workability

"Workability of Concrete" shall be as per clause 7 of IS 456.

5.4 Durability

For achieving sufficiently durable concrete, strong, dense aggregates, low water-cement ratio and adequate cement content shall always be used. Workability of concrete shall be such that concrete can be completely compacted with the means available. Leak-proof formwork shall be used so as to ensure no loss of cement-slurry during pouring and compaction. Cover to reinforcement shall be uniform. Concrete mix design shall always take into account the type of cement, minimum cement content irrespective of the type of cement and maximum water cement ratio and minimum grade of concrete conforming to environmental exposure conditions (refer Table 3 of IS 456) as given in Table 5 of IS: 456.

Generally, following types of cement shall be used for Plain and Reinforced concrete works:

a) 43/ 53 Grade Ordinary Portland Cement conforming to IS 269.
b) Rapid hardening Portland Cement conforming to IS 8041.
c) Portland Slag Cement conforming to IS 455.
d) Portland Pozzolana Cement(fly ash based) conforming to IS 1489(Part 1)
e) Portland Pozzolana Cement (calcined clay based) conforming to IS 1489(Part-2).
f) Sulphate Resisting Portland Cement conforming to IS 12330

Sulphate Resisting Portland Cement shall be used only for specific requirements depending on environmental and process exposure conditions to which the structures may be subjected to like high Sulphate concentrations, processes involving Sulphur handling etc.

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5.4.1 Water Cement Ratio

Once a mix, including its water cement ratio, has been determined and approved for use by the Engineer-in-Charge, that water cement ratio shall be maintained. The Contractor shall determine the water content of the aggregates frequently as the work progresses, and the amount of mixing water shall be adjusted so as to maintain the approved water cement ratio. Maximum water-cement ratio shall be as per Table 5 of IS 456 for different exposure condition.

The minimum cement content as mentioned in Table 5 of IS 456 shall be adjusted for aggregates other than 20 mm nominal maximum size as defined in Table 6 of IS 456.

For maximum cement content refer Cl.8.2.4.2 of IS 456.

5.4.2 Where specified, Bipolar concrete penetrating corrosion inhibiting Admixture in reinforced concrete as per EIL specification No. 6-68-0017 shall be used for protecting the reinforcement from corrosion.

5.5 Limits to Deleterious Constituents

Careful selection of the mix and the constituent materials shall be made to limit the presence of deleterious constituents in concrete. The total acid soluble chloride content calculated from the mix proportion and the measured chloride content of each of the constituents shall not exceed 0.6 kg/m^3 at the time of placing of concrete. The total water soluble Sulphate content of the concrete mix shall not exceed 4 percent by mass of the cement in the mix.

6.0 BATCHING

Refer clause 10.2 of IS 456.

7.0 CONCRETE MIXING

7.1 Ready Mixed Concrete supplied by Ready Mixed Concrete Plants or from on/off-site batching plants (IS 4926) shall be used for structural concrete.

All records and charts for the batching and mixing operations shall be prepared and maintained by the contractor in accordance with IS 4926 or as per the instructions of Engineer-in-Charge.

In case Ready Mixed Concrete is not available, the mixing of concrete shall be strictly carried out in an approved type of mechanical concrete mixer. The mixer shall be fitted with water measuring devices. The mixing shall be continued until there is a uniform distribution of the material and the mass is uniform in colour and consistency. If there is segregation after unloading from the mixer, the concrete shall be remixed.

7.2 Mixer

7.2.1 Mechanical Mixers shall comply with IS 1791 and 12119 and shall be maintained in satisfactory operating condition. These shall be used only for producing lean/ plain concrete and/ or nominal mix concrete wherever permitted.

7.2.2 Mixing Time

Mixing time shall be as indicated in the following Table-2. Excessive mixing requiring additions of water shall not be permitted. Time shall start when all solid materials are poured in the revolving mixer drum, provided that all of the mixing water shall be introduced before one-fourth of the mixing time has elapsed. The Engineer-in-Charge may, however, direct a change in the mixing time, if he considers such a change necessary.

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TABLE-2

MINIMUM MIXING TIME FOR MIXERS

Capacity of mixer	Minimum mixing time
2 m^3 or less	2 minutes
Above 2 m^3	3 minutes or as recommended by the mixer manufacturer.

7.3 Hand Mixing

Hand mixing of concrete shall not be permitted. However, for non-critical applications namely foundations for crossovers, isolated operating platforms etc., using concrete upto grade M20 and located at far away isolated places, this may be permitted by the Engineer-in-charge as a special case. Mixing shall be carried out on a water tight platform and care shall be taken to ensure that mixing is continued until the mass is uniform in colour and consistency. No extra payment shall be made to the Contractor for mixing by hand or for using extra cement due to hand mixing.

7.4 Additives

Additive in concrete shall be used only with the prior approval of the Engineer-in-Charge and shall comply with Cl. 5.5 of IS 456. Any additive used for obtaining proper workability or leak proofness of concrete or repair/rendering works of concrete due to non-conformance to the specifications, shall not be measured and paid for. All costs relating to such usage shall be borne by the Contractor.

8.0 TRANSPORTATION, PLACING AND COMPACTION

8.1 General

The entire concrete placing programme including transportation arrangements, deployment of equipment, layout, proposed procedures and methods, shall be submitted to the Engineer-in-Charge 24 hours prior to concreting for approval. No concreting shall be placed until his approval has been received. Approval of the Engineer-in-Charge for pouring concrete shall be taken as 'conveyed', when the concrete pour card is signed by him.

8.1.1 Chuting

The use of long troughs, chutes and pipes for conveying concrete from the mixer to the forms shall be permitted only on written authorization from the Engineer-in-Charge. In case an inferior quality of concrete is produced by the use of such conveyors, the Engineer-in-Charge may order discontinuance of their use and the substitution of a satisfactory method of placing the concrete. Open troughs and chutes shall be equipped with baffles and be in short lengths to avoid segregation. Chutes shall be designed so that the concrete is, to some extent, remixed at the lower end by passing down through a funnel shaped pipe or drop chute. Alternatively, they shall discharge into a storage hopper from which the concrete shall be transported to the point of placing by wheel barrows or other means. Where drop chutes are used, a sufficient number of these must be provided, so that the concrete discharged from the chute is not required to flow laterally more than 1.0 metre. Where a drop chute is swung from the vertical, the bottom two sections must be maintained in a vertical position to avoid segregation. The addition of water at any point in the system of transportation, to facilitate the movement of concrete shall not be permitted. All chutes, troughs and pipes, shall be kept clean and free from coatings of hardened concrete by thoroughly flushing them with water after each run; water used for flushing shall be discharged clear of the structure.

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8.1.2 Vibrators

8.1.2.1 Concrete shall be compacted with mechanical vibrating equipment supplemented, if necessary to obtain consolidation, by hand spreading, rodding and tamping. The vibrators shall be of immersion type with operational frequency ranging between 8,000 to 12,000 vibrations per minute. All vibrators shall comply with IS 2505. Screed board concrete vibrators or concreting vibrating tables or form vibrators conforming to IS 2506, 2514 and 4656 respectively shall be used where specifically required and directed by Engineer-in-Charge.

8.1.2.2 Immersion type vibrators shall be inserted in a vertical position at intervals of about 600 mm, depending upon the mix, the equipment used, and experience on work. The vibrators shall be withdrawn slowly. The spacing shall provide some overlapping of the area vibrated at each insertion. In no case shall vibrators be used to transport concrete inside the forms. Over vibration or under vibration shall not be permitted as both are harmful. Hand tamping in some cases may be allowed subject to the approval of the Engineer-in-Charge.

8.1.2.3 In placing concrete in layers which are advancing horizontally as the work progresses, great care shall be exercised to ensure adequate vibration, bonding and moulding of the concrete between the succeeding batches.

8.1.2.4 The vibrator shall penetrate the layer being placed and also penetrate the layer below while the under layer is still plastic to ensure good bond and homogeneity between the two layers and prevent the formation of cold joints.

8.1.2.5 Care shall be taken to prevent contact of vibrators against all embedded reinforcing steel or inserts. Vibrators shall not be allowed to come in contact with forms.

8.1.2.6 The use of form vibrators shall not be permitted for compaction of in-situ concrete without specific authorization of the Engineer-in-Charge.

8.1.2.7 The use of surface vibrators of screed board type shall not be permitted for consolidation of concrete under ordinary conditions. However, for thin slabs (of thickness less than 200 mm) surface vibration by such vibrators may be permitted, upon approval of the Engineer-in-Charge.

8.1.2.8 Whenever vibration has to be applied externally, the design of formwork and the disposition of vibrators shall be carefully planned to ensure efficient compaction and to avoid surface blemishes.

8.2 Transportation

8.2.1 All concrete shall be conveyed from the mixer to the place of final deposit such as formwork as rapidly as possible using suitable buckets, dumpers, pumps, transit mixers containers or conveyors which shall be mortar leak tight. Care shall be taken to prevent the segregation or loss of the ingredients and maintaining the required workability. For structural concrete produced from Ready Mixed Concrete/ Batching Plants, concrete shall be transported from the plants to the sites only by transit mixers and Delivery Ticket for each delivery of concrete shall be maintained by the contractor.

8.2.2 During hot or cold weather, concrete shall be transported in deep containers. Other suitable methods to reduce the loss of water by evaporation in hot weather and heat loss in cold weather may also be adopted. All equipment used for transporting and placing of concrete shall be maintained in clean condition. All buckets, hoppers, chutes, dumpers and other equipment shall be thoroughly cleaned after each use.

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8.3 Placing and Compaction

8.3.1 Before placing concrete, all soil surfaces upon which or against which concrete is to be placed shall be well compacted and free from standing water, mud or debris. Soft or yielding soil shall be removed and replaced, with lean concrete or with selected soils/sand and compacted to the density as directed by Engineer-in-Charge. The surface of absorptive soil (against which concrete is to be placed) shall be moistened thoroughly so that moisture is not drawn from the freshly placed concrete. Similarly, for concrete to be placed on formworks, all chippings, shavings and sawdust etc. shall be removed from the interior of the forms before the concrete is placed.

8.3.2 Concrete shall not be placed until the formwork, the placement of reinforcing steel, embedded parts; pockets etc. have been inspected and approved by the Engineer- in-Charge. Any accumulated water on the surface of the bedding layer shall be removed by suitable means before start of placement. No concrete shall be placed on a water covered surface.

8.3.3 Concrete shall be discharged by vertical drop only and the drop height shall not normally exceed 1.5 metre throughout all stages of delivery until the concrete comes to rest in forms. However, drop height can be relaxed by the Engineer-in-Charge as per the provisions given under Cl. 8.1.1. For continuous concreting operation windows of suitable size shall be kept in the formwork or chutes shall be used to avoid segregation of concrete.

8.3.4 Concrete shall be deposited as near as practicable in its final position to avoid rehandling. Concrete shall be placed in successive horizontal layers. The bucket loads, or other units of deposit, shall be placed progressively along the face of the layer with such over-lap as will facilitate spreading the layer of uniform depth and texture with a minimum of hand shoveling. Any tendency to segregation shall be corrected by shovelling coarse aggregates into mortar rather than mortar on the coarse aggregates. Such a tendency for segregation shall be corrected by redesign of mix, change in process or other means, as directed by the Engineer-in-Charge.

8.3.5 All struts, stays and braces (serving temporarily to hold the forms in correct shape and alignment pending the placing of concrete at their locations) shall be removed when the concrete placing has reached an elevation rendering their service unnecessary. These shall not be buried in the concrete. Concrete shall be thoroughly compacted with vibrators and fully worked around the reinforcement, embedded fixtures and into corners of formwork before setting commences and shall not be subsequently disturbed. Methods of placing shall be such as to preclude segregation and avoid displacement of reinforcement or formwork. The formation of stone-pockets or mortar bondage in corners and against face forms shall not be permitted. Should these occur, they shall be dug out, reformed and refilled to sufficient depth and shape for thorough bonding as directed by the Engineer-in-Charge. Care shall be taken to avoid displacement of reinforcement and embedded inserts or movement of formwork.

8.3.6 Unless otherwise approved, concrete shall be placed in single operation to the full thickness of foundation rafts, slabs, beams and similar members. Concrete shall be placed continuously until completion of the part of the work between approved construction joints or as directed by the Engineer-in-Charge.

8.3.7 The method of placing and compaction employed in any particular section of the work shall be to the entire satisfaction of the Engineer-in-Charge.

8.3.8 During hot weather (atmospheric temperature above 40 degree Celsius) or cold weather (atmospheric temperature below 5 degree Celsius, the concreting shall be done as per the procedure set out in IS 7861).

8.3.9 Concrete that has set standing and becomes stiffened shall not be used in the work.

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8.3.10 Continuous Concreting

Where called out on the drawings, continuous concreting shall be done in a single operation as per the requirements of IS 456 and IS 2974. Sufficient "Windows" shall be left in the formwork for pouring & compaction of concrete and inspection. These windows shall be fixed tight once the level of concrete reaches their levels.

8.3.11 Concreting under special conditions

a) Work in extreme weather conditions during hot or cold weather, the concreting shall be done as per procedure set out in IS 7861(Part 1) or IS 7861 (Part2).

b) Under water concreting shall be as per clause 14.2 of IS 456.

8.4 Items Embedded in Concrete

8.4.1 Concreting shall not be started unless the electrical conduits, pipes, fixtures etc., wherever required, are laid by the concerned agency. The Contractor shall afford all the facilities and maintain co-ordination of work with other agencies engaged in electrical and such other works as directed by the Engineer-in-Charge.

8.4.2 Before concreting, the Contractor shall provide, fabricate and lay in proper position all metal inserts, anchor bolts, pipes etc. (which are required to be embedded in concrete members) as per relevant drawings and directions of Engineer-In-Charge.

8.4.3 All embedment, inserts etc. shall be fully held and secured in their respective positions by the concerned agencies to the entire satisfaction of Engineer-in-Charge so as to avoid any dislocation or displacement during the concreting operations. The Contractor shall take all possible care during concreting to maintain these embedment/inserts in their exact locations.

9.0 CONSTRUCTION JOINTS

9.1 Construction joints shall be provided in position as shown or described on the drawings or as directed by the Engineer-in-Charge. Such joints shall be kept to the minimum. These shall be straight and at right angles to the direction of main reinforcement and shall be placed at accessible locations to permit cleaning out of laitance, cement slurry and unsound concrete.

9.2 In a column, the joint shall be formed about 100 mm to 150 mm below the lowest soffit of the beams framing into it. Concrete in a beam and slab shall be placed throughout without a joint but if the provision of a joint is unavoidable, the joint shall be vertical and located within 1/3 to 1/4 of the span, unless otherwise shown on the drawings.

9.3 When stopping the concrete on a vertical plane in slabs and beams, an approved stop board shall be placed with necessary slots for reinforcement bars. The construction joints shall be keyed by providing a triangular or trapezoidal fillet nailed on the stop board. Inclined joints shall not be permitted. Any concrete flowing through the joints of stop board shall be removed soon after the initial set. When concrete is stopped on a horizontal plane, the surface shall be roughened and cleaned after the initial set and a triangular or trapezoidal groove shall be provided for keying with the new concrete later.

9.4 When the work has to be resumed on a surface which has hardened, such surface shall be cleared of any foreign materials and roughened to expose the tips of the coarse aggregate. This may be done by manual chipping of concrete, with a high pressure water jet or by any other appropriate means as per Engineer-in-Charge's directions. It shall then be swept clean and thoroughly washed and wetted before any new concrete is poured. Any set mortar or concrete sticking to the exposed reinforcing rods in and around such joints shall be thoroughly removed. The reinforcements shall be wire brushed and washed just before

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pouring any cement slurry or mortar. For vertical joints neat cement slurry shall be applied on the surface before it is dry. For horizontal joints the surface shall be covered with a layer of mortar about 10 to 15 mm thick composed of cement and sand in the same ratio as the cement and sand in concrete mix. This layer of cement slurry or mortar shall be freshly mixed and applied immediately before placing new concrete.

9.5 Where the concrete has not fully hardened, all laitance shall be removed by scrubbing the wet surface with wire or bristle brushes, care being taken to avoid dislodgement of particles of aggregate. The surface shall be thoroughly wetted and all free water removed. The surface shall then be coated with neat cement slurry. On this surface layer of concrete not exceeding 150 mm in thickness shall first be placed and shall be well rammed against old work, particular attention being paid to corners and close spots; work thereafter shall proceed in normal way.

10.0 SEPARATION JOINT

10.1 Separation joint shall be obtained by using an approved Alkathene sheet stuck on the surface against which concrete shall be placed. Adequate care shall be taken to cause no damage to the sheet.

11.0 EXPANSION JOINTS/ISOLATION JOINT

11.1 Expansion/ Isolation joints in structures shall be formed in the positions and to the shapes shown in the relevant drawings. Joints shall be filled with joint filling material as stipulated in the drawings/schedule of rates. Isolation joints shall be provided around all equipment foundations, columns, pedestals, trenches etc. on grade.

12.0 WATER STOPS

PVC water stops as per EIL Specification No. 6-68-0002 for materials shall be accurately cut, fitted and integrally joined as per manufacturer's specifications to provide a continuous, watertight diaphragm at all points.

The water stops shall be located and embedded at expansion/contraction/ construction joints as indicated in the drawings or directed by the Engineer-in-Charge.

Adequate provision shall be made for the support and protection of water stops during the progress of the work. Damaged water stops shall be replaced and/or repaired as directed.

13.0 PROTECTION OF FRESHLY LAID CONCRETE

13.1 Newly placed concrete shall be protected, by approved means, from rain, sun and wind. Concrete placed below the ground level shall be protected from falling earth during and after placing. Surface shall be kept free from contact with such ground or with water draining from such ground during placing of concrete for a period of at least 3 days, unless otherwise directed by the Engineer-in-Charge. The ground water around newly poured concrete shall be kept to an approved level by pumping or other approved means of drainage and adequate steps shall be taken to prevent floatation and flooding. Steps shall be taken to protect immature concrete from damage by debris, loading, vibration, abrasion, mixing with deleterious materials that may, in the opinion of the Engineer-in-Charge, impair the strength and/or durability of the concrete.

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14.0 CURING

14.1 Concrete shall be cured by keeping it continuously moist wet for the specified period of time to ensure complete hydration of cement and its hardening. Curing shall be started after 8 hours of placement of concrete in normal weather, and in hot weather after 4 hours. The water used for curing shall be of the same quality as that used for making of concrete.

Curing shall be assured by use of an ample water supply under pressure in pipes, with all necessary appliances such as hose, sprinklers etc. A layer of sacking, canvas, hessian, or other approved material, which will hold moisture for long periods and prevent loss of moisture from the concrete, shall be used as covering. Type of covering which would stain, disfigure or damage the concrete, during and after the curing period, shall not be used. Only approved covering shall be used for curing.

Exposed surfaces of concrete shall be maintained continuously in a damp or wet condition for at least the first 7 days after placing of concrete.

The Contractor shall have all equipment and materials required for curing on hand and ready to use before concrete is placed.

For curing the concrete in pavements, floors, flat roofs or other level surfaces, the ponding method of curing shall be used. For the first 24 hours after concreting, the concrete shall be cured by use of wet sacking, canvas, hessian etc. The minimum water depth of 25 mm for ponding shall be maintained. The method of containing the ponded water shall be approved by the Engineer-in-Charge. The ponded areas shall be kept continuously filled with water, and leaks, if any, shall be promptly repaired. Areas cured by ponding method shall be cleared of all debris and foreign materials after curing period is over.

Alternatively, membrane curing may be used in lieu of moist curing with the permission of the Engineer-in-Charge. Such compounds shall be applied to all exposed surfaces of the concrete by spraying or brushing as soon as possible after the concrete has set. Minimum film thickness of such curing compounds shall be as per the recommendation of the manufacturer so as to obtain an efficiency of 90% as specified by BS-8110. This film of curing compound shall be fully removed from the concrete surface after the curing period specified earlier. Engineer-in-Charge may not allow curing by curing compounds for those surfaces where use of curing compound may be detrimental to application of future finishes over the concrete. Impermeable membranes such as polyethylene sheeting closely covering the concrete surface may also be used.

14.2 For concretes containing Portland pozzolana cement or Portland slag cement, the curing period as given in Cl. 14.1 shall be doubled. Curing by ponding shall, however, commence after the first 24 hours of concreting.

15.0 FIELD TESTS

15.1 Materials Testing

15.1.1 Aggregates

Grading test on fine and coarse aggregates shall be carried out as per IS 2386 at intervals specified by the Engineer-in-Charge.

The mandatory tests and their frequencies shall be done as given in Table-3A & 3B below:

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TABLE – 3A
(For Concrete prepared at site by using Mechanical mixers)

MANDATORY TESTS ON SAND & STONE AGGREGATES

S. No	MATERIAL	TEST	FIELD / LAB TEST	MIN. QTY OF MATERIAL/ WORK FOR CARRYING OUT TEST	FREQUENCY OF TESTING*
1.	Sand	(a) Bulking of sand	Field Test	20 m^3	Every 20 m^3 or part thereof or more frequently as decided by the Engineer-in-Charge
		(b) Silt content	Field Test	20 m^3	
		(c) Particle size distribution	Field or Lab as decided by the Engineer-in-Charge	40 m^3	1) Every 40 m^3 of fine aggregate/sand required in RCC works only 2) Every 80 m^3 of fine aggregate/ sand required for other items
2.	Stone aggregate	a) Percentage of soft or deleterious materials	General visual inspection, laboratory test where required by Engineer -in-Charge or as specified	As required by Engineer-in-Charge	For all quantities
		b) Particle size distribution	Field or lab. as required by Engineer-in-Charge	45 m^3	For every 45 m^3 or part thereof as decided by Engineer-in-Charge
		c)Ten percent Fine value	Laboratory	45 m^3	Initial test and subsequent test as & when required by Engineer-in-Charge

* Fresh testing is mandatory whenever there is change in Source of materials.

TABLE – 3B
(Refer Cl. 4.4 & 4.6.1 of IS 4926)

(For Ready Mixed Concrete supplied by Ready Mixed Concrete Plants or from on/off-site Batching Plants)

MATERIALS TESTING REQUIREMENTS

S. No	AGGREGATE PROPERTY/ PARAMETER	TYPE OF AGGREGATE	ASSESSMENT OF TYPICAL PROPERTIES AND HIGH TEST RATE*	NORMAL MONITORING AND LOW TEST RATE*	REQUIREMENT FOR NORMAL MONITORING AND LOW TEST RATE
1.	**Grading**	Sand/Fine	Weekly	Monthly	Last 8 results conform to IS 383 or representative values
		Coarse-Single sized/ Graded	Weekly	Monthly	
2.	**Particle density** -Oven Dry -Saturated Surface Dry -Apparent	All Types	Weekly	3 Monthly	Last 4 results ±0.04 percent
3.	**Absorption**	All Types	Weekly	3 Monthly	Last 4 results ±0.04 percent

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S. No	AGGREGATE PROPERTY/ PARAMETER	TYPE OF AGGREGATE	ASSESSMENT OF TYPICAL PROPERTIES AND HIGH TEST RATE*	NORMAL MONITORING AND LOW TEST RATE*	REQUIREMENT FOR NORMAL MONITORING AND LOW TEST RATE
4.	**Bulk Density** - Loose - Compacted	All Types	Monthly	6 Monthly	Last 4 results ± 75kg/m³
5.	**Fines(Silt) Content**	Sand	Weekly	Monthly	Last 10 results <75 percent maximum allowed
		Coarse	Monthly	3 Monthly	
6.	**Aggregate Impact Value**	Coarse	As specified	As specified	-
7.	**10 % Fines**	Coarse	Yearly	Yearly	-
8.	**Flakiness**	Coarse	2 Weekly	6 Monthly	Last 3 results conform to standard
9.	**Chloride Content**	All Types	Weekly	6 Monthly	Last 3 results < 0.01 percent
10.	**Aggregate Abrasion Value** (Los Angeles Method)	Coarse	-	Yearly/ Source Change	-
11.	**Soundness**	Fine and Coarse	-	Yearly/ Source Change	-
12.	**Potential Alkali Aggregate Reactivity Including Petrography**	Fine and Coarse	-	5 Yearly/ Source Change	-
13.	**Petrographic Description** (General)	All Types	-	5 Yearly	-

***Note** : The high or low test rates apply in accordance with the following conditions:

a) High test rate
   i) To establish the typical characteristics of an aggregate, and
   ii) When significant changes in properties occur outside the tolerances for low test rates given.

b) Low test rate
   i) When the typical characteristics of the aggregate have been established, and
   ii) When subsequent tests lie within the tolerances for low test rates given

15.1.2 Water

The minimum testing frequencies shall be as follows:

SOURCE	PARAMETERS	FREQUENCY	REQUIEMENT
Non mains water (Untreated water extracted from wells, ponds, lakes, rivers, underground, etc.)	p^H value, Chloride ion content, Sulphate content and any other parameter in accordance with IS 456	Initially every week for first 6 weeks (average of test results to be taken) and then at 3-monthly interval	Need further investigation in case significant deviation observed in test results of 3-monthly interval samples from the original 6 weeks average
Mains water (Treated water supplied through piped network)	Same as above	Annual basis once all tests for source are satisfactory	In case Chloride content > 0.01%, testing frequency shall be reduced to 3 months

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15.2 Compaction Factor Test /Slump Test of Concrete

15.2.1 For structural quality concrete (excluding pavements, flooring etc.) at least one Slump Test shall be made for every compressive strength test carried out. More frequent tests shall be made if there is a distinct change in working conditions or if required by the Engineer-in-Charge.

In case of Ready Mixed Concrete, provisions of IS 4926 shall be followed.

15.2.2 For structural quality concrete for pavements & floorings, measurement of workability shall be by determination of compacting factor. Value of compacting factor of 0.75 to 0.8 shall generally be acceptable.

15.3 Strength Test of Concrete

15.3.1 Samples from fresh concrete shall be taken as per IS 1199 and cubes shall be made, cured and tested at 28 days in accordance with IS 516.

15.3.2 In order to get a relatively quicker idea of the quality of concrete, optional tests on beams for modulus of rupture at 72±2 hours or at 7 days, or compressive strength tests at 7 days may be carried out in addition to 28 days compressive strength tests. For this purpose, the values shall be arrived at based on actual testing. In all cases, the 28 days compressive strength specified in Table-1 shall alone be the criterion for acceptance or rejection of the concrete in accordance with clause 15.3.9.

15.3.3 Sampling Procedure

A random sampling procedure shall be adopted to ensure that each concrete batch shall have a reasonable chance of being tested that is, the sampling should be spread over the entire period of concreting and cover all mixing units.

15.3.4 Frequency of Sampling

The minimum frequency of sampling of concrete for each grade shall be in accordance with Table-4.

TABLE – 4
(Refer Cl. 15.2.2 of IS 456)

FREQUENCY OF CONCRETE SAMPLING

Quantity of concrete in the work (m^3)	Number of samples
1-5	1
6-15	2
16-30	3
31-50	4
51 & above	4 plus one additional sample for each additional $50m^3$ or part thereof.

At least one sample shall be taken from each shift.

When concrete is produced at continuous production units such as ready mixed concrete/ batching plants, atleast one sample shall be taken for every $50m^3$ of concrete or after every 50 batches, whichever occurs at a greater frequency or as decided by the Engineer-in-Charge. Samples shall be avoided from the first and the last cubic metre of concrete mix in a lot.

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15.3.5 Test Specimen

Three test specimens shall be made for each sample for testing at 28 days. Additional cubes may be required for various purposes such as to determine the strength of concrete at 7 days or at the time of striking the formwork or to check the testing error. Additional samples may also be required for testing samples cured by accelerated methods as described in IS 9013. The specimen shall be tested as described in IS 516.

15.3.6 Identification mark on concrete test cubes:

The following numbering system shall be adopted on each 150 mm cube:

First line: ZZ	(Alpha code assigned by the Engineer -in-Charge to the Contractor for a particular contract starting with AA and progressing to AB, AC and so on).
Second line: XXXX	(Unique integer in ascending order starting from 1).
Third line: DD-MM-YY	(Date of casting of cube)

15.3.7 Test Results of Sample

The test results of the sample shall be the average of the strength of three specimens. The individual variation should not be more than $\pm$ 15 percent of the average. If more, the test results of the sample shall be considered invalid.

15.3.8 Standard Deviation

Standard deviation for each grade of concrete shall be calculated separately.

Standard deviation based on test results of samples:

a) The total number of test samples required to constitute an acceptable record for calculation of standard deviation shall be not less than 30. Attempts shall be made to obtain the 30 samples, as early as possible, when a mix is used for the first time.

b) For design of mix in the first instance, the value of standard deviation given in Table 8 of IS 456, Amendment No. 4 may be assumed.

c) As soon as sufficient results of samples are available, actual calculated standard deviation shall be used and the mix design shall be revised/ updated. However, when adequate past records for a similar grade exist and justify to the designer a value of standard deviation different from that shown in Table 8 of IS 456, Amendment No. 4, it shall be permissible to use that value.

d) For additional requirement on standard deviation refer clause 9.2.4 of IS 456.

15.3.9 Acceptance Criteria

15.3.9.1 Compressive Strength

The concrete shall be deemed to comply with the strength requirement when both the conditions as given in col. 2 & col.3 of Table-5 for that particular grade of concrete are simultaneously met. For working out standard deviation compressive test result of date wise serially logged 30 sample test result shall be used.

15.3.9.2 Flexural Strength

The concrete shall be deemed to comply with flexural strength requirements when both the following conditions are simultaneously met:

a) The mean strength determined from any group of four non-overlapping consecutive test results exceeds the specified characteristic strength by at least 0.3 N/mm^2.

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(For non overlapping consecutive compressive test result any one alternate set of four samples shall be used for verification of compliance to clause no. 16.1.a of IS 456)

b) The strength determined from any test result is not less than the specified characteristic strength less 0.3 N/mm^2

Table-5
(Refer Cl. 16.1 & 16.3 of IS 456)

Characteristic Compressive Strength Compliance Requirement

Specified Grade	Mean of the Group of 4 Non-Overlapping Consecutive Test Results in N/mm^2	Individual Test Results in N/mm^2
M15 or above	$\geq f_{ck}$ + 0.825 x established standard deviation (rounded off to nearest $0.5N/mm^2$) or $\geq f_{ck}$ + 3 N/mm^2, Whichever is greater	$\geq f_{ck}$ – 3 N/mm^2

NOTE : 1) In the absence of established value of standard deviation, the values given in Table 8 of IS 456, Amendment No. 4, 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.

2) For concrete of quantity 30 m^3 (where the number of samples to be taken is less than four as per the frequency of sampling given in cl. 15.3.4, Table 4), the mean of test results of all such samples shall be f_{ck} + 4 N/mm^2, minimum and the requirement of individual test results shall be f_{ck} – 2 N/mm^2, minimum. However, when the number of sample is only one as per Table 4, the requirement shall be f_{ck} + 4 N/mm^2.

15.3.9.3 Quantity of Concrete Represented by Strength Test Results

The quantity of concrete represented by group of four consecutive test results shall include the batches from which first and last samples were taken together with all intervening batches. Acceptance of concrete shall be applicable for serially logged 30 samples. In case serially logged samples are less than 30 then standard deviation of adjoining previous sample sets will be used for establishing acceptance criteria as per clause 16.1.a of IS 456.

For the individual test result requirements given in col. 3 of Table-5 or in item (b) of 15.3.9.2, only the particular batch from which the sample was taken shall be at risk.

Where the mean rate of sampling is not specified, the maximum quantity of concrete that four consecutive test results represent shall be limited to $60m^3$.

15.3.9.4 If the concrete is deemed not to comply pursuant to Cl. 15.3.9.1 or 15.3.9.2, the structural adequacy of the parts affected shall be investigated and any consequential action as needed shall be taken (Refer Cl. 16.0).

15.3.9.5 Concrete of each grade shall be assessed separately.

15.3.9.6 Concrete is liable to be rejected if it is porous or honey-combed, its placing has been interrupted without providing a proper construction joint, the reinforcement has been displaced beyond the tolerances specified, or construction tolerances have not been met. However, the hardened concrete may be accepted after carrying out suitable remedial measures and tests to the fullest satisfaction of the Engineer-in-Charge.

15.3.9.7 Tolerance in leveling of concrete surface at foundation/ pedestal top level where grouting is to be done:

Maximum Plan Dimension	≤ 2m	>2m but ≤4m	> 4m
Tolerance in leveling	+ 10 mm	+ 10 mm	+ 10 mm
	- 10 mm	- 20 mm	- 25 mm

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15.3.9.8 Tolerance in dimensions of pocket:

20 mm overall maximum tolerance on the size of pocket.

For pockets, chemically dissolvable moulds shall be preferred. Smooth removal of moulds without affecting the pocket size shall be ensured.

16.0 INSPECTION AND TESTING OF STRUCTURES

16.1 Inspection

To ensure that the construction complies with the design, an inspection procedure shall be set up by the contractor and duly approved by the Engineer-in Charge covering materials used, receipt of materials, their test results, records, workmanship and construction etc.

Contractor shall ensure that the surface which is to receive the grout is at proper level and so are the openings for pockets as per Cl. 15.3.9.7 & 15.3.9.8.

16.2 Immediately after stripping the formwork, all concrete shall be carefully inspected and any defective work or small defects either removed or made good before concrete has thoroughly hardened.

16.3 Testing

In case of doubt regarding the grade or soundness of concrete used, either due to poor workmanship or based on results of cube strength, compressive strength tests of concrete on the basis of clause 17.4 of IS 456 and/or load test as per clause 17.6 of IS 456 shall be carried out.

The Engineer-in-Charge shall be the final authority for interpreting the results of all tests and shall decide upon the acceptance or otherwise. The decision of the Engineer-in-Charge shall be final and binding on the contractor. In case the results of the tests are unsatisfactory, the Engineer-in-Charge may instruct the contractor to demolish and reconstruct the structure or part thereof without any extra cost to the Owner.

16.4 Members other than Flexural Members

Members other than flexural members like columns etc. shall be referred to the designer to investigate the structural adequacy. The decision of the designer shall be final and binding on the contractor.

16.5 Non-destructive Tests

Non-destructive tests using Ultrasonic Pulse Velocity and Rebound Hammer methods shall be resorted to for checking the soundness of concrete placed and shall be as per the directions of Engineer-in-Charge. The testing shall be based on IS 13311, Part-1. However, the Rebound Hammer test (IS 13311, Part-2) shall only be used in combination with other tests (Destructive or Non-Destructive) for checking the concrete quality.

17.0 FINISHING OF CONCRETE

17.1 On striking the formwork, all surface defects such as bulges, ridges and honey-combing etc. observed shall be brought to the notice of the Engineer-in-Charge. The Engineer-in-Charge may, at his discretion allow rectification by necessary chipping and packing or grouting with concrete or cement mortar. However, if honey-combing or sagging is of such extent as being undesirable, the Engineer-in-Charge may reject the work totally and his decision shall be binding. No extra payment shall be made for rectifying these defects, demolishing and reconstructing the structure. However, quantity of cement actually used for this purpose may

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be considered for reconciliation of materials. All burrs and uneven faces shall be rubbed smooth with the help of carborundum stone.

The surface of non-shuttered faces shall be smoothened with a wooden float to give a finish similar to that of the rubbed down shuttered faces. Concealed concrete faces shall be left as from the formwork except that honey-combed surface shall be made good as specified above. The top faces of slabs not intended to be covered shall be levelled and floated to a smooth finish to the rises or falls shown on the drawings or as directed. The floating shall not be executed to the extent of bringing excess fine materials to the surface. The top faces of slabs intended to be covered with screed, granolithic or similar finishes, shall be left with a rough finish.

17.2 Repair and Replacement of Unsatisfactory Concrete

17.2.1 Repair shall be made as soon as possible after the forms are removed and before the concrete becomes too hard with prior permission from the Engineer-in-Charge, in writing. Stone pockets, segregation patches and damaged areas shall be chipped out and the edges undercut slightly to form a key. All loose material shall be washed out before patching. No excess water shall be left in the cavity, but the concrete shall be damp. A good bond between the patch and parent concrete shall be obtained by sprinkling dry cement on the wet surface or by throwing mortar with force on to the wetted concrete, or by brush in a coat of thick cement grout of about 1:1 (1 cement:1 sand) just before applying the patching material. Before this has dried, the remainder of the patch shall be filled with mortar or concrete, depending on the extent of the repair.

17.2.2 Cement concrete/mortar used in repair of exposed surfaces shall be made with cement from the same source as that used in concrete and blended with sufficient amount of white Portland cement to produce the same colour as in the adjoining concrete. The proportions of ingredients shall be same as those used in parent concrete. The mortar shall be as dry as possible and well compacted into the cavity. All filling shall be tightly bonded to the concrete and shall be sound, free from shrinkage cracks after the filling has been cured and dried.

17.2.3 For larger repairs to hardened concrete, necessary formwork bearing tightly at the edges of the cavity shall be provided. Concrete shall be chipped out to a depth of at least 100 mm and preferably 150 mm. Mortar shall be scrubbed into all surfaces with a wire brush before placing the concrete. Damaged reinforcement shall be adequately spliced with new steel so as to maintain the original strength. Additional reinforcement, if required in the patch, shall be provided as per the instructions of Engineer-in-Charge.

17.2.4 In case, in the opinion of the Engineer-in-Charge, defects in the concrete is excessive or beyond repair, the contractor shall either redo the structure or take other remedial measures as instructed by the Engineer-in-Charge. The decision of the Engineer-in-Charge shall be final and binding to all in this respect.

17.2.5 Approved epoxy formulation for bonding fresh concrete used for repairs with already hardened concrete shall be used by the Contractor if asked by the Engineer-in-Charge. Epoxy shall be applied in strict accordance with EIL Specification 6-68-0056 and the instructions of the manufacturer.

17.2.6 All repair works due to non-conformance or non-adherence to specification, if allowed by the Engineer-in-Charge, shall be carried out free of cost to the owner.

17.3 Curing of Patched Work

Immediately after patching is completed, the patched area shall be covered with an approved non-staining water saturated material which shall be kept wet and protected against sun and wind for a period of 12 hours. Thereafter, the patched area shall be kept continuously wet by a fine spray or sprinkling for not less than 10 days.

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18.0 WATERPROOF CEMENT PAINT

Wherever specified, concrete elements (whether cast-in-situ or precast) exposed to atmosphere shall be provided with three coats of cement based waterproof paint as per IS 5410 provided these surfaces shall not contain any protective coating. Prior to application of the paint, the surface shall be prepared to remove all foreign particles, loose materials, extra deposited concrete lumps, etc. using appropriate mechanical/ manual means.

19.0 FORM WORK

19.1 General

19.1.1 Forms for concrete shall be of plywood conforming to IS 6461 (Part-5) or steel or as directed by the Engineer-in-Charge and shall give smooth and even surface after removal thereof.

19.1.2 If it is desired by Engineer-In-Charge, the Contractor shall prepare, before commencement of actual work, design and drawings for formwork and get them approved by the Engineer-in-Charge. For details regarding design, detailing etc., reference may be made to IS 14687.

19.1.3 Form work and its supports shall maintain their correct position and be to correct shape and profile so that the final concrete structure is within the limits of dimensional tolerances specified below, unless required otherwise, for functional/aesthetic reasons. The decision of the Engineer-in-Charge shall be final and binding in this regard.

(a) Deviation from specified dimensions of cross section of columns and beams. — - 5 mm to +10 mm

(b) Deviation from dimensions of footings (see Note below)

i)	Dimensions in plan	-10 mm to +50 mm
ii)	Eccentricity	0.02 times the width of the footing in the direction of deviation but not more than 50 mm.
iii)	Thickness	-10 mm to +50 mm or $\pm$0.05 times the specified thickness, whichever is less

Note: These tolerances apply to Cast-in-situ concrete dimensions only, not to positioning of vertical reinforcing steel or dowels.

(c) Deviation in length (major dimension of single unit)

upto 3m	$\pm$6 mm
3m to 4.5m	$\pm$9 mm
4.5m to 6m	$\pm$12 mm
Additional deviation for every subsequent 6m.	$\pm$6 mm

(d) Deviation in straightness or bow (deviation from specified line) for a single or continuous member) e.g. beam, column or slab edge.

upto 3m	6 mm
3m to 6m	9 mm
6m to 12m	12 mm
additional for every subsequent 6m.	6 mm

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(e) Deviation in squareness shall be measured taking the longer of two adjacent sides as the base line.

The shorter side shall not vary in its distance from a perpendicular so that the difference between the greatest and shortest dimensions exceeds 6 mm. For this purpose, any error due to lack of straightness shall be ignored. Squareness shall be checked with respect to the straight lines that are most nearly parallel with the features being checked. When the nominal angle is other than 90 degree, the included angle between check lines shall be varied accordingly.

(f) Deviation in twist shall be within a limit such that any corner shall not be more than the limit given below from the plane containing other three corners:

upto 600 mm wide and upto 6m in length	:	6 mm
over 600 mm wide and for any length	:	12 mm

(g) Maximum deviation in flatness from a 1.5m straight edge placed in any position on a nominally plain surface shall not exceed 6 mm.

(h) Tolerance in leveling of concrete surface at foundation/ pedestal top level where grouting is to be done : As per Cl. 15.3.9.7

19.2 Form Requirement

19.2.1 The formwork shall be true, rigid and adequately braced both horizontally as well as diagonally. The forms shall have smooth and even surface and be sufficiently strong to carry, without deformation, the dead weight of the green concrete, working load, wind load and also the side pressure exerted by the green concrete. As far as practical, clamps shall be used to hold the forms together. Where use of nails is unavoidable minimum number of nails shall be used. Projected part of nail shall not be bent or twisted for easy withdrawal.

19.2.2 Where through tie rods are required to be put to hold the formwork and maintain accurate dimension, they shall always be inserted through a precast concrete block (of same mix proportion as is to be used for concreting) with a through hole of bigger diameter. The Precast block shall tightly fit against in inner faces of formwork. The holes left after the withdrawal of tie rods shall be fully grouted with cement-sand mortar of same proportion as that used for concrete. However, use of such precast block shall in no case impair the desired appearance or durability of the structure. No such tie rods shall be used in any liquid retaining or basement structure.

19.2.3 Tie wires shall be permitted only upon approval of the Engineer-in-Charge and shall be cut off flush with the face of the concrete or counter sunk, filled and finished in the manner specified in clause 17.

19.2.4 Form joints shall not permit any leakage. The formwork shall be strong enough to withstand the effect of vibrations practically without any deflection, bulging, distortion or loosening of its components.

19.2.5 Forms for beams and slabs (span more than 6.0m) shall have camber of 1 in 500 so as to offset the deflection and assume correct shape and line after deposition of concrete. For cantilevers, the camber at free end shall be 1/100th of the projected length. Where architectural considerations and adjunctive work are critical, smaller form cambers shall be adopted as decided by the Engineer-in-Charge.

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19.2.6 All vertical wall forms may be designed and constructed for the following minimum pressure. The pressures listed in Table-6 are intended as guide only and the Contractor shall ensure that the formwork is adequately strong and sturdy.

TABLE - 6
MINIMUM DESIGN PRESSURE FOR WALL FORMWORK

Rate of pour in meter/hour	Pressure in KN/m^2	
	at 10^0 (in Celsius)	at 24^0 (in Celsius)
0.6	36.0	29.0
0.9	40.0	32.0
1.2	44.0	35.0
1.5	46.0	37.0

All horizontal forms shall be designed and constructed to withstand the dead load of the green concrete, reinforcement, equipment, material, embedment and a minimum live load of 2.0 kN/m^2.

19.3 Inspection of Forms

Temporary openings shall be provided at the base of column and wall forms and other places necessary to facilitate cleaning and inspection. Before concrete is placed, all forms shall be carefully inspected to ensure that they are properly placed, sufficiently rigid and tight, thoroughly cleaned, properly treated and free from foreign material. The complete form work shall be inspected and approved by the Engineer-in-Charge before the reinforcement bars are placed in position. When forms appear to be unsatisfactory in any way, either before or during the placing of concrete, the work shall be stopped until the defects have been rectified as per the instructions of the Engineer-in-Charge.

19.4 Cleaning and Treatment of Formwork

The surfaces of forms that would come in contact with concrete shall be well treated with approved non-staining form release agents such as soft soap, oil, emulsions etc. Release agents shall be applied so as to provide a thin uniform coating to the forms without coating the reinforcement.

19.5 Chamfers and Fillets

All corners and angles shall be formed with 45 degree mouldings to form chamfers or fillets on the finished concrete. The standard dimensions of chamfers and fillets, unless otherwise detailed or specified shall be 25x25 mm. For heavier work chamfers or fillets shall be 50x50 mm. Care shall be exercised to ensure accurate mouldings. The diagonal face of the moulding shall be planed or surfaced to the same texture as the forms to which it is attached.

19.6 Reuse of forms

Before reuse, all forms shall be thoroughly scrapped, cleaned, examined and when necessary, repaired and retreated, before resetting. Formwork shall not be reused, if declared unfit or un-serviceable by the Engineer-in-Charge.

19.7 Removal of Forms/Stripping Time

In the determination of time for removal of forms, consideration shall be given to the location and character of the structures, the weather and other conditions including the setting and curing of the concrete and material used in the mix.

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Forms and their supports shall not be removed without the approval of the Engineer-in-Charge. Forms shall not be released until the concrete has achieved a strength of at least twice the stress to which the concrete may be subjected at the time of removal. The formwork shall be removed without shock and methods of form removal likely to cause over stressing or damage to the concrete shall not be adopted. Supports shall be removed in such a manner as to permit the concrete to uniformly and gradually take the stresses due to its own weight.

In normal circumstances when average air temperature exceeds 15 degree Celsius during the period under consideration after pouring of concrete and where ordinary Portland cement is used, forms may generally be removed after expiry of following periods.

(a) Walls, columns and vertical faces of all structural members	16 to 24 hours as may be decided by the Engineer-in-Charge.
(b) Slabs (props left under)	3 days.
(c) Beam Soffits (props left under)	7 days.
(d) Removal of props under slabs:	
Spanning upto 4.5m.	7 days.
Spanning over 4.5m.	14 days.
(e) Removal of props under beams and arches:	
Spanning upto 6m	14 days.
Spanning over 6m	21 days

(f) Cantilever Construction Formwork shall remain till structures for counter acting or bearing down have been erected and have attained sufficient strength (minimum 14 days).

Notes:

i) For other cements, the stripping time recommended for ordinary Portland cement shall be suitably modified as per the instructions of the Engineer- in-Charge.

ii) The number of props left under, their sizes, supporting arrangement, and disposition shall be such as to be able to safely carry the full dead load of the slab, beam or arch as the case may be together with any live load likely to occur during curing or further construction.

iii) Where the shape of the element is such that the formwork has re-entrant angles, the form work shall be removed as soon as possible after the concrete has set, to avoid shrinkage cracking occurring due to the restraint imposed.

iv) For rapid hardening cement, 3/7 of the above mentioned periods shall be considered subject to a minimum of 16 hours.

v) For Portland pozzolana or low heat cement, 10/7 of the above mentioned periods shall be considered.

19.8 Staging/Scaffolding

19.8.1 Staging/Scaffolding shall be properly planned and designed by the Contractor. Use of only steel tubes is permitted for staging/scaffolding. The Contractor shall get it reviewed by Engineer-in-Charge before commencement of work. While designing and during erection of scaffolding/staging, the following measures shall be considered:

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(a) Sufficient sills or underpinnings in addition to base plates shall be provided particularly where scaffolding is erected on soft grounds.

(b) Adjustable bases to compensate for uneven ground shall be used.

(c) Proper anchoring of the scaffolding/staging at reasonable intervals shall be provided in each direction with the main structure wherever available.

(d) Horizontal braces shall be provided to prevent the scaffolding/staging from rocking.

(e) Diagonal braces shall be provided continuously from bottom to top between two adjacent rows of uprights.

(f) The scaffolding/staging shall be checked at every stage for plumb line.

(g) Wherever the scaffolding/staging is found to be out of plumb line it shall be dismantled and re-erected afresh and effort shall not be made to bring it in line with a physical force.

(h) All nuts and bolts shall be properly tightened and care shall be taken that all clamps/couplings are firmly tightened to avoid slippage

(i) Erection work of a scaffolding/staging under no circumstances shall be left totally to semi-skilled or skilled workmen and shall be carried out under the supervision of a technically qualified civil engineer of the Contractor.

19.8.2 For smaller works or works in remote areas, wooden ballies may be permitted for scaffolding/staging by the Engineer-in-Charge at his sole discretion. The contractor must ensure the safety and suitability of such works as described under clause 19.8.1 above.

20.0 EXPOSED/ARCHITECTURAL CONCRETE WORK

20.1 Form Work

Other things remaining same as per clause 19.0, formwork shall be of high quality. Care shall be taken to arrange the forms so that the joints between forms correspond with the pattern indicated in the drawings. The forms shall be butting with each other in straight lines, the corners of the boards being truly at right angles. The joints between the forms shall cross in the two directions at right angles. The size of forms shall be so selected as to exactly match with the pattern of forms impression on the concrete face indicated in the drawings. Maximum care shall be taken to make the form work watertight. Burnt oil shall not be used for treatment of forms. The Contractor shall be permitted reuse of forms brought new on the work place only if forms are properly cared for, stored and treated after each use.

The Engineer-In-Charge may, at his absolute discretion, order removal of any forms considered unsuitable for use in the work.

20.2 Finishing

Repairing to exposed concrete work shall be avoided. Rendering and plastering shall not be done. Minor repairing, if unavoidable shall be done as specified in clause 17.0 with the written permission of the Engineer-in-Charge.

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21.0 REINFORCEMENT

21.1 The Contractor shall develop the bar bending schedule for all RCC structures/ structural parts at no extra cost to the Owner and shall get it reviewed by the Engineer-in-charge. Reinforcement shall be cut and bent to shape as per dimensions shown in the bar bending schedule/ drawings.

If protective fusion bonded epoxy coating is required to be applied on reinforcement bars, the same shall be done as per IS 13620. All repairs to applied protective coating required due to mishandling and/ or bending of reinforcement bars shall also be done as per relevant clauses of IS 13620.

21.2 Straightening, Cutting and Bending

Procedure for cutting and bending shall be as given in IS 2502. Bars shall be bent in a slow and regular movement to avoid fractures by mechanical means only. In case bars are supplied in coils, they shall be smoothly straightened without any kinks.

Cold twisted deformed bars shall be bent cold. Bars larger than 25 mm in size (except cold twisted deformed bars) may be bent hot at cherry red heat to a temperature not exceeding 850^0 Celsius as per the instructions of the Engineer-in-Charge. The bars shall be allowed to cool gradually without quenching.

Bars shall be cut & bend in a Bar Bending Machine. Bars which develops cracks or splits after bending shall be rejected. A second bending of reinforcement bars shall be avoided but when reinforcement bars are bent aside at construction joints and afterwards bent back into their original position, care should be taken to ensure that at no time is radius of the bend less than 6 times bar diameter for high strength deformed bars. Care shall also be taken when bending back the dowel bars to ensure that concrete around the bars is not damaged. All bars shall be properly tagged for easy identification.

21.3 Placing and Fixing

All reinforcement shall be cleaned to ensure freedom from loose mill scale, loose rust, oil, form releasing agents, grease or any other harmful material before placing them in position. Reinforcement shall not be surrounded by concrete unless it is free from all such materials. Rough handling and dropping of reinforcement from a height shall be avoided.

All reinforcement shall be fixed in the correct position and shall be properly supported to ensure that displacement will not occur when the concrete is placed and compacted.
The uncoated reinforcement bars shall be tied at every intersection by two strands of 16 SWG black soft annealed binding wire. The Epoxy coated reinforcement bars shall be tied with 2 strands of PVC coated GI 18 SWG wire at every intersection. Crossing bars shall not be tack welded for assembly of reinforcement. The reinforcement bars shall be kept in position by using the following methods:

a) In case of beam and slab construction, precast cover blocks (having the same sand contents as the concrete which shall be placed) of size 40 x 40 mm and thickness equal to the specified covers shall be placed firmly in between the bars and forms so as to secure and maintain the specified covers over the reinforcement.

   When reinforcement bars are placed in two or more layers in beams, the vertical distance between the horizontal bars shall be maintained by introducing spacer bars at 1 to 1.2m centre to centre.

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b) In case of thick rafts & pile caps having two or multi layers of reinforcement, the vertical distance between the horizontal bars shall be maintained by introducing suitable chairs, spacers, etc.

c) In case of columns and walls, the vertical bars shall be kept in position by means of timber templates with slots accurately cut in them. The templates shall be removed after the concreting has been done below it.

d) Exposed portions of reinforcement bars shall not be subjected to impact or rough handling and workmen will not be permitted to climb on extending bars until the concrete has attained sufficient strength so that no movement of the bars in the concrete is possible.

21.4 Special requirements for Handling, Stacking, Placing of Epoxy coated Reinforcing bars.

Epoxy coated reinforcing bars shall be carefully handled and it shall be ensured that these do not rub on any hard surface or against another epoxy coated/uncoated reinforcing bar whether during conveying/transportation, stacking or placing.

During transportation and while stacking the epoxy coated reinforcing bars shall be placed on wooden planks not spaced farther than 600 mm. When placed in stacks the epoxy coated reinforcing bars shall be neatly tied in bundles using PVC binding material.

The cut ends of bars shall be touched up with special touch up material of specifications as provided by the coating agency. After cutting of the bar the application of touch up material shall be completed within four hours.

While bending the bars the pins of work bench(s) shall be provided with a PVC or plastic sleeve. Each bending operation on epoxy coated reinforcing bar shall be completed in time not less than 90 seconds.

Epoxy coated reinforcing steel bar shall not be directly exposed to sun rays or rain, and shall be protected with opaque polyethylene sheets or similar means as approved by the Engineer in Charge.

While doing concreting the workmen or machinery shall not rest or move on the epoxy coated reinforcing bars. Wooden planks shall suitably be placed to create proper gang-way.

21.5 Splicing/Overlapping

Only bars of full length shall be used as shown in the drawings. But where this cannot be done, overlapping of bars shall be done as directed by the Engineer-in-Charge. The overlapping bars shall be tied with two strands of 16 SWG black soft annealed binding wire. The overlaps shall be staggered for different bars and located at points along the span where neither shear nor bending moment is maximum.

21.6 Welded Joints

Welding of reinforcing bars shall not be permitted without the written permission of the Engineer-in- Charge. Where welding of reinforcing bars is permitted, it shall be in accordance with the recommendations of IS 2751 and IS 9417. Welded joints shall be located at suitable staggered positions. Tests shall be made as directed by the Engineer-in-Charge to prove that the joints are of the full strength of the bars. Maximum one welded joint shall be allowed per bar.

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21.7 Mechanical Connections

The mechanical splices in reinforcement by means of couplers, clamps etc. shall be used (as per manufacturer's specifications) with the written approval of the Engineer-in-Charge. Following tests, at the minimum, shall be conducted in advance to prove efficiency of the coupled joint before putting them in actual use. This covers requirements of couplers to be used with bars conforming to grades less than & equal to Fe550D of IS 1786.

Name of the Test	Testing Requirement	Code of conformance
Static Tensile test: 1. Tensile strength	Each connection shall develop at least 125% of the specified yield strength of the reinforcing bar & 100% of the specified tensile strength. Bar break requirement shall be satisfied to avoid splice failure & to develop full tensile strength of the bar.	ASTM A370/ ACI 318/ **AC 133**/ ISO 15835/ IS 16172
Static Tensile test: 2. Percentage elongation (Ductility)	The minimum percentage elongation (at maximum forces), in the reinforcing bar outside the length of the mechanical splice shall be minimum 3% before the failure of the test piece.	ISO 15835 IS 16172
Static compression test	Each connection shall develop atleast 125% of the specified yield strength of the reinforcing bar.	ASTM A370/ ACI 318/ AC 133
Permanent Elongation (Slip)	Permanent elongation across the coupled joint shall be less than 0.1 mm after loading at 60% of the yield strength of the reinforcing bar	BS 8110/ ISO 15835 IS 16172
Cyclic tensile test	Mechanical splice shall withstand 100 cycles of stress variation from 5% to 90% of the yield strength of reinforcing bar & without loss of static tensile strength capacity when compared with like specimen.	IS 16172
Moderate Oligocyclic (Seismic) Test (Cyclic Tension & Compression Test) **(Refer note- 1)**	Deformation across the coupled joint shall be less than 0.3 mm after subjecting the joint to a series of 20 cycles with 95% tension as well as 50% compression of the yield strength of the reinforcing bar & without loss of static tensile strength capacity when compared with like specimen.	ISO 15835/ ASTM A370/ ACI 318/ AC 133
Violent Oligocyclic (Seismic) Test (Cyclic Tension & Compression Test) **(Refer note- 2)**	The joint shall be subjected from zero strain upto twice the yield strain in tension followed by compression stress of 50% of yield strength of reinforcing bar for 4 cycles. Thereafter, from zero strain upto five times the yield strain in tension followed by compression stress of 50% of yield strength of reinforcing bar for 4 cycles. Deformation across the coupled	ISO 15835/ ASTM A370/ ACI 318/ AC 133

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Name of the Test	Testing Requirement	Code of conformance
	joint shall be less than 0.3 mm after 4 cycles & less than 0.6 mm after 8 cycles & without loss of static tensile strength capacity when compared with like specimen.	
Low cycle fatigue test **(Refer note- 3)**	Mechanical splice shall withstand 10,000 cycles of alternating tension & compression load from +173Mpa to -173Mpa & without loss of static tensile strength capacity when compared with like specimen.	IS 16172

Notes-

1) Moderate Oligocyclic (Seismic) test shall be performed for structures in seismic zone II.

2) Violent Oligocyclic (Seismic) test shall be performed for structures in seismic zone III, IV & V.

3) Low cycle fatigue test shall be performed for all structures except for concrete structures which are subjected to high cycle of fatigue like machine foundations etc.. For concrete structures which are subjected to high cycle of fatigue, High cycle fatigue test shall be performed as per IS 16172.

All operations relating to reinforcement coupling shall be done by using manufacturer's patented machine/ equipment in the presence of Engineer-in-Charge. Mechanical connections shall be placed away from points of high stress and shall be staggered.

21.8 Tolerances on Placing of Reinforcement

Unless otherwise directed by the Engineer-in-Charge, reinforcement shall be placed within the following tolerances:

a) For effective depth 200 mm or less $\pm$ 10 mm

b) For effective depth more than 200 mm $\pm$ 15 mm

21.9 Substitution

When indicated diameter of reinforcement bar is not available, the Contractor shall use other diameter of reinforcement bars on written approval of the Engineer-In-Charge.

21.10 Tolerance to Cover

The actual concrete cover shall not deviate from the required nominal cover by + 10 mm measured over the steel reinforcement including links.

22.0 PAYMENT

22.1 Plain and Reinforced Concrete

22.1.1 Payment for plain and reinforced cement concrete shall be made on cubic metre basis of the volume of the actual finished work done or as per approved construction drawings, whichever is less and shall be inclusive of providing pockets, openings, recesses of all sizes, chamfers, fillets, grooves, separation/ expansion/ isolation/ construction/ movement joints, curing by normal moist curing or using curing compound etc. as directed by Engineer-in-Charge etc. The rates shall be deemed to include complete cost of getting the

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respective mix designs approved, making and testing concrete cubes and carrying out other tests including tests of various ingredients, as per specifications and as directed by Engineer-in-Charge. Payment shall, however, be separately made for tests on concrete cubes done by accelerated methods of curing as defined in IS 9013.

22.1.2 No separate payment shall be made for any additive/ admixture/ Plasticizer/ Fibres used by the contractor for accelerating or retarding the strength of concrete or for achieving specified workability. The rate quoted shall be deemed to be inclusive of all costs related to any such additive/admixture/ Plasticizer/ Fibres.

22.1.3 The rate shall however be exclusive of reinforcement, metal inserts, pipe sleeves, formwork, water stops and any filler material in expansion/isolation joints.

22.1.4 Where the strength of concrete mix as indicated by tests, lies in between the strengths of any two grades given in Table-1 and it is accepted by the Owner/Engineer-in-Charge, such concrete shall be classified as a grade belonging to the lower of the two grades between which it lies. In case the cube strength shows higher results than those specified for the particular grade of the concrete, it shall not be placed in the higher grade nor shall the Contractor be entitled for any extra payment on such account. The concrete giving lower strength than specified may be accepted at reduced rates after satisfying the safety of the structure by checking it with tests as specified or rejected entirely at the discretion of the Engineer-in- Charge. The rejected concrete shall be dismantled at no extra cost to the owner and no payment or extension of time shall be granted for the concrete so rejected and the formwork and reinforcement used for the same. Cost of any material supplied by the Owner free of cost shall be recovered from the Contractor at double the prevailing market rate. In case the concrete of lower strength can be improved by carrying out some strengthening measures entirely at the discretion of the Engineer-in-Charge, then the said measures including all related tests shall be carried out by Contractor at his own cost. If the Contractor is able to make up the strength to the required grade by such improvement measures to the entire satisfaction of Engineer-in-Charge, payment shall be made for the grade achieved. However, if the strength of concrete is not made up to the strength of required grade, payment shall be made only for the lower strength if such concrete is accepted by the Engineer-in-Charge.

22.1.5 Deductions for openings, pockets etc. shall be as specified in relevant parts of IS 1200.

22.1.6 The rate quoted for reinforced cement concrete, also includes single pour concreting wherever specified. The rate shall be inclusive of all extra cost related to labour, shuttering, staging and making all other arrangements for such continuous casting e.g. provisions for adequate movement and storage spaces, special gangways, scaffolding, additional construction equipments, adequate lighting and supervision while the work continues round the clock etc. The rate shall also be inclusive of all costs related to concreting in any thickness, shape and position and at any height or depth so as to avoid any cold joint between specified construction joints.

22.1.7 Form Work

Unless otherwise specified, payment for form work shall be on square metre basis of the actual area in contact with the concrete cast. The rates shall be inclusive of keeping the formwork for the full period as specified in the above clauses and removing the same after the period is over. No extra payment shall be made for providing scaffolding/ staging/ access/ stairways/ ladders etc.

The rates shall be inclusive of any provision to be made or kept in the formwork for providing dowels, inserts etc.

Superior quality formwork for exposed/architectural concrete work shall be measured and paid separately under the relevant item in the schedule of rates.

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22.2 Reinforcement

22.2.1 Payment for plain round mild steel reinforcement bars, high strength deformed steel bars and epoxy coated reinforcing steel bar shall be on the basis of weight of bare steel irrespective of any coating applied in metric tons. The weight of the bar shall be derived from the sizes and corresponding nominal unit weight given in Table-1 of IS 1786. In case actual unit weight of the bars is less than nominal unit weight, but within permissible tolerances, the weight of reinforcement shall be calculated on the basis of actual unit weight. In case actual unit weight of the bars is more than nominal unit weight, the payment shall be made on the basis of nominal unit weight. Standard hook lengths, chairs, spacer bars and authorized laps only shall be included in the weight calculated. Binding wire shall not be weighed nor otherwise measured. Measurements for weight shall not include cutting allowance etc.

22.2.2 Rate quoted for reinforcement shall include cost of supplying, decoiling, straightening, cleaning, cutting, bending, placing, binding, welding (if required) and providing necessary cover blocks of concrete.

22.2.3 Payment for a mechanical threaded coupler/ clamp shall be made by measuring the Lap length of the respective rebar on which coupler/ clamp is used. The rate shall include supply of complete assembly, fixing, testing etc. all complete.

22.3 Water Stops/Water Bars & Expansion/Isolation Joints

22.3.1 Payment for water bars shall be made on running metre (RM) basis of the water stops provided in position. Rate shall include supplying, cutting, fixing, jointing by vulcanising or any other approved method, wastage, etc. complete.

22.3.2 Payment for filler materials in Expansion/Isolation joints shall be made on running metre basis of the joint provided. For boards provided at expansion/isolation joints, the measurement shall be made on square metre basis. Rate shall be inclusive of supply, cutting, fixing, jointing, wastage etc. complete.

22.4 Waterproof Cement Paint

22.4.1 Payment for waterproof cement paint as per Cl. 18.0 shall be made separately on Sqm basis.

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मानक विनिर्देशन
सिविल एवं संरचनात्मक कार्य

बाईपोलर कंक्रीट अंतर्वेशित क्षारण अंतर्अधिमिश्रण

STANDARD SPECIFICATION
CIVIL & STRUCTURAL WORKS

BIPOLAR CONCRETE PENETRATING CORROSION INHIBITING ADMIXTURE

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
2	21.07.2025	UPDATED AND ISSUED AS STANDARD SPECIFICATION	AV	RM/SP	AS	MN
1	18.06.2019	UPDATED AND REISSUED	TK	AJS	RS	RKT
0	26.04.2012	ISSUED AS STANDARD SPECIFICATION	AJS	PKM	SC	DM

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ABBREVIATIONS:

AASHTO	:	American Association of State Highway and Transportation Officials
ASTM	:	American Society for Testing & Materials
CPCIA	:	Concrete Penetrating Corrosion Inhibiting Admixture
IS	:	Indian Standard
JIS	:	Japanese Industrial Standard
OPC	:	Ordinary Portland Cement
PPC	:	Portland Pozzolana Cement
PSC	:	Portland Slag Cement
SRC	:	Sulphate Resistant Cement

Structural Standards Committee:

Convener: Mr. Anurag Sinha

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1.0 SCOPE

This specification prescribes the requirements and test methods including performance test for evaluating the efficiency of Bipolar Concrete Penetrating Corrosion Inhibiting Admixture (CPCIA) for protecting steel reinforcement embedded in concrete from corrosion. Non-concrete penetrating, Nitrite & Nitrate corrosion inhibitors are excluded from the scope.

2.0 REFERENCES

2.1 Codes

ASTM G1-03, ASTM G3-14, ASTM G109, ASTM G180-04, ASTM C1202, JIS Z-1535, AASHTO T259, IS 2, IS 101(Part1/Sec.5), IS 456, IS 1202, IS 1448, IS 1786, IS 9103, etc.

2.2 EIL Specifications

6-68-0001 : General Scope
6-68-0002 : Materials

3.0 SAMPLING

3.1 The representative samples of the material shall be drawn as per the table given below:

No. of containers (Lot)	No. of containers to be selected for sampling (N)
Up to 50	1
51-100	2
101-300	3
301-500	4
501& Above	5 Plus 1 for every lot of 300 containers

4.0 TESTING REQUIREMENTS

4.1 The product shall comply with the requirements specified in Annexure-A (Short Term Tests) and Annexure-B (Long Term Tests). Both the tests shall be conducted in an approved laboratory.

4.2 Unless specified otherwise, all the tests under Indian tropical conditions shall be conducted at room temperature 27 ± 2°C and relative humidity at 65 ± 5 % in a well ventilated chamber free from dust.

4.3 The contractor shall select the product from EIL approved vendor list and submit the Manufacturer Test Certificate to the Engineer-in-Charge. Approval for usage of product shall be given after satisfactory Short Term test results. Long Term tests are not mandatory for the products listed in EIL approved vendor list.

If the product is not from an EIL approved vendor, both Short term as well as Long term tests are mandatory. The contractor shall submit the Manufacturer Test Certificate to the Engineer-in-Charge and approval for usage of product shall be given after satisfactory Short Term test results. However, payment shall be released after the product complies with the requirements of Long Term test results.

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5.0 HEALTH, SAFETY & ENVIRONMENT CONSIDERATIONS

5.1 The CPCIA shall not cause harm to applicators by mean of inhalation or skin contact. All precautionary measures shall be prescribed by the manufacturers along with instructions of usage. Application methodology shall be approved by the Engineer-in-Charge.

5.2 The waste shall be discharged in accordance with applicable Environmental laws of land.

5.3 CPCIA shall not degrade or damage the construction materials like concrete, aggregates, steel reinforcement, formwork/shuttering.

6.0 PACKAGING

The product shall be supplied in air tight containers and following information shall be labeled on each container:

a) Name of the material
b) Name of the manufacturer
c) Volume/ weight of material
d) Specification number
e) Batch No. or Lot No. in bar code or otherwise
f) Month and year of manufacture
g) Ingredients & method of usage
h) Instructions for safe usage

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ANNEXURE-A

SHORT TERM TESTS

S. No.	Characteristics	Requirements	Methods of Tests
1.	Appearance	Brownish Liquid free from any visible residual deposits	Visually
2.	Odour	Mild Ammonical Odour	By smell
3.	Skin irritation	No irritation	By applying on reverse of the palm for 5 minutes.
4.	Ph i) As in supplied condition ii) 1% dilution ,w/w	 i) 9.0-12.0 ii) 9.0-12.0	 pH meter / Standard pH paper
5.	Specific Gravity at 27 ± 2°C	1- 1.1	IS 1448
6.	Viscosity of the material as in supplied condition, by Ford cup No 4, at 27 ± 2°C	10 - 20 sec.	IS 101(Pt.1/Sec.5)
7.	Accelerated Corrosion Test, for 21 hrs. i) Raw water without CPCIA ii) Raw water with CPCIA	 i) Excessive corrosion spots. ii) There shall not be more than 1-2 corrosion spots.	Modified accelerated corrosion test based on Japanese standard JIS Z 1535 (Refer Appendix-I)
8.	Open circuit potential ECorr Test	Minimum shift in potential by 120 mV upon addition of CPCIA	Modified ASTM G 69 (Refer Appendix-II)
9.	Reduction in Corrosion Current ICorr	Minimum reduction by 15 times upon addition of CPCIA	Modified ASTM G 69 (Refer Appendix-III)
10.	Electrical resistivity (R)	R with CPCIA ≥ R without CPCIA	ASTM C1876

Notes:

a) Tests of Sr. Nos. 7, 8, and 9 shall be performed from supplied material received at the site and witnessed by the owner's representative or Engineer in Charge.

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ANNEXURE-B

LONG TERM TESTS
(Shall be performed in triplicate)

S. No .	Characteristics	Requirements		Methods of Tests
		Without CPCIA	With 1% CPCIA	
1.	Immersion test for 720 hrs. (Rebar weight loss method)	40.00 mpy, max.	2.00 mpy, max.	Immersion Test (Rebar weight loss test) as per ASTM G1-03 (Refer Appendix-IV)
2.	Effect of Concrete admixture on compressive strength	Concrete strength in sample with CPCIA* should be ≥concrete strength in sample without CPCIA*		Test for effect on compressive strength by addition of CPCIA as per IS 9103 (Refer Appendix-V)
3.	Polarization test by Tafel polarization with 3.5% Sodium Chloride, for 20 days: Rate of corrosion shall be	45 mpy, max.	9 mpy, max.	Electrochemical polarization test conducted on steel rebars embedded in concrete as per ASTM-G 3-14 & IS 9103 (Refer Appendix-VI)
4.	Effect of CPCIA* on corrosion of embedded steel rebars exposed to chloride environments after 09 cycles (14 days wetting and 14 days drying): Rate of corrosion shall be	25 Coulombs, max.	0.50 Coulombs, max.	Long term corrosion test as per ASTM G109 (Refer Appendix-VII)
5.	Chloride Migration profile properties of concrete (for all types of cements viz. OPC, PPC, PSC, SRC)			AASHTO T-259 (Refer Appendix-VIII)
	i) Chloride % in concrete at 30mm depth after 90 days.	0.025%, max.	Nil	Chloride ion penetration (Salt ponding test) as per IS 456
	ii) Ability to resist chloride ion penetration			
	a) Concrete grade M-30, Water cement ratio: 0.45	1650 Coulombs, max.	1000 Coulombs, max.	Electrical indication of concrete ability to resist Chloride Ion Penetration (Rapid Chloride Permeability test) as per ASTM C1202
	b) Concrete grade M-40, Water cement ratio: 0.40	1550 Coulombs, max.	1000 Coulombs, max.	

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6.	Initial screening of CPCIA for Steel in Concrete	Meeting criteria as described in point number 8, "Interpretation of Results"	ASTM G180-04

Notes:

a) CPCIA* : The CPCIA shall be used as 1% w/w of cement or as recommended by the manufacturer for conducting the tests mentioned in Annexure-B except Immersion test for 720 hrs. mentioned at S.No.1 where it shall be used as 1% w/w of water or as recommended by the manufacturer.

b) Rebars conforming to IS 1786 shall be used for testing purposes

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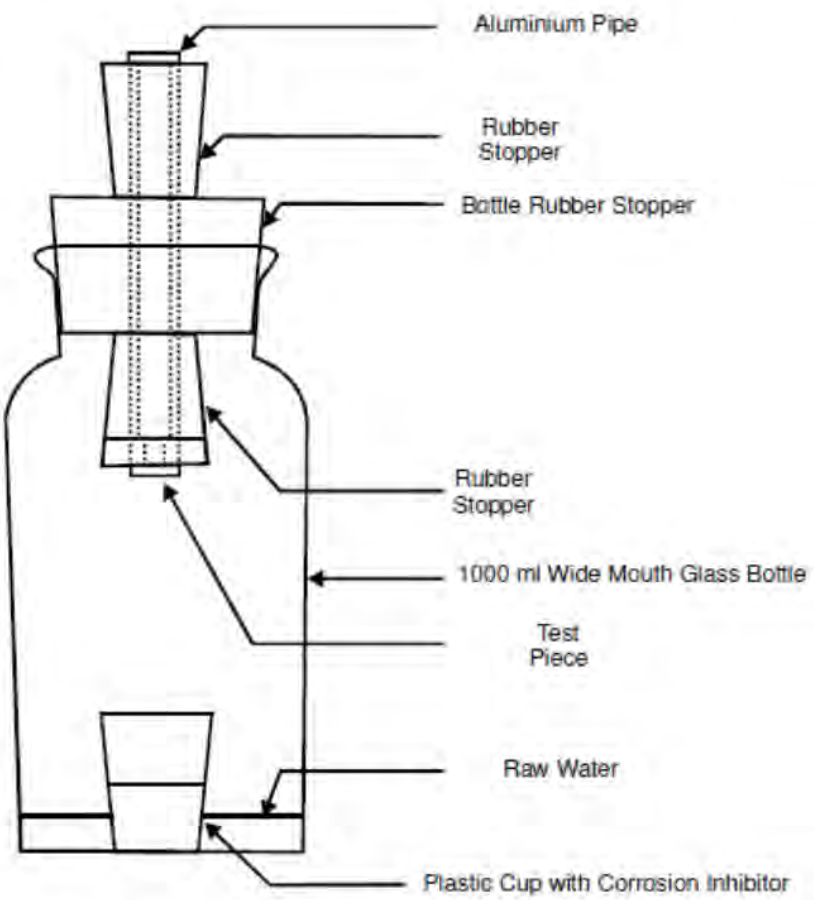
APPENDIX-I

MODIFIED ACCELERATED CORROSION TEST (BASED ON JAPANESE STANDARD JIS Z 1535)

TEST PROCEDURE

Attach steel test pieces conforming to IS 1786 (of size approx. 15mm dia and 12mm thickness drilled from one side c/c to a dia of 10mm and a depth of 10 mm to hold the Aluminium pipe) after thorough cleaning to white metal by using 1000 grade grit paper and subsequently polishing with 3/0 grade and finally with 4/0 grade grit paper to the Aluminium pipe with the help of cello tape so that it is firmly attached. The Aluminium pipe is then slid upwards till the test piece rests in the slot provided in the rubber cork, as shown in the figure.



Assembly with Corrosion Inhibitor

Pour 100 ml of tap water in both the bottles. Fill the plastic cup with 25 ml CPCIA solution as in supplied condition. In one of the bottles place the plastic cup with the CPCIA solution so that the cup is placed in the tap water. Allow to remain for 18 hours at ambient temperature. After 18 hrs. add chilled water having temperature below 1.0 ºC into the Aluminium pipes and allow to remain for 3 hrs. The temperature of the chilled water in the Aluminium pipes shall be maintained at 2.0 ± 0.5 ºC by frequently changing the chilled water with the help of the pipette. Observe the steel test pieces after the experiments i.e. 18+3=21 hrs., for any corrosion spots.

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APPENDIX-II

OPEN CIRCUIT POTENTIAL (Ecorr) TEST

This test is intended to show a live demonstration of the reduction in corrosion potential of steel under 3.5 % NaCl water with the addition of corrosion inhibitor.

Test Apparatus & Consumables

- **Working Electrode** : Polished TMT steel sample (dia. 15 ±2 mm) embedded in cast epoxy/ polymer
- **Reference Electrode** : Saturated Calomel Electrode (SCE) with KCl inserted
- **Voltmeter** : High Input resistance Digital Multimeter
- **Electrolyte Medium** : 3.5 % NaCl water solution 250 ml (Temperature 25-28^{0}C).
- **Water** : DM water or Potable water (Maximum TDS 200)
- **Salt** : Sodium chloride (lab grade) or table salt white powder
- **Test Temperature** : Ambient /At room temperature 23 to 35^{0}C

Sample Preparation

(a) Working Electrode : A working electrode shall be prepared by selecting proper available size of TMT/Carbon steel rebar, a desirable diameter is 16 mm or 20 mm, steel cutting & turning longitudinally on lathe machine to achieve desired shape & size as given in Fig.1. After that, a strong joint connection should be made by soldering or brazing a flexible, shielded and approximately 1 feet long copper wire to the steel disk over the round flat surface to achieve good electrical continuity. For masking this steel & joint connection, use a strong two-pack adhesive (polymer or epoxy system). Choose a proper size of mould and cast this probe attached steel by keeping it in the center of polymer as shown in Fig. 1. The sealed electrode should not leak from any side. Before proceeding to open circuit potential (OCP) testing, a good electrical continuity must be ensured between the exposed steel surface and the copper wire end by checking through a continuity tester or multimeter.

(b) Surface Polishing Preparation: The exposed surface of the mounted sample, the working electrode, should be polished very neatly and systematically up to the mirror finish level without any scratch marks. Follow the stepwise procedure for the preparation:

1. For polishing, keep emery paper horizontal on a clean & plain surface and start polishing with a coarser grade of emery paper 200 grit, or if necessary, start with 100 grit & use subsequent finer grades, i.e., 200, 300, 400,600, 800/1000, or 1200, & finally 02/04 grade.
2. Hold the sample tightly by hand & rub it on the exposed surface in full strokes in the forward direction and raise hand backward without rubbing on paper, similarly repeat the process until the complete grinding of the surface comes evenly in one direction.
3. To shift further to a finer grade turn the sample in perpendicular position (90 degrees) rather than previous direction & polish back and forth as in previous cycle. Continue this for subsequently every new paper and in addition to this before starting a new paper grade simultaneously wipe off surface with clean cloth or tissue paper using acetone / methanol solvent to remove any previous dirt picked up by the sample. Repeat the stepwise procedure systematically until a final mirror finish level is achieved without any scratch line mark.

Testing Procedure

1. Take a clean glass beaker of 500 ml capacity.
2. Fill the beaker with 3.5 % NaCl electrolyte water solution up to 250 ml.

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3. Prepare a working electrode of 15±2 mm dia. disk by cutting & grinding longitudinally TMT reinforced steel as per IS 1786 & solder it with a copper wire to edge of round section. It is completely bounded with epoxy/polymer casting, except the facing portion in exposed conditions. (refer Fig. 1a)
4. The exposed surface of steel must be hand polished with graded emery paper as explained in sample preparation.
5. Clean the polished surface with alcohol or any organic solvent & put the working electrode in the beaker containing the electrolyte solution.
6. For measuring E_{corr} of the polished steel surface in electrolyte solution, connect the other end (probe) of the copper wire to positive polarity of multimeter & turn the knob to the DC volt 2-5 mV range. Similarly connect the SCE banana pin to the –ve terminal of multimeter, after that immerse the SCE electrode near to exposed steel in the electrolyte solution up to the center of the exposed steel area (Refer figure 2), and ensure minimum gap between two electrodes.
7. Measure the reading. It must be more negative than -500 mV, or wait till it reaches between -500 to -550 mV (idle condition is >-550 mV w.r.t. SCE).
8. After showing Ecorr > -500 mV by multimeter, now add 2% of corrosion inhibitor by volume of the total electrolyte solution. Stir the solution slowly & wait up to 15-20 minutes.
9. The Ecorr of steel will shift towards the positive side as compared to the initial Ecorr without the addition of corrosion inhibitor (a minimum shift of -120 mV in Ecorr value is preferable for this test).

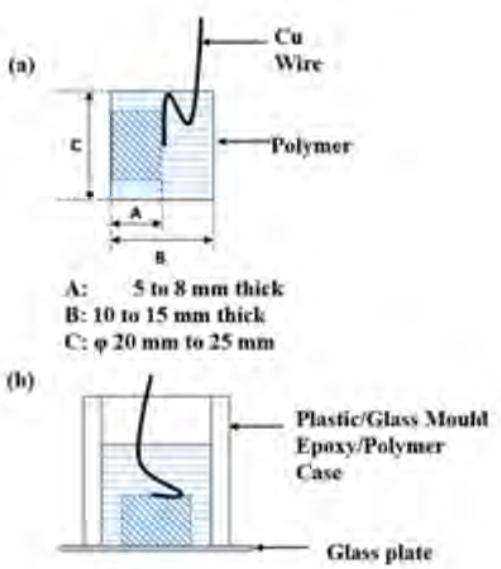

Figure 1.

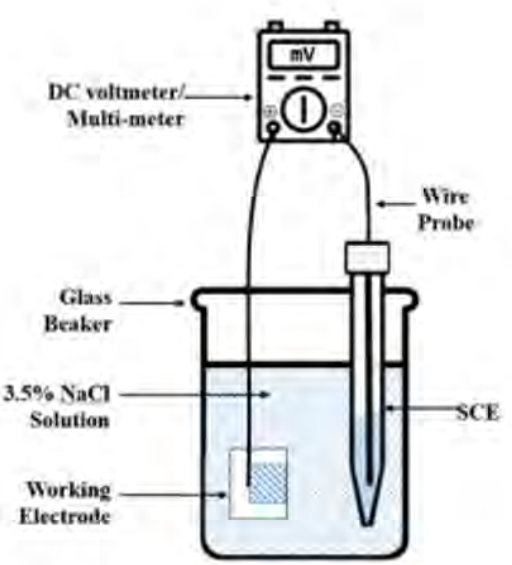

Figure 2.

Result Interpretation

Shifting of Ecorr towards the positive side by min. 120 mV clearly indicates that the corrosion inhibitor is capable of inhibiting corrosion, which displaces the corrosive ion away & chemically generates an invisible passive film on the steel surface when the corrosion inhibitor is added to the electrolyte solution.

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APPENDIX-III

INSTANT REDUCTION IN CORROSION CURRENT (I_{Corr}) AT FREE CORROSION POTENTIAL (E_{Corr}) ON SURFACE TREATED REINFORCED TMT/CARBON STEEL WITH CORROSION INHIBITOR

This test is intended to show a live demonstration of reduction in ongoing instant corrosion current when the surface attains near corrosion cell potential (E_{corr}), which is measured by SCE reference electrode of TMT/Carbon Steel under 3.5 % NaCl water solution with the addition of corrosion inhibitor. This is a short term electrochemical test which can be carried out easily in the laboratory to measure the quality and performance evaluation of corrosion inhibitor directly against TMT/Carbon steel rebar for the corrosion protection of steel in the concrete in a very short duration at ambient temperature.

Test Apparatus & Consumables

- **Working Electrode** : Surface finished TMT or Carbon steel rod sample (dia .10 mm to 16mm) treated with shot blasting or acid pickling (bright or silver finishing level)
- **Reference Electrode** : Saturated Calomel Electrode (SCE) with KCl inserted
- **Voltmeter** : High input resistance digital multimeter
- **Ammeter** : Very low resistance ammeter/ multimeter in DC micro and milliampere range
- **Counter Electrode** : Noble series metal (Nichrome/ Titanium/ SS 316 grade mesh)
- **Electrolyte Medium** : 3.5 % NaCl water solution 200 ml. (Temp. 25-28^{0}C).
- **Electrode support holder** : Non metallic or plastic disc having three hole around the disc
- **Water** : Clean potable water max. TDS 200
- **Salt** : Sodium chloride (lab grade) or table salt (white powder)
- **Test Temperature** : Ambient to 35 ^{0}C

Working electrode preparation

A surface treatment process like blasting or pickling should be carried out over the tempered martensite zone on the top of outer core surface of TMT rebar and it should be done completely free from rust & pit without any crevice marks or corrosion spots.

Since different surface treatment processes attributes significant variation in the corrosion potential and corrosion current of steel due to the intense degree of reaction taking place on the surface topography & profile across varying surface roughness as well as the rapid formation of active anodic and active cathodic cells on the metal surface when exposed to an electrolytic solution at a particular temperature, therefore the comparison shall be made between similar kinds of surface preparation treatments i.e. acid pickling, shot blasting, mechanical polishing or any other types in view to compare the inter and intra laboratory test results.

Counter electrode (CE): A counter electrode mesh made from a metal more noble than carbon steel must be used. The surface area of the CE should be at least 5 times or greater than that of the working electrode.

Testing Procedure

1. Take a clean glass beaker of 500 ml capacity.
2. Fill the beaker with 3.5 % NaCl electrolyte solution up to 350 ml.
3. Prepare the working electrode by selecting a suitable dia. of 12 mm TMT/reinforced steel up to 200 mm in length. The surface finish shall be prepared with fine shot blasting grit or acid pickling. & rinse with plenty of water prior to washing with alkaline solution.

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4. The treated surface area of steel, i.e. the area under test in the electrolyte must be cleaned thoroughly with an organic solvent (acetone/methanol or alcohol) before placing it in the chloride solution.
5. Place the cylindrical-shaped mesh as the counter electrode (SS 316 or superior metal mesh) inside the glass beaker by covering circumferential touching the beaker & shall be over around the test steel working electrode. For measuring corrosion current, extend a sufficient portion of the mesh outside the beaker for making contact with the ammeter probe.
6. Now insert the TMT steel working electrode in the centre of the beaker through a suitable nonmetallic support cover & again insert the calomel ref. electrode in between mesh & working electrode location through the nonmetallic support 12.5 mm hole.
7. First for measuring E_{corr} by using voltmeter connect the (+) polarity probe at top side of TMT steel rebar & connect banana socket pin adjoining calomel electrode to the (–) terminal of socket on voltmeter range and switch on the voltmeter by keeping the knob on the 2 or 5 DC mV range. Measure the reading, it must be more negative than -550 mV or wait till it reaches in between -550 to -625 mV (idle condition is around -600 mV w.r.t. SCE).
8. In the meantime, make connection ready for connecting DC ammeter probe, connect one terminal of the probe to the counter mesh electrode, and connect other end to the DC current socket on the ammeter through a toggle switch by keeping DC current on more than 10 mA range, the second end of probe shall be maintained in standby mode to connect directly to the working electrode when it is required. Keep watching the voltmeter reading, when it is showing around -600 mV (±10 mV), then note down the reading & immediately disconnect the TMT steel connection through the toggle switch connected with voltmeter & connect the ammeter probe to the TMT steel electrode promptly. Read out the current reading in mA range carefully and continuously. Note down the reading after 3 seconds time has elapsed right from the time of immediate connecting probe to the steel electrode. So, this current & voltage reading of TMT steel shall be considered the maximum value in 3.5 % chloride solution before the addition of the inhibitor.
9. Now add 3 % of bipolar corrosion inhibitor to the electrolyte solution & stir properly with a portable stirrer or spatula to mix the solution homogeneously. Disconnect the working electrode probe from the ammeter & connect it with the voltmeter probe. Continuously watch the E_{corr} reading, leave it in this position for 15 to 20 minutes. Finally, the E_{corr} reading will gradually decrease until maximum reduction is observed towards the positive side. At the moment when it reaches momentarily in stable condition and comes down to maximum 120 mV or more reduction in mV value versus previous E_{corr} reading then note down the final E_{corr} reading & disconnect the steel probe & immediately connect the ammeter probe to the steel electrode. Note down the current readings in microampere range after 3 seconds of visible reading at just moment of connecting probes as mentioned in point no. 8.

   To avoid jumbled wire connections & simplify the operation during testing a user can conduct this test in a more comfortable and simple way by using a SPDT switch board with a multiple probe connection setup.

Result Interpretation

The E_{corr} of steel will shift towards positive side as compared to initial E_{corr} without addition of corrosion inhibitor. The current (Icorr) will also reduce instantly, and the preferable value of reduction in current is minimum 15 times lower than the value without addition of corrosion inhibitor in the chloride solution.

Remark

Shifting of E_{corr} towards the positive side along with ongoing current which is falling rapidly, clearly indicates that the corrosion inhibitor is capable of inhibiting corrosion by displacing the corrosive ions away & chemically generating an invisible passive film on the steel surface when added to the electrolyte solution.

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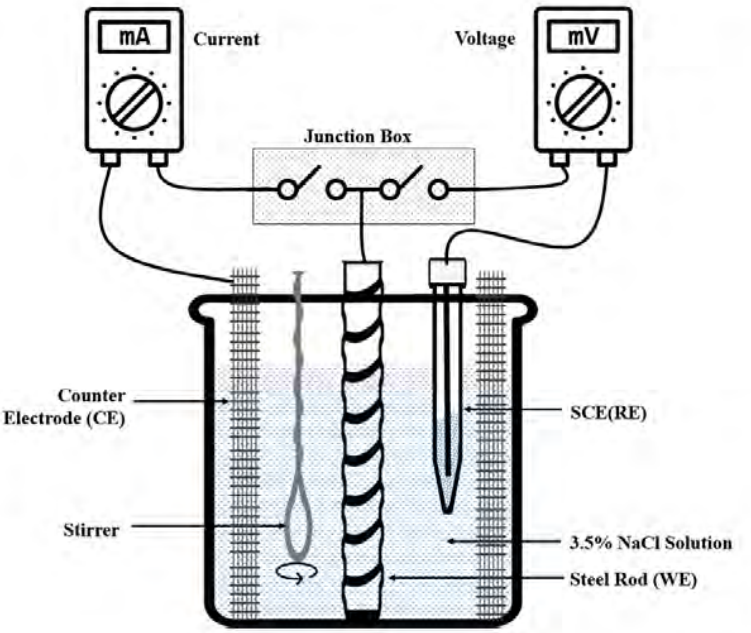

Pictures showing different surface treated TMT Steel reinforced bar

The results should include the following:

1. Type and size of rebar (diameter and length).
2. Types of surface treatment processes on steel in detail.
3. Max. E_{corr} & I_{corr} values just before the addition of the corrosion inhibitor.
4. Added dosage of corrosion inhibitor to the electrolytes.
5. Final values of reduced E_{corr} & I_{corr} measured after adding the bipolar corrosion inhibitor.
6. Lag time duration in seconds (waiting period in seconds) when taking corrosion current readings after switching on the ammeter.
7. Temperature of the electrolytic solution & the surrounding room temperature.

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APPENDIX-IV

IMMERSION TEST (REBAR WEIGHT LOSS TEST) (AS PER ASTM G 1)

TEST PROCEDURE

Take six pieces of Tor steel rebar conforming to IS 1786 of size approx. 40 mm length and 10 mm dia. Clean the rebar of any rust, mill scale etc., with the help of steel wire brush, till it has overall a shining surface. Now clean all the six pieces with solvent such as Benzene/Acetone to remove any loose rust /dust from the surface. Dry at 100 ± 2 ºC for 15 minutes in an oven. Cool and take the weights of all the six pieces and record it.

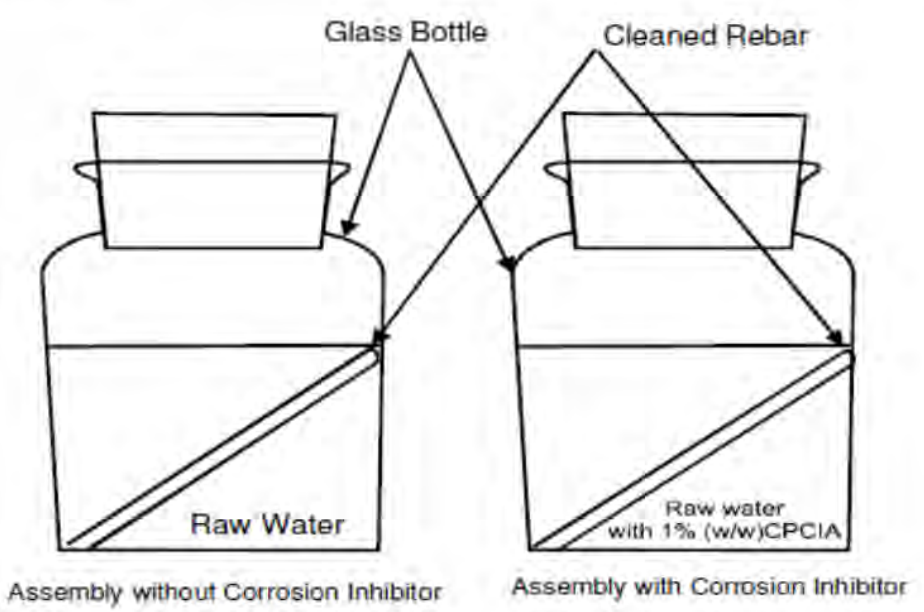
Take six transparent glass/plastic bottles of approx. 150±10 ml with air tight caps. Clean all the bottles with tap water and then fill them with 100 ml of tap water so that the bottles are approx. three fourth filled. In three of the six bottles, add CPCIA 1%, w/w or as recommended by the manufacturer of the water in the bottle. Now put one cleaned and weighed rebar test piece completely immersed in water/water + CPCIA, in all the six bottles and close the cap.

After 30 days (720 hrs.), take out all the six test pieces and put them in Clark solution (prepared by dissolving 20 gms. of Antimony Trioxide and 50 gms of Stannous Chloride in 1000 ml of Conc. Hydrochloric acid, S.G. 1.18) so that corrosion products are dissolved. After complete removal of corrosion products (in 5 minutes approximate), take out the test pieces and wash in running water and finally with distilled water. Then wash the test pieces, with solvent such as Benzene/Acetone. Dry at 100 ± 2 ºC for 30 minutes in an oven. Cool and take the weights of all the six pieces and record it.

Calculate the corrosion rate in mpy, by using the formula

Corrosion rate (mpy) = 534 (W1-W2) / DAT

Where W1-W2 is the weight loss in mg., D is the density of steel , A is the area in sq.inch and T is the time of exposure in hrs



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APPENDIX-V

TEST FOR EFFECT ON COMPRESSIVE STRENGTH BY ADDITION OF CPCIA

TEST PROCEDURE

Cast three concrete blocks of size 100mm x 100mm x 100mm each without and with CPCIA 1% (w/w) of cement or as recommended by the manufacturer, by casting the concrete of M20 grade as per Clause 6.2.3 of IS 9103.

The above casted blocks shall be demoulded after 24 hrs. These blocks shall be moist cured for 28 days. After completion of the curing period, the blocks of each type shall be tested for compressive strength in compression testing machine (Universal Tensile Machine) and data recorded.

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APPENDIX-VI

BRIEF OUTLINES OF ELECTROCHEMICAL POLARIZATION TEST CONDUCTED ON STEEL REBARS EMBEDDED IN CONCRETE (AS PER ASTM G 3)

TEST PROCEDURE

Cast three concrete cylinders, of size 75mm dia and 150mm length each without and with CPCIA 1% (w/w) of cement or as recommended by the manufacturer, by casting the concrete of M 20 grade as per Clause 6.2.3 of IS 9103, and placement of one cleaned rebar conforming to IS1786 of size 375mm length and 12mm dia (preferably cleaned by pickling in Hydrochloric acid 20% (v/v) approximately, till surface shines and washed in running water) in each block .

The above casted blocks shall be demoulded after 24 hrs. These blocks shall be moist cured for 28 days.

After completion of the curing period, the blocks shall be subjected for Polarization test for 20 days as per ASTM G-3 and observations recorded.

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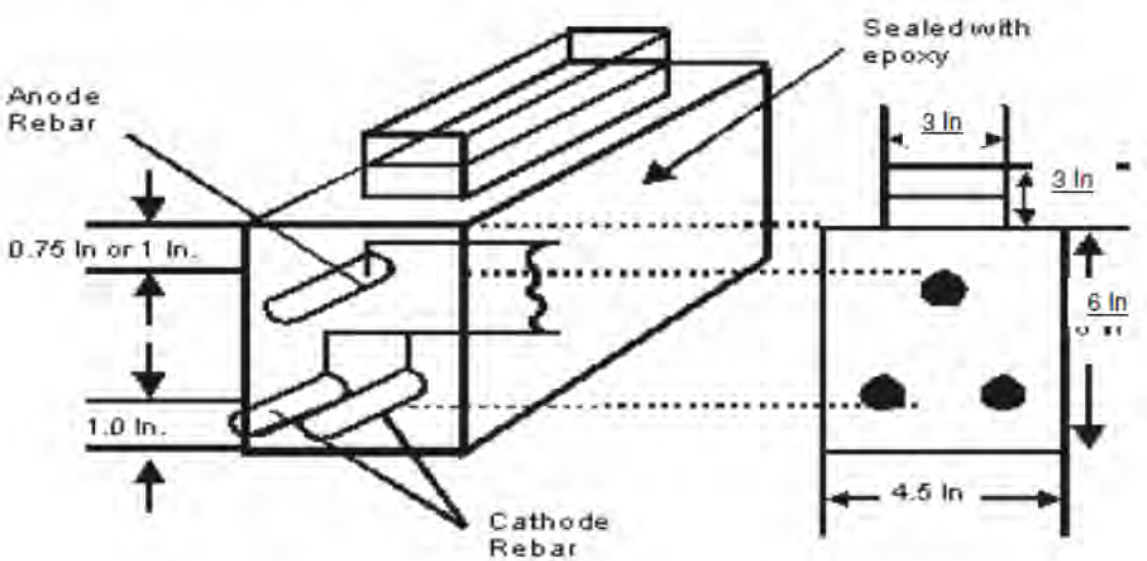
APPENDIX-VII

BRIEF OUTLINES OF LONG TERM CORROSION TEST (AS PER ASTM G 109)

TEST PROCEDURE

Three specimens each of control concrete and that of CPCIA admixed concrete (1% w/w of cement or as recommended by the manufacturer) should be cast as per the size 280mmx150mmx115mm and with placement of three cleaned reinforcement bars conforming to IS 1786 (preferably cleaned by picking in Hydrochloric acid 20% (v/v) approx, till surface shines and washed in running water) of size 12mm and length 375mm as per the details shown in the figure. Admixture shall be added as per manufacturers recommended dosage. All the casted concrete samples shall be moist cured for 28 days.

Ponding of samples with 3% NaCl solution as shown in the figure to be continued and measuring of voltage across 100-ohm resistor to be continued beginning of the second week of ponding. Calculate the current IJ from the measured voltage and record. Also measure the corrosion potential of the bars against reference electrode. The experiment should be continued till the macrocell current reaches a value of 10 µA. After the experiment break the specimens and examine the rebars for extent of corrosion, measure the corroded area and record.



Note - All Measurements in In. (25.4 mm = 1 In.)

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APPENDIX-VIII

BRIEF OUTLINES OF RESISTANCE OF CONCRETE TO MIGRATION OF CHLORIDE ION TEST (AS PER AASHTO T259)

Part-A : Chloride Ion Penetration (Salt Ponding Test As per IS 456)

TEST PROCEDURE

Cast three concrete blocks of size 300mmx300mmx75mm each without and with CPCIA 1% (w/w) or as recommended by the manufacturer, by using the concrete mix as under:

S.No.	Material	M30 (Kg)	M40 (Kg)
i)	53 Grade Cement	50	50
ii)	Coarse Sand	104	87
iii)	Aggregate, passes through 20 mm and retained on 10 mesh	160	134
iv)	Water (subject to 55±5 slump)	24	20
v)	CPCIA	0.5*	0.5*
	* as recommended by the manufacturer with each type of cement viz. Ordinary Portland Cement, Portland Pozzolana Cement, Portland Slag cement, Sulphate resisting Cement		

AASHTO T259 test (commonly referred to as the salt ponding test) is a long-term test for measuring the penetration of Chloride ions into concrete. Three slabs of 75 mm thick and having a surface area of 300 mm square shall be casted. These slabs are moist cured for 14 days and then stored in drying room at 50 percent relative humidity for 28 days. The sides of the slabs are sealed except for bottom and top face. After the conditioning period, a 3% NaCl solution is ponded on the top surface for 90 days, while the bottom face is left exposed to the drying environment (see figure below).

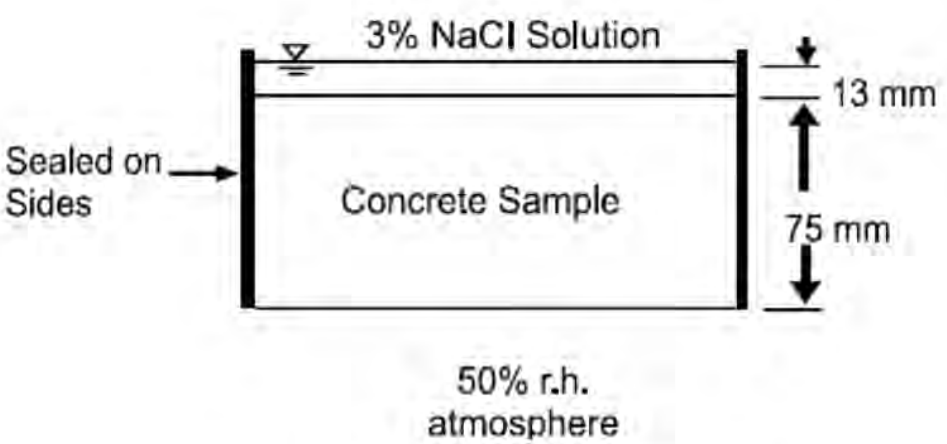

Figure: AASHTO T259 (Salt ponding) test setup

At the end of this time (90 days) the slabs are removed from the drying environment and the Chloride concentration of 10 mm thick slices is then determined (AASHTO T259). Two or three slices are taken at progressive depth. The salt ponding test does provide a crude one-dimensional chloride ion ingress profile. Test results should meet the requirements as stipulated in IS 456.

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BRIEF OUTLINES OF RESISTANCE OF CONCRETE TO MIGRATION OF CHLORIDE ION TEST (AS PER AASHTO T259).....Contd.

Part-B : Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration (Rapid Chloride Permeability test As per ASTM C-1202)

TEST PROCEDURE

Cast three concrete cylinders of size 50 mm thick, 100 mm diameter without and with CPCIA 1% (w/w) or as recommended by the manufacturer, by using the concrete mix as under:

S.No.	Material	M 30 (Kg)	M 40 (Kg)
i)	53 Grade Cement	50	50
ii)	Coarse Sand	104	87
iii)	Aggregate, passes through 20 mm and retained on 10 mesh	160	134
iv)	Water (subject to 55±5 slump)	24	20
v)	CPCIA	0.5*	0.5*
	* as recommended by the manufacturer with each type of cement viz. Ordinary Portland Cement, Portland Pozzolana Cement, Portland Slag cement, Sulphate resisting Cement		

As per ASTM C-1202, water-saturated concrete specimen is subjected to a 60 V applied DC voltage for 6 hrs. using the apparatus shown in Figure below. In one reservoir is a 3.0% NaCl solution and in the other reservoir is a 0.3 M NaOH solution. The total charge passed is determined and this is used to rate the concrete's resistance to chloride ion penetration.

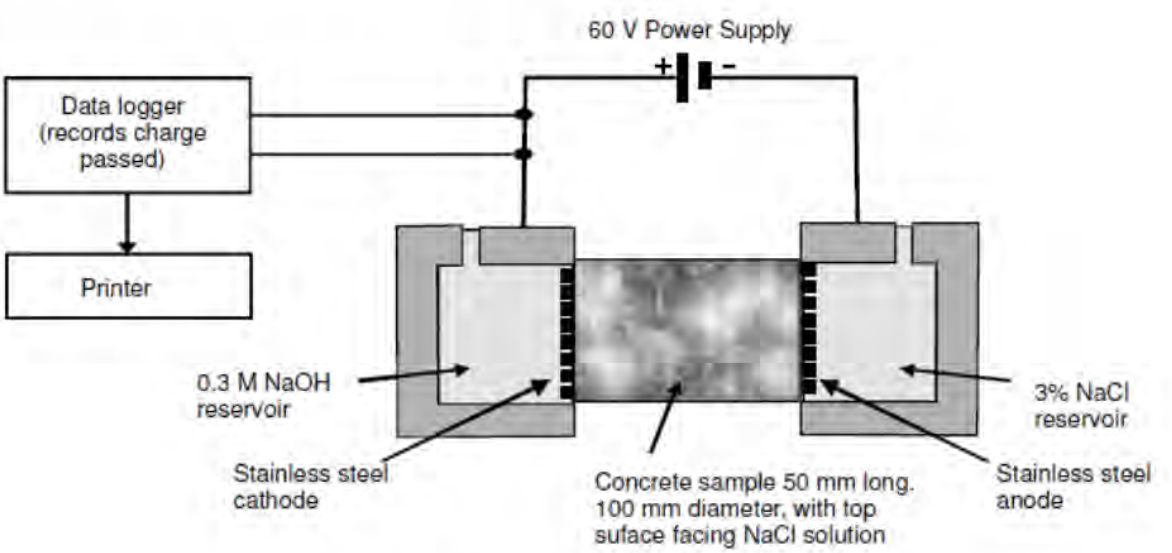

Figure: AASHTO T277 (ASTM C1202) test setup

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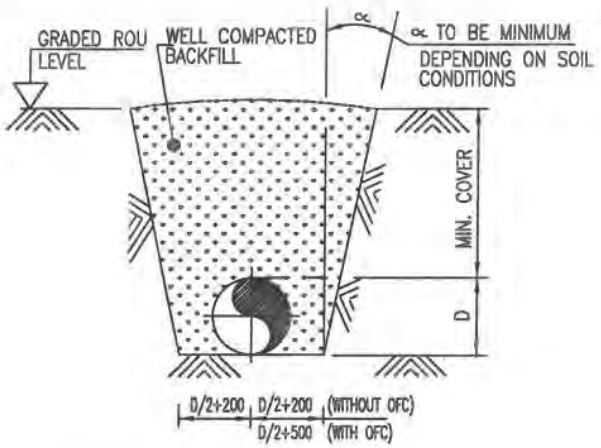
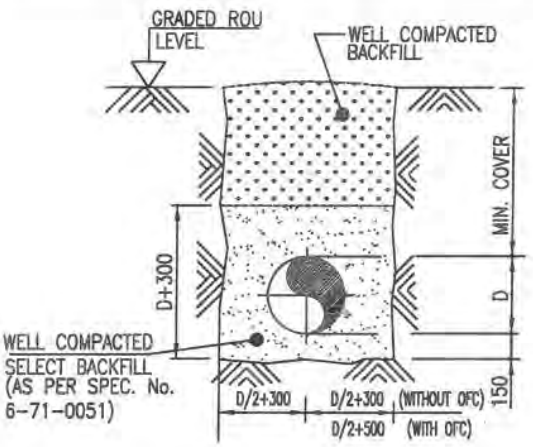
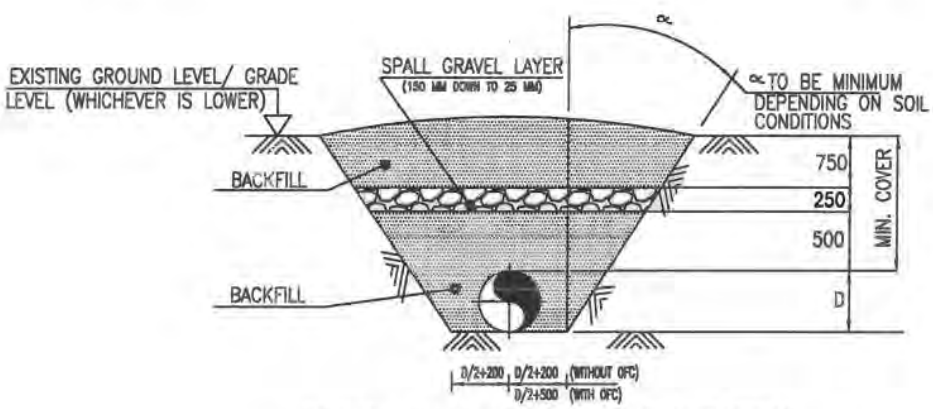


TRENCH IN NORMAL SOIL
(CROSS SECTION)



TRENCH IN CONSOLIDATED ROCK
(CROSS SECTION)



TRENCH IN SAND DUNES (ELEVATED)
(CROSS SECTION)

NOTES:-

1. ALL DIMENSIONS ARE IN mm, UNLESS SPECIFIED OTHERWISE.
2. TRENCH DIMENSIONS/COVER REQUIREMENTS SHOWN IN THIS STANDARD ARE MINIMUM REQUIRED DIMENSIONS. ANY INCREASE IN THE TRENCH WIDTH/COVER SHALL BE SPECIFIED IN THE PROJECT SPECIFIC REQUIREMENTS OF CONTRACT.
3. MINIMUM COVER REQUIREMENT SHALL BE SUBJECT TO APPROVAL OF CONCERNED AUTHORITIES HAVING JURISDICTION OVER THE AREA.
4. EXTRA COVER REQUIREMENT SHALL BE PROVIDED AT OVER BENDS AND SAG BENDS AS REQUIRED DURING CONSTRUCTION.
5. REFER RELEVANT STANDARDS FOR MINIMUM COVER REQUIREMENT IN CASE OF PIPELINE CROSSING AT ROADS, RAILWAY TRACKS, RIVERS, MARSHY AREAS, WATER BODIES (STREAMS) ETC.
6. ALL PIPELINES TO BE CONSTRUCTED IN THE LAND UNDER JURISDICTION OF GOVT. OF INDIA, A MINIMUM COVER OF 1000 mm FOR GAS PIPELINE & 1200 mm FOR LIQUID/LPG PIPELINES SHALL BE ADOPTED FOR NORMAL TERRAIN, IN ACCORDANCE WITH GOVT. OF INDIA, PETROLEUM AND MINERAL PIPELINES (ACQUISITION OF RIGHT OF USER IN LAND) ACT NO. 50, 1962 AND IT's AMENDMENTS THEREON.
7. FOR ROCKY TERRAIN, MINIMUM COVER SHALL BE 1000 MM FOR SAND DUNES MINIMUM COVER SHALL BE 1500 MM.
8. REFER APPLICABLE STANDARDS/DRAWINGS FOR OFC.

Rev. No.	Date	Purpose	Prepared by	Checked by	Stds. Committee Convenor	Stds. Bureau Chairman
					Approved by	
6	01.12.25	REVISED & REISSUED AS STANDARD	SAYANTAN GANGOPADHYAY	R.S.BAINS	M.S. GUNJIYAL	M.NANDI
5	26.10.20	REVISED & REISSUED AS STANDARD	TRIBHUWAN TYAGI	RAJ KISHORE	M.S. GUNJIYAL	S. MAZUMDAR

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PROPOSED PIPELINE

EXISTING PIPELINE

INTERSECTION POINT/ TURNING POINT

UNCASED CROSSING

CASED CROSSING

CONTINUOUS CONCRETE WEIGHT COATING

GRAVEL FILLED GEO TEXTILE BAGS

OPTICAL FIBER CABLE INSIDE HDPE CONDUIT

OPTICAL FIBER CABLE INSIDE HDPE CONDUIT SUBDUCTED IN CS PIPE

INTERMEDIATE PIGGING STATION

SECTIONALISING VALVE (SV)/ BLOCK VALVE

PUMP/COMPRESSOR STATION

HOT INDUCTION BEND

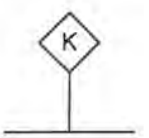
INSULATING JOINT

DUMP SITE (FOR LINEPIPE) (DS)

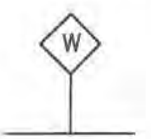
SUSPENSION CROSSING

EXISTING UNDERGROUND CABLE/PIPELINE/ STRUCTURE CROSSING

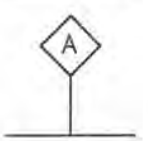
UNDER PINNED OR SPANNED CROSSING



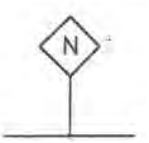
KM POST



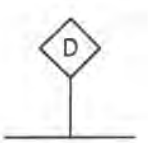
PIPELINE WARNING SIGN



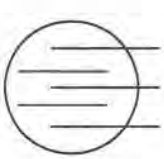
AERIAL MARKER



NAVIGABLE WATERWAY PIPELINE WARNING SIGN



DIRECTION MARKER



TEST STATION
CHAINAGE C.P
TYPE INSTALLATION

Rev. No.	Date	Purpose	Prepared by	Checked by	Stds. Committee Convenor	Stds. Bureau Chairman
6	01.12.25	RE–AFFIRMED & REISSUED AS STANDARD	SAYANTAN GANGOPADHYAY	R.S.BAINS	M.S. GUNJIYAL	M.NANDI
5	26.10.20	REVISED & REISSUED AS STANDARD	TRIBHUWAN TYAGI	RAJ KISHORE	M.S. GUNJIYAL	S.MAZUMDAR

Approved by

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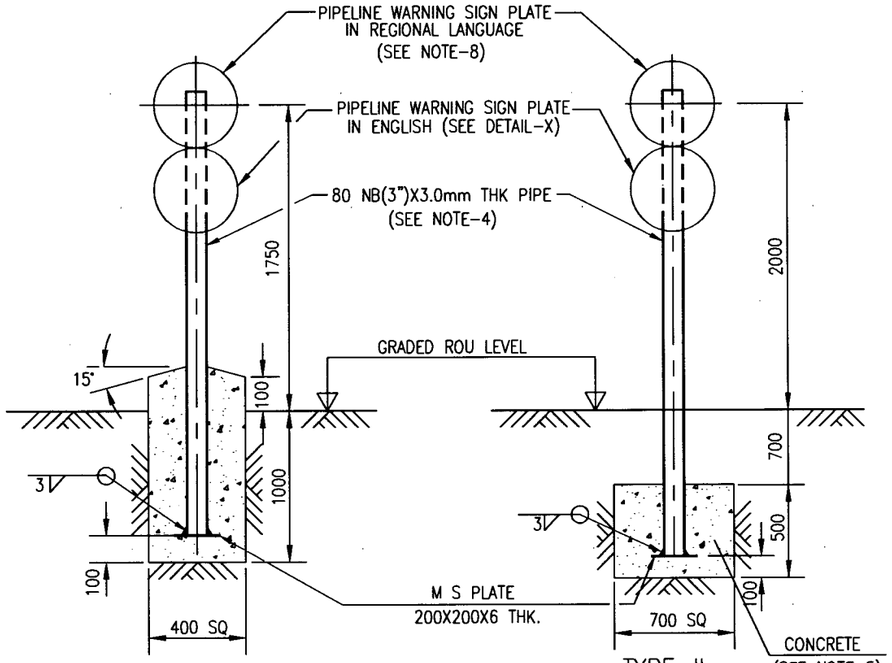
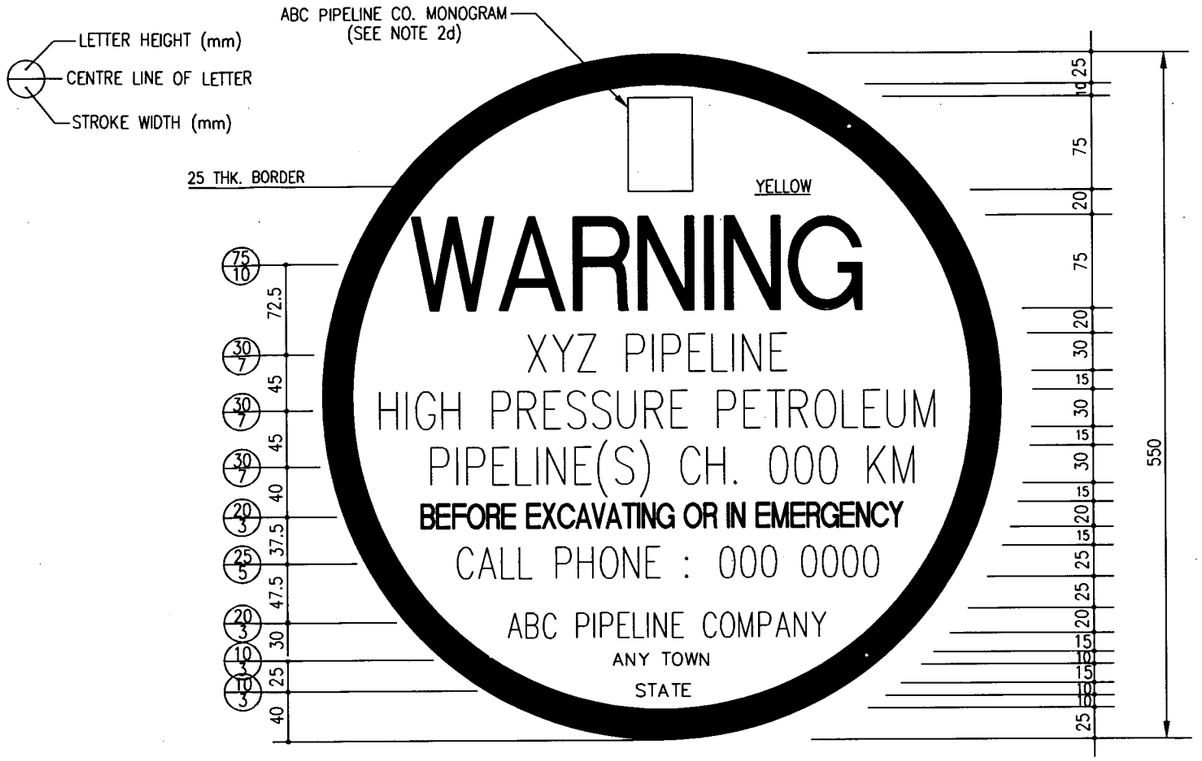
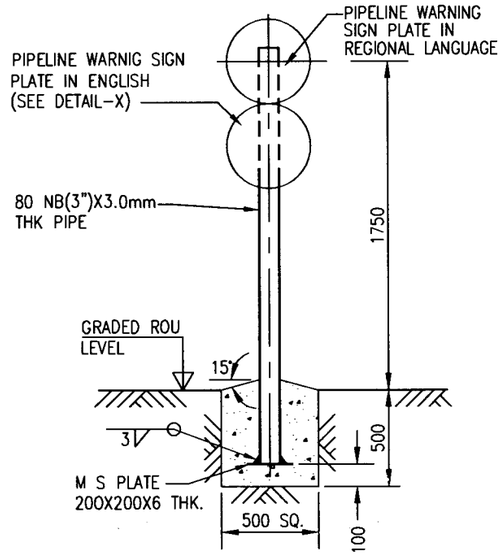


TYPE-I
FOR NORMAL SOIL

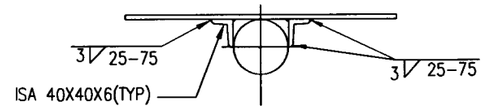
TYPE-II
FOR DRIFTING SAND AREAS (TYP.)
(NOTE-9)



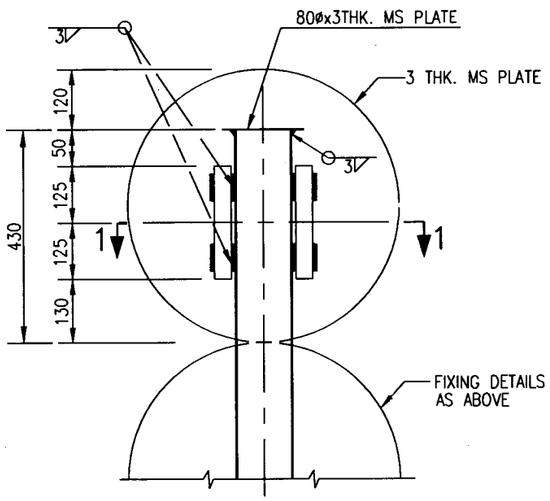
DETAIL-X



TYPE-III
FOR ROCK AREAS



SECTION 1-1



WARNING SIGN PLATE FIXING DETAILS

NOTES:-

1 ALL DIMENSIONS ARE IN mm. UNLESS SPECIFIED OTHERWISE.

2 SCHEME OF PAINTING & COLOURING
- a) UNDERGROUND STEEL (EXCEPT THAT EMBEDDED IN CONCRETE): LIQUID EPOXY (MIN. 400 MICRON THK).
- b) OVERGROUND STEEL STRUCTURE: AS PER STANDARD SPECIFICATION FOR SURFACE PREPARATION AND AND PROTECTIVE COATING NO. 6-79-0020 OR JOB SPECIFICATION, AS APPLICABLE.
- c) AREAS/ LETTERS SHOWN AS: ■ ARE TO BE PAINTED RED. □ ARE TO BE PAINTED YELLOW.
- d) COLOUR SCHEME FOR ABC PIPELINE CO. MONOGRAM SHALL BE AS DIRECTED BY COMPANY.
- e) ALL LETTERS SHALL BE PAINTED BLACK EXCEPT 'WARNING' WHICH SHALL BE PAINTED RED.
- f) POST SHALL BE PAINTED WITH 250mm WIDE ALTERNATE BANDS OF BLACK AND WHITE PAINT.
- g) ALL OTHER ABOVE-GROUND STEEL SHALL BE PAINTED YELLOW.

3 LOCATION
- a) THE PIPELINE WARNING SIGN SHALL BE INSTALLED IN ACCORDANCE WITH CONTRACT REQUIREMENTS AND AS DIRECTED BY COMPANY. IT SHALL BE INSTALLED TO THE LEFT OF THE PIPE CENTRE LINE VIEWING IN THE DIRECTION OF FLOW AT 3000mm. FROM PIPELINE CENTERLINE AND THE WARNING SIGN PLATE SHALL FACE THE UTILITY BEING CROSSED.
- b) THE WARNING SIGN PLATE MAY BE MOUNTED ON VENT PIPES OR KM POST WHEREVER FEASIBLE.

4 MATERIAL FOR MARKERS SHALL BE AS MENTIONED BELOW :-
PLATE - IS 2062, Gr. E250 A
PIPE - IS - 1239

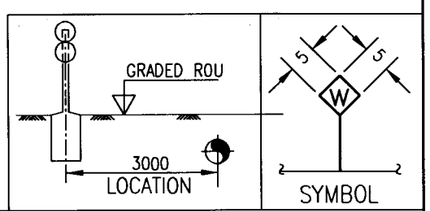
5 FOUNDATION SHALL BE MADE OF CONCRETE M20.

6 FOR FLUIDS COVERED BY CODE ASME B 31.4, USE WORD 'PETROLEUM' AS INDICATEO, FOR FLUIOS COVERED BY ASME B 31.8, USE WORD 'GAS' IN PLACE OF 'PETROLEUM'. FOR ANY OTHER FLUID, MENTION THE FLUID IN PLACE OF THE WORO 'PETROLEUM'.

7 IN CASE THE WARNING SIGN IS TO BE USED WHERE THE PIPELINE CROSSES A HAZARDOUS FACILITY LIKE A H.T. CABLE OR ANOTHER PETROLEUM PIPELINE. IN PLACE OF WOROS 'HIGH PRESSURE PETROLEUM PIPELINE' WRITE "HIGH PRESSURE PETROLEUM PIPELINE CROSSING H.T. CABLE (OR THE CONCERNED FACILITY)" IN LETTERS OF SIZE WHICH ARE TO BE DECIDED AT SITE.

8 SIGN PLATE IN REGIONAL LANGUAGE SHALL BE PREPARED BY CONTRACTOR ON SIMILAR LINES AND APPROVED BY COMPANY.

9 INSTALLATION OF MARKERS ON SLOPE OF SAND DUNES SHALL BE AVOIDED. IN SUCH CASE, SAME SHALL BE INSTALLED EITHER BEFORE OR AFTER THE DUNE SLOPE.



इंजीनियर्स इंडिया लिमिटेड (भारत सरकार का उपक्रम) ENGINEERS INDIA LIMITED (A Govt. of India Undertaking)

Rev. No.	Date	Purpose	Prepared by	Checked by	Stds. Committee Convenor	Stds. Bureau Chairman
5	08.03.21	REVISED & REISSUED AS STANDARD	SHUBHA SHUKLA	R.S.BAINS	M.S.GUNJIYAL	S.MAZUMDAR
4	25.02.16	REVISED & REISSUED AS STANDARD	MANISH TIWARI	RAJKISHORE	VINAY MITTAL	S.CHANDA
			Approved by			

PIPELINE WARNING SIGN

STANDARD No.
7-71-0012 Rev. 5

Format No.7-80-0760-F5 Rev. 0
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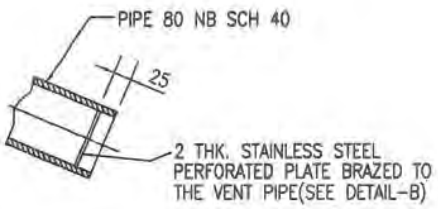
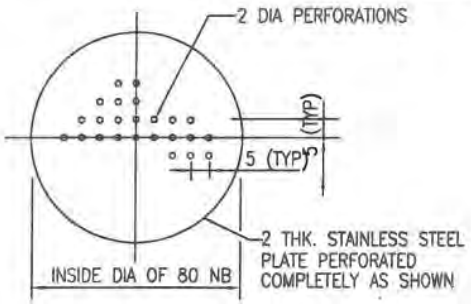
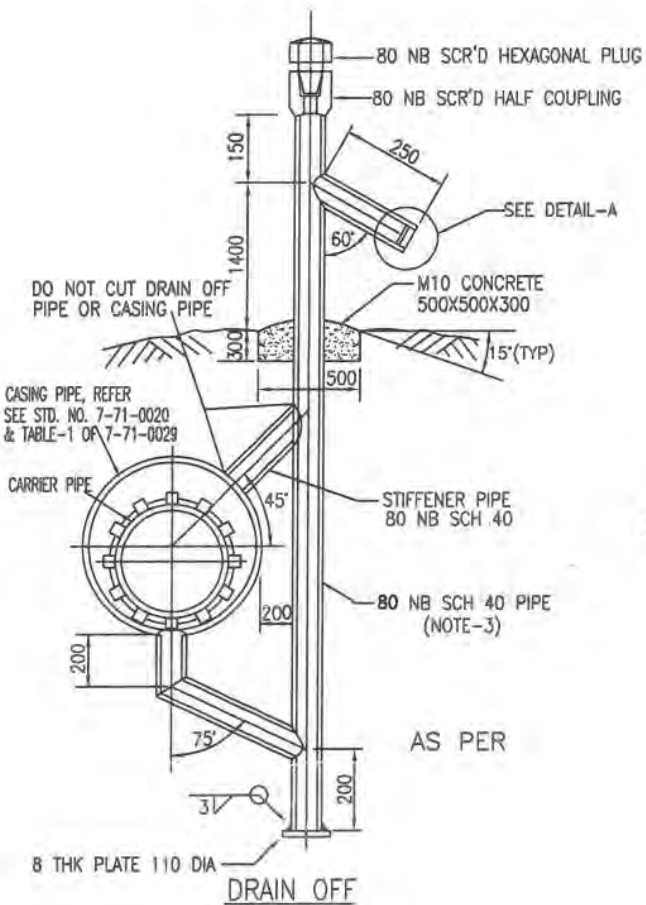


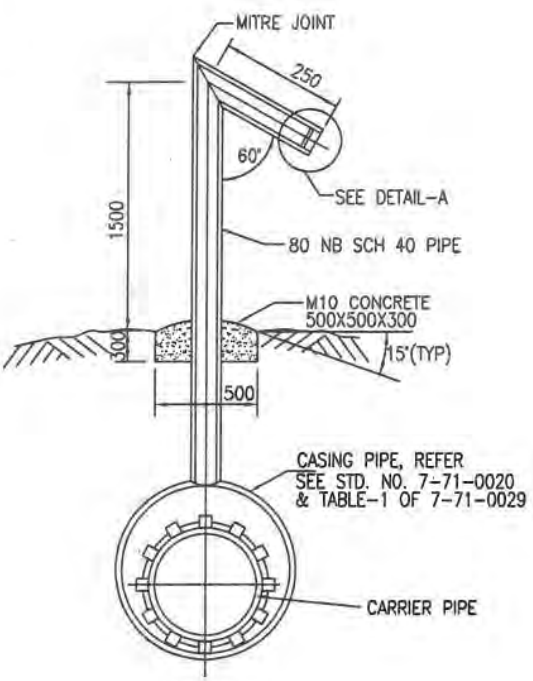
DETAIL-A



DETAIL-B



DRAIN OFF



VENT

NOTES:-

1. ALL DIMENSIONS ARE IN mm, UNLESS SPECIFIED OTHERWISE.
2. VENT AND DRAIN OFF TO FACE LEFT WHEN LOOKING IN DIRECTION OF FLOW AND SHALL BE PARALLEL TO CROSSING.
3. VENT AND DRAIN OFF PIPE SHALL BE API 5L Gr. B OR IS1239.
4. PORTION OF VENT AND DRAIN OFF PIPES WHICH ARE UNDER GROUND OR WHICH MAY BE UNDER WATER ARE TO BE COATED WITH LIQUID EPOXY (MIN. 500 MICRON THK. OF APPROVED QUALITY). PAINTING FOR PORTION ABOVE GROUND/WATER LEVEL SHALL BE AS PER APPLICABLE SPECIFICATION FOR SURFACE PREPARATION & PROTECTIVE COATING.
5. VENT PIPES MAY BE USED FOR MOUNTING WARNING SIGNS.

Rev. No.	Date	Purpose	Prepared by	Checked by	Stds. Committee Convenor	Stds. Bureau Chairman
6	01.12.25	REVISED & REISSUED AS STANDARD	PAWAN NEGI	GS DUGGAL	M.S. GUNJIYAL	M.NANDI
5	28.09.20	REVISED & REISSUED AS STANDARD	MANISH TIWARI	RAJ KISHORE	M.S. GUNJIYAL	S.MAZUMDAR
4	25.02.16	REVISED & REISSUED AS STANDARD	MANISH TIWARI	RAJ KISHORE	VINAY MITTAL	S.CHANDA

Approved by

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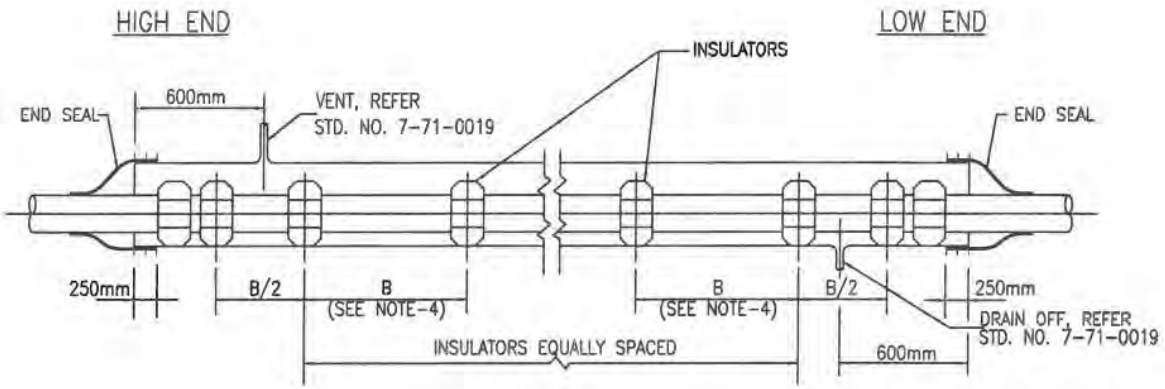

NOTES:-

1. THE CASING PIPE SHALL BE DESIGNED IN ACCORDANCE WITH API RP 1102 (LATEST EDITION).
2. CASING PIPE IS NOT NORMALLY TO BE COATED BUT IN HIGHLY CORROSIVE AREAS THE CASING SHALL BE COATED, WRAPPED AND CATHODIC PROTECTION PROVIDED WITH SACRIFICIAL ANODES.
3. AT BOTH ENDS OF CASING PIPE A DOUBLE SET OF INSULATORS SHALL BE INSTALLED.
4. THE MAXIMUM SPACING OF THE INSULATORS SHALL NOT BE MORE THAN 1000mm.
5. ELECTRICAL INSULATION BETWEEN THE CASING AND CARRIER PIPE SHALL BE CHECKED WITH A SUITABLE MEGGER AND TO BE ENSURED THAT CASING AND CARRIER PIPE ARE NOT SHORTED.
6. CASING INSULATORS AND END SEALS SHALL BE AS PER THE SPECIFICATION ISSUED FOR THE SAME.
7. END SEALS SHOWN HERE ARE ONLY INDICATIVE, POSSIBILITY OF PROVIDING OTHER TYPES OF FLEXIBLE END SEALS MAY BE CONSIDERED.

Rev. No.	Date	Purpose	Prepared by	Checked by	Stds. Committee Convenor	Stds. Bureau Chairman
					Approved by	
6	01.12.25	REVISED & REISSUED AS STANDARD	PAWAN NEGI	DUGGAL	M.S. GUNJIYAL	M.NANDI
5	28.09.20	REVISED & REISSUED AS STANDARD	MANISH TIWARI	RAJ KISHORE	M.S. GUNJIYAL	S.MAZUMDAR
4	25.02.16	RE-AFFIRMED & REISSUED AS STANDARD	MANISH TIWARI	RAJ KISHORE	VINAY MITTAL	S.CHANDA

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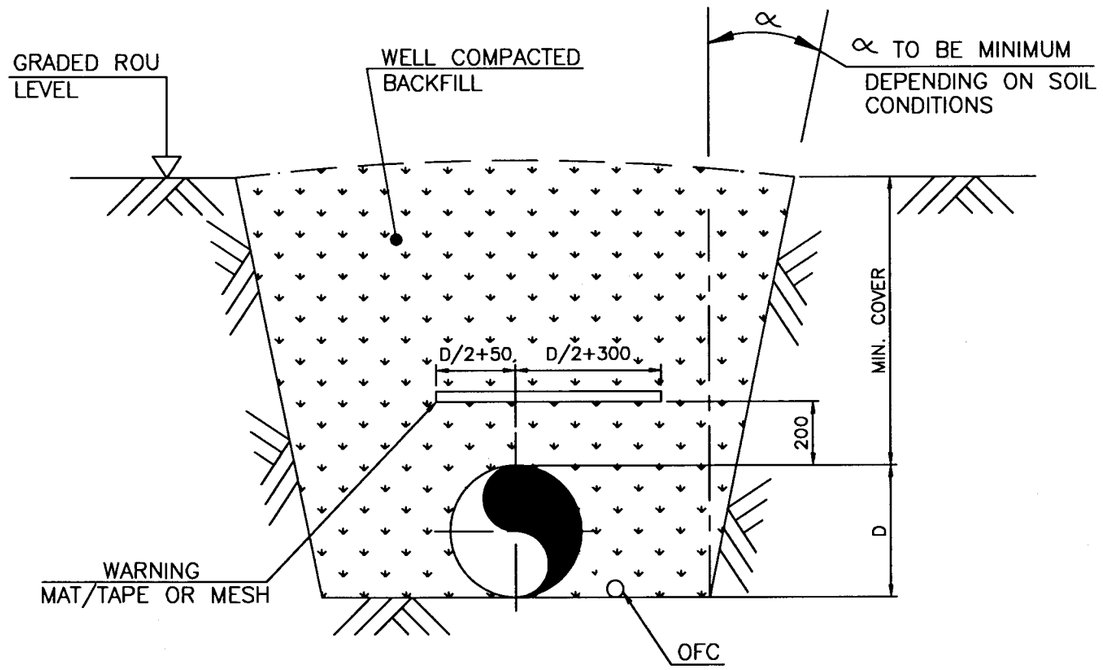
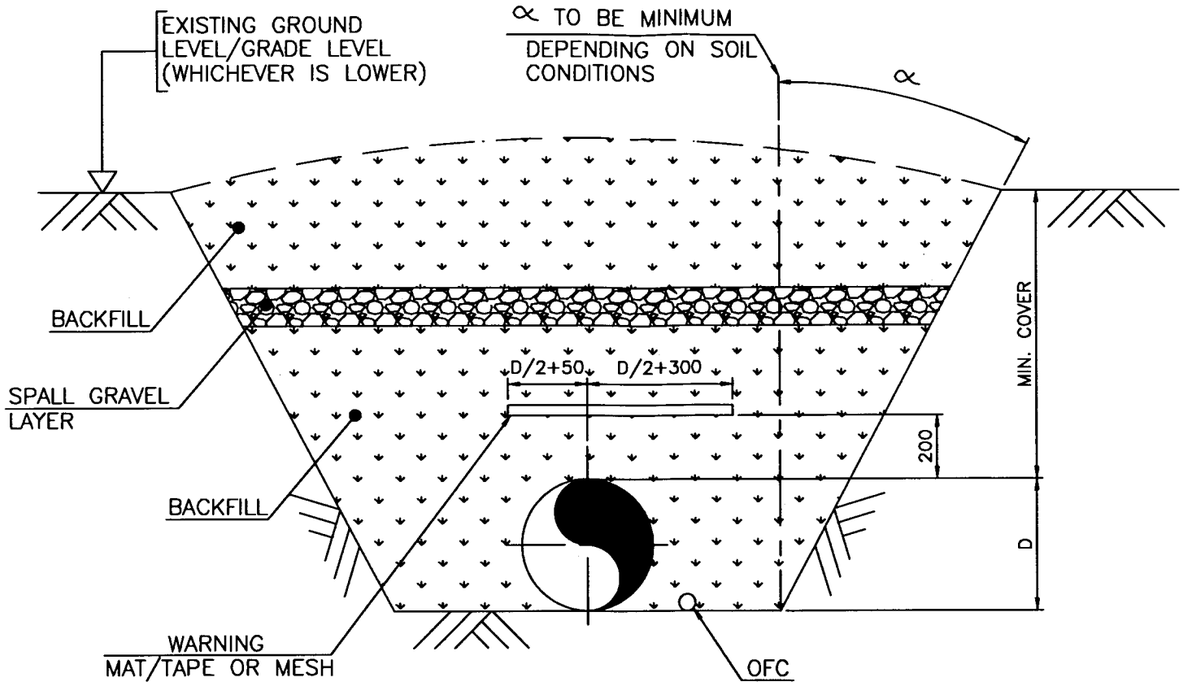
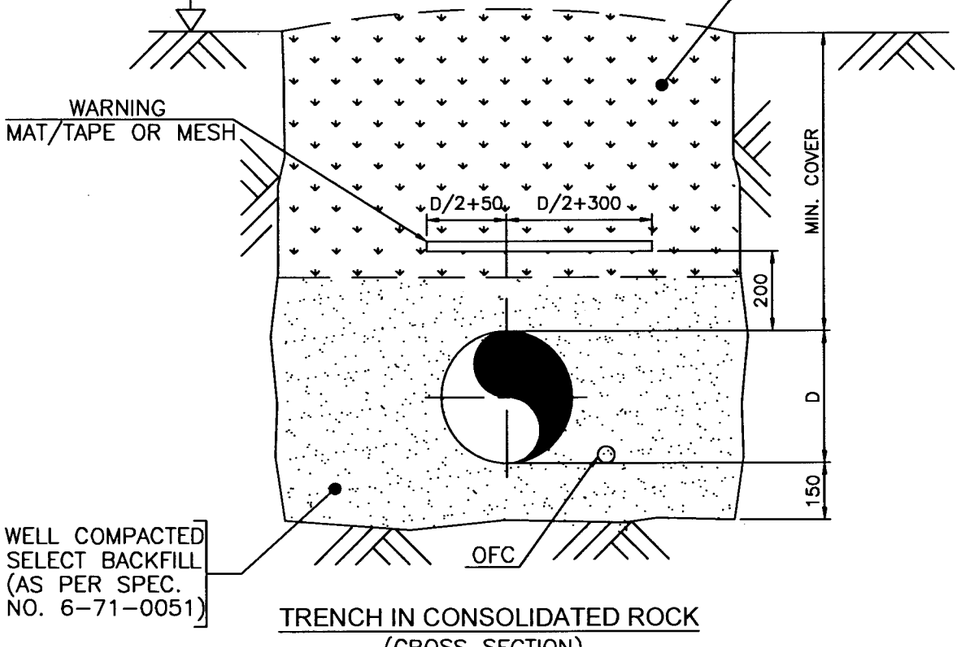


TRENCH IN NORMAL SOIL
(CROSS SECTION)



TRENCH IN SAND DUNES (ELEVATED)
(CROSS SECTION)



TRENCH IN CONSOLIDATED ROCK
(CROSS SECTION)

NOTES:

1. ALL DIMENSIONS ARE IN mm, UNLESS SPECIFIED OTHERWISE.
2. ALL THE TRENCH DETAILS SHALL BE AS PER STANDARD NO. 7-71-0005.
3. THIS STANDARD IS APPLICABLE FOR WARNING MAT/ TAPE (TYPE-1 WARNING DEVICE) OR MESH (TYPE-2 WARNING DEVICE) INSTALLATION OVER PIPELINE.
4. WIDTH OF THE WARNING MAT/ TAPE (TYPE-1) OR MESH (TYPE-2) SHALL BE D+350 mm, WHERE 'D' IS THE OUTSIDE DIAMETER OF THE PIPELINE.
5. WARNING MAT/TAPE (TYPE-1) OR MESH (TYPE-2) SHALL BE MANUFACTURED AND TESTED STRICTLY AS PER EN 12613:2009.
6. WARNING MAT/TAPE (TYPE-1) OR MESH (TYPE-2) MATERIAL SHALL BE POLYETHYLENE (PE) OR POLYPROPYLENE (PP) AND SHALL BE NON-BIODEGRADABLE TYPE. MATERIAL SHALL ALSO HAVE NON-TOXIC AND ANTI-RODENT PROPERTIES.
7. THICKNESS OF WARNING MAT/TAPE (TYPE-1) SHALL BE 0.5 mm, IT SHALL WITHSTAND THE TENSILE LOAD OF 200 N AND SHALL BE TESTED AS PER EN 12613:2009. THICKNESS OF THE WARNING MESH (TYPE-2) SHALL BE SUCH THAT IT SHALL WITHSTAND THE TENSILE LOAD OF 300 N AND SHALL BE TESTED AS PER EN 12613:2009.
8. WARNING MAT/TAPE (TYPE-1) OR MESH (TYPE-2) SHALL BE UV RESISTANT AND SHALL BE TESTED AS PER EN ISO 4892-1.
9. TRANSVERSAL RIGIDITY TEST SHALL BE CONDUCTED FOR WARNING DEVICES (TYPE-1 AND TYPE-2) ACCORDING TO EN 12613:2009.
10. WARNING MAT/TAPE (TYPE-1) OR MESH (TYPE-2) SHALL BE OF GOLDEN YELLOW COLOR WITH LETTERS PRINTED IN RED OF NON-DETECTABLE TYPE WITH HIGH ABRASION RESISTANCE.
11. THE ART WORK SHALL BE PRINTED IN ENGLISH AND LOCAL LANGUAGE AT EVERY ONE METER DISTANCE AND CONTAIN THE INFORMATION AS BELOW:
    a. HIGHLY INFLAMMABLE HIGH PRESSURE GAS/ OIL PIPELINE BELOW
    b. OWNER'S LOGO
    c. IN CASE OF EMERGENCY PLEASE CONTACT PHONE NOS.....
12. IN CASE OF MESH (TYPE-2), WIDTH OF CENTRE BAND SHALL BE 100 mm TO PRINT THE INFORMATION AS PER REQUIREMENTS MENTIONED IN NOTE-11 ABOVE AND IT SHOULD BE INTEGRAL PART OF THE MESH.

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Rev. No.	Date	Purpose	Prepared by	Checked by	Approved by: Stds. Committee Convenor	Approved by: Stds. Bureau Chairman
1	29.09.20	REVISED & REISSUED AS STANDARD	A. K. SINGH	RAJ KISHORE	M. S. GUNJIYAL	S. MAZUMDAR
0	21.08.15	ISSUED AS STANDARD	A. K. SINGH	RAJ KISHORE	VINAY MITTAL	S. CHANDA

TYPICAL DETAILS OF WARNING DEVICES (MAT/ TAPE OR MESH) FOR PIPELINE

STANDARD No.
7-71-0031 Rev. 1
Page 1 of 1

Format No. 8-00-0001-F5 Rev. 0

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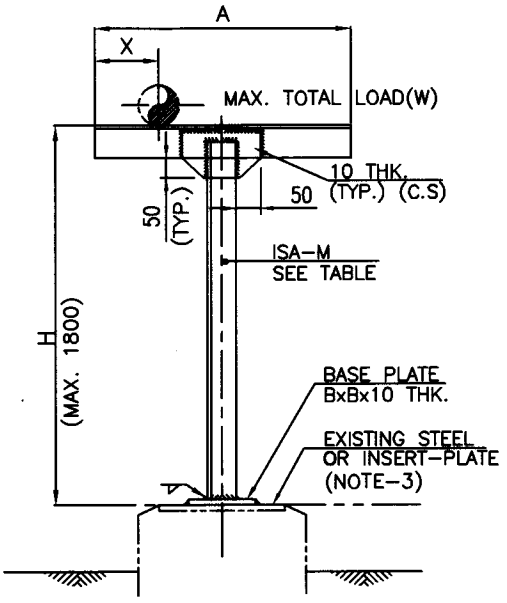
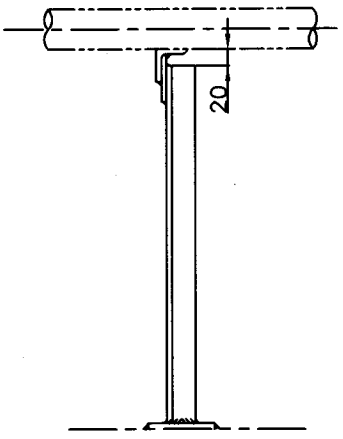
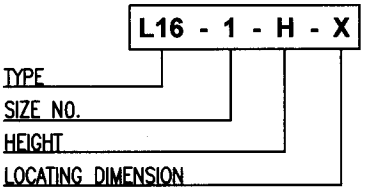
LOW SUPPORT STANCHION FOR BARE AND INSULATED CS/AS/SS PIPE TYPE - L16 AND L16A



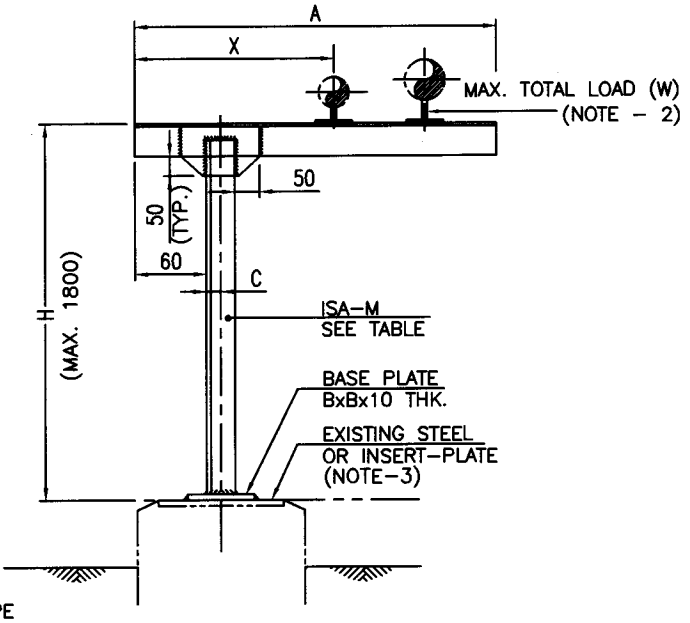


SIDE VIEW



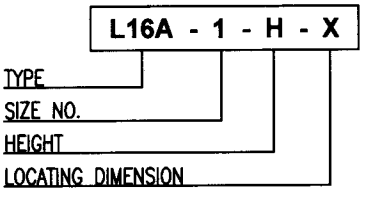
SYMBOL

SIZE NO.	MAX. TOTAL LOAD (W)Kg	M	A	B	C
1	500	ISA 90x90x8	600	150	45
2	800	ISA 100x100x10	700	150	60
3	1500	ISA 130x130x12	800	150	80



NOTES:-

1. DO NOT USE THIS SUPPORT FOR ANCHORING THE PIPE.
2. IN CASE OF ALLOY AND STAINLESS STEEL LINE–PIPE SHOE OF MATERIAL EQUIVALENT TO THAT OF LINE–PIPE SHALL BE PROVIDED.
3. IN CASE SUPPORT IS TO BE PROVIDED ON A FOUN–DATION, INSERT PLATE OF 250X250X10THK. SIZE SHALL BE USED. OTHERWISE, IN CASE CALCULATED H EXCEEDS THE MAXIMUM VALUE, PEDESTAL SHALL BE RAISED ACCORDINGLY.



SYMBOL

Rev. No.	Date	Purpose	Prepared by	Checked by	Stds. Committee Convenor	Stds. Bureau Chairman
					Approved by	
6	24.08.2021	REAFFIRMED & ISSUED AS STANDARD	SG	SH	CB	SM
5	11.08.2016	REAFFIRMED AND ISSUED AS STANDARD	SH	AK	MI	RN

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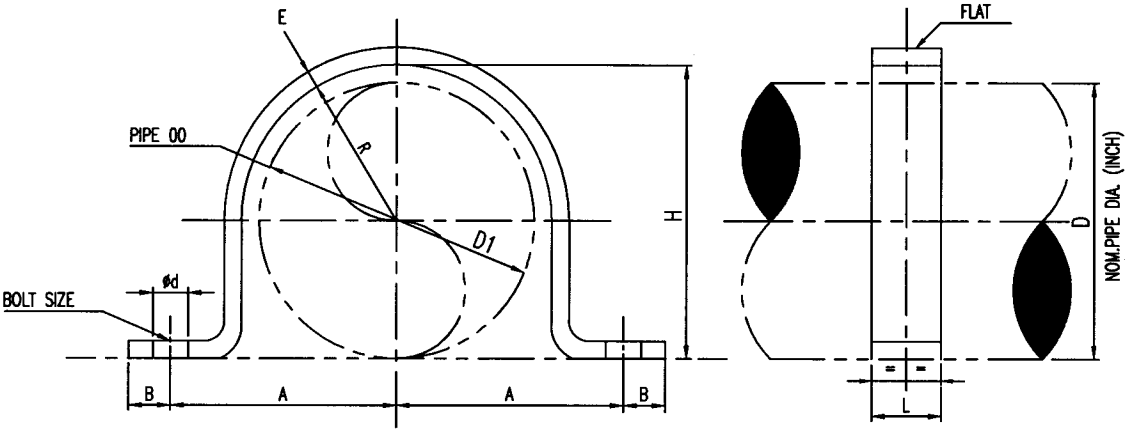
ENGINEERS INDIA LIMITED (A Govt. of India Undertaking)

PIPE U-CLAMP FOR BARE CS/AS/SS PIPE SIZE 3/4" THRU 24", TYPE - C15

STANDARD No.
7-44-0655 Rev. 5



D	DIMENSIONS									ALLOWED LOAD KGS	BOLT SIZE
	D1	R	A	B	H	L	E	dØ	DEV. LENGTH OF FLAT		
3/4"	27	17	35	20	30	30	6	12	160	450	M10 X 45
1"	34	20	43	20	37	30	6	12	190		
1 1/2"	49	28	52	20	52	40	6	14	230		M12 X 50
2"	60	33	58	25	64	50	6	14	260		
3"	89	48	80	30	93	60	6	18	360	850	M16 X 60
4"	115	61	90	30	119	60	6	18	430		
6"	169	88	125	35	173	80	8	22	610	1350	M20 X 70
8"	220	114	160	40	226	80	8	22	750		
10"	274	141	190	40	280	100	10	27	900	1950	M24 X 75
12"	324	166	220	40	330	100	10	27	1030		
14"	356	182	230	50	362	100	10	27	1110		
16"	407	208	270	50	413	120	12	30	1280	2600	M27 X 70
18"	458	233	290	60	464	140	16	33	1410	3800	M30 X 95
20"	508	258	320	60	514	140	16	33	1550		
22"	559	284	340	65	565	140	16	39	1670		M36 X 110
24"	610	309	370	65	616	140	16	39	1810		

PIPE MATL.	TEMPERATURE	CLAMP TYPE
CS / AS	UPTO 343°C	C15A
	344°C TO 427°C	C15B
	ABOVE 427°C	C15C
SS	ALL TEMP.	C15C

CLAMP TYPE	MATERIAL	
	CLAMP	BOLTS AND NUTS
C15A	IS-2062	IS-1367 CLASS 10.9 IS-1367 CLASS 12
C15B	ASTM A516/A515 (GR.60/65/70)/ IS-2002 GR.2	ASTM A193 GR.B7 ASTM A194 GR.2H
C15C	SS-316 PLATE	ASTM A193 GR.B16 ASTM A194 GR.4

NOTES:-

1. WHEREVER THE PIPE CLAMPS ARE SUBJECTED TO VIBRATION AN ADDITIONAL LOCK-NUT SHALL BE USED. M/C-BOLT/STUD-BOLT LENGTH SHALL BE SUITABLY INCREASED TO ACCOMODATE THE LOCK-NUT.
2. FOR CARBON STEEL PIPE, M/C-BOLTS SHALL BE USED, WHEREAS FOR ALLOY STEEL AND STAINLESS STEEL PIPE, STUD-BOLTS SHALL BE USED.

SYMBOL

C15A - D

TYPE — NOM. PIPE DIA. (INCH)

Rev. No.	Date	Purpose	Prepared by	Checked by	Stds. Committee Convenor	Stds. Bureau Chairman
5	30.12.2020	REAFFIRMED AND ISSUED AS STANDARD	SG	SH	GB	SM
4	16.11.2015	REAFFIRMED AND ISSUED AS STANDARD	SH	AK	RN	SC

Approved by

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GENERAL NOTES :-

1. ALL LUGS SHALL BE OF HIGH STRENGTH DEFORMED BARS OF GRADE Fe500/Fe500D CONFORMING TO IS 1786 (WITH GUARANTEED WELDABILITY) AND SHALL BE CONNECTED TO METAL INSERT PLATES BY 6 mm FILLET WELDS AS SHOWN IN SKETCHES.
2. METAL INSERT PLATES SHALL BE OF GRADE E250, CONFORMING TO IS 2062 (GR-A/BR/BO).
3. METAL INSERT PLATES MARKED ON DRAWING REFER AS UNDER

   IP-(A) @ (C)

   IP = INSERT PLATE

   A = TYPE OF INSERT PLATE

   C = ELEVATION OF INSERT PLATE (TOP EDGE)

   e.g IP-R9a @ EL.110.300 MEANS INSERT PLATE TYPE R9a AT EL.110.300.
4. METAL INSERT PLATES SHALL BE KEPT FLUSH WITH CONCRETE SURFACE.
5. THE LONGER SIDE OF METAL INSERT PLATE SHALL BE KEPT VERTICAL UNLESS SHOWN OTHERWISE.
6. METAL INSERT PLATE ON COLUMN OR BEAM SHALL BE KEPT SYMMETRICAL ABOUT ℄ OF COLUMN OR BEAM, UNLESS SHOWN OTHERWISE.

Rev. No.	Date	Purpose	Prepared by	Checked by	Stds. Committee Convenor	Stds. Bureau Chairman
					Approved by	
8	14.03.24	REVISED AND ISSUED AS STANDARD	EMMANUEL	SUDIP PAUL	ANURAG SINHA	MAINAK NANDI
7	06.06.18	REAFFIRMED AND ISSUED AS STANDARD	CS	AVM	R SRIVASTAVA	RK TRIVEDI

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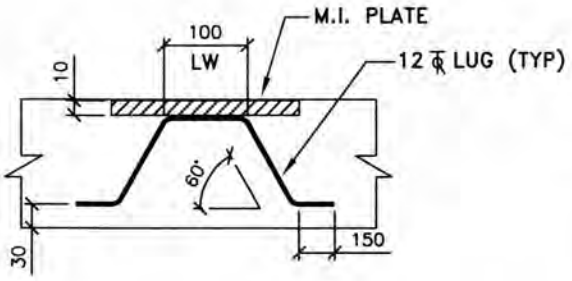
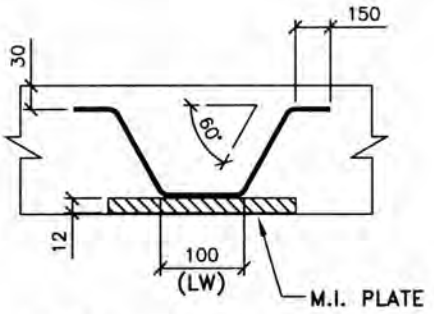
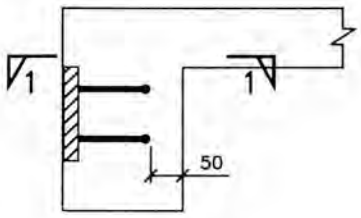
LUG BENDING DETAILS



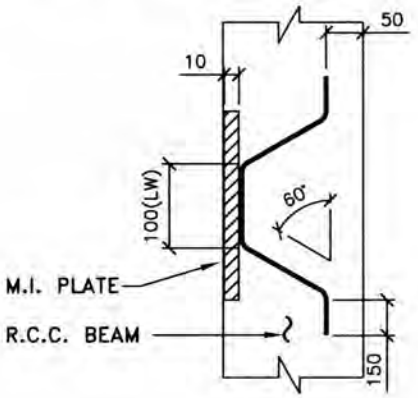
METAL INSERT DETAIL
ON TOP OF SLAB



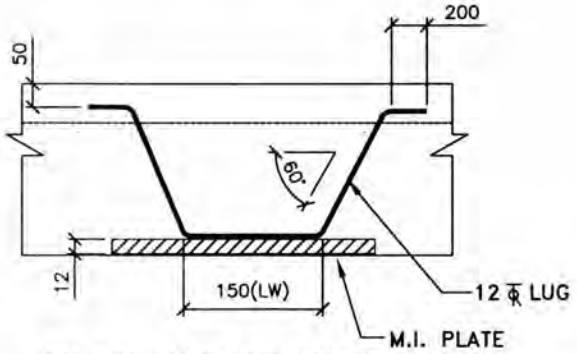
METAL INSERT DETAIL
ON BOTTOM OF SLAB



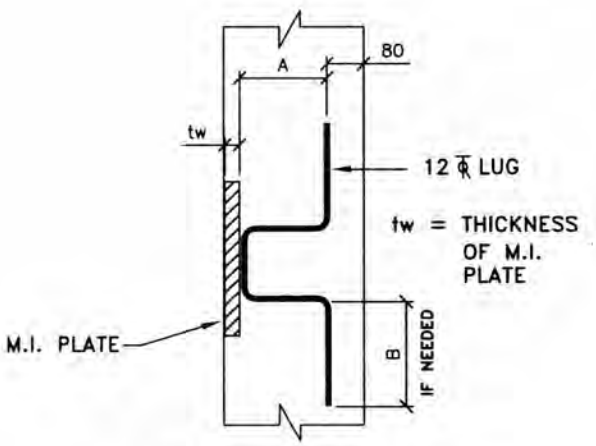
METAL INSERT DETAIL
ON SIDE OF BEAM



VIEW 1–1



METAL INSERT DETAIL
ON BOTTOM OF BEAM
(FOR ALTERNATE DETAIL REF. SHT. 7 OF 7)



METAL INSERT DETAIL
ON COLUMNS

A+B = LUG EMBEDMENT REQUIRED AS PER SHT. 4,5,6 OF 7

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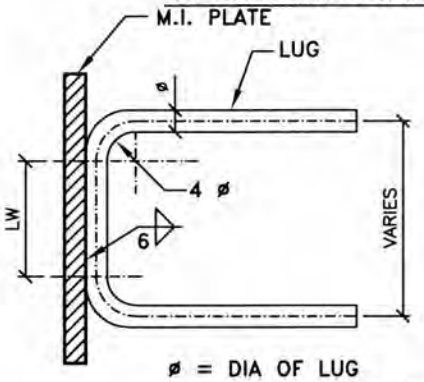
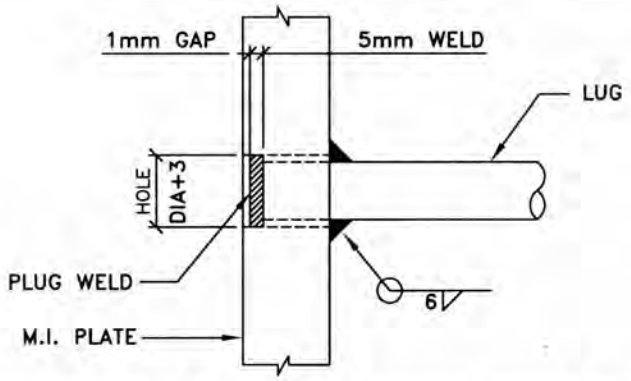
LUG BENDING DETAILS



ø = DIA OF LUG
LW = WELD LENGTH AVAILABLE

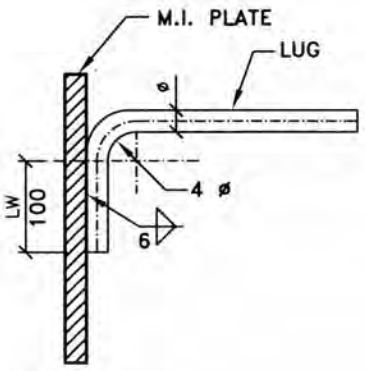
BENDING DIMENSIONS FOR 12ϕ & 16ϕ LUGS

(FOR SPACING OF LUGS ≥ 190)
(NOT APPLICABLE FOR S1, S2, R1 & PS1)



WELD DETAIL OF 12ϕ & 16ϕ LUGS WITH M.I. PLATE

(FOR SPACING OF LUGS < 190)
(VALID FOR S1, S2 R1 & PS1)



BENDING DIMENSIONS FOR 12ϕ & 16ϕ LUGS

(VALID FOR R9, R10, R12, R13, R14, PS11, & PS12)

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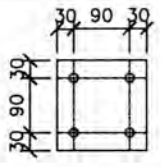
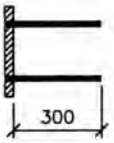
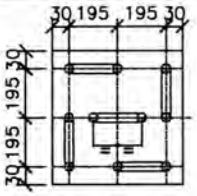
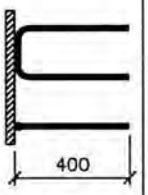
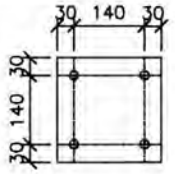
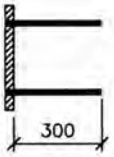
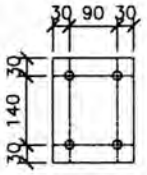
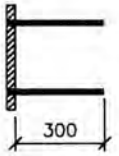
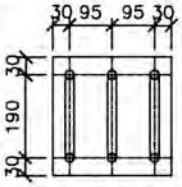
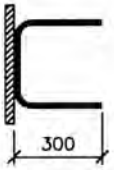
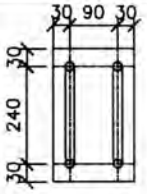
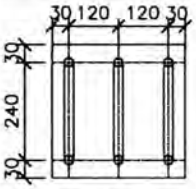
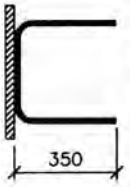
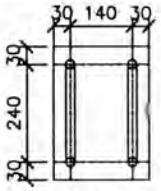
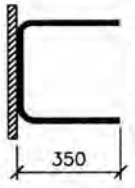
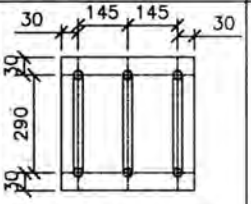
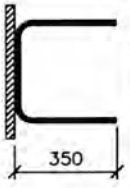
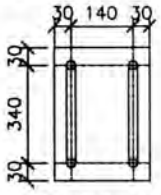
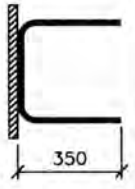
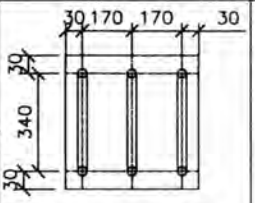
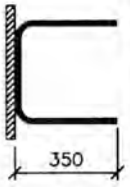
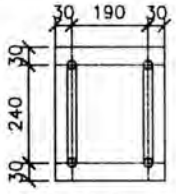
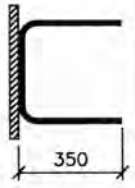
S/R DESIGNATES

S. NO.	TYPE OF INSERT	DIA OF LUGS	THK. OF INSERT	DETAILS OF INSERT PLATE		S. NO.	TYPE OF INSERT	DIA OF LUGS	THK. OF INSERT	DETAILS OF INSERT PLATE	
				PLAN	CROSS SECTION					PLAN	CROSS SECTION
1.	S1a	12	12	 SIZE 150x150		7.	S7a	12	12	 SIZE 450x450	
	S1b	16	16				S7b	16	16		
2.	S2a	12	12	 SIZE 200x200		8.	R1a	12	12	 SIZE 150x200	
	S2b	16	16				R1b	16	16		
3.	S3a	12	12	 SIZE 250x250		9.	R2a	12	12	 SIZE 150x300	
	S3b	16	16				R2b	16	16		
4.	S4a	12	12	 SIZE 300x300		10.	R3a	12	12	 SIZE 200x300	
	S4b	16	16				R3b	16	16		
5.	S5a	12	12	 SIZE 350x350		11.	R4a	12	12	 SIZE 200x400	
	S5b	16	16				R4b	16	16		
6.	S6a	12	12	 SIZE 400x400		12.	R5a	12	12	 SIZE 250x300	
	S6b	16	16				R5b	16	16		

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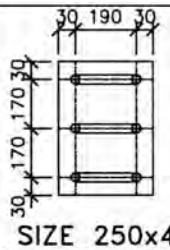
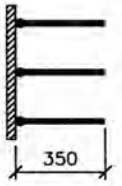
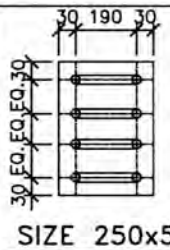
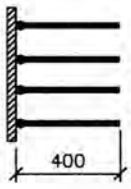
R DESIGNATES

S. NO.	TYPE OF INSERT	DIA OF LUGS	THK. OF INSERT	DETAILS OF INSERT PLATE	
				PLAN	CROSS SECTION
13.	R6a	12	12		
	R6b	16	16		
14.	R7a	12	12		
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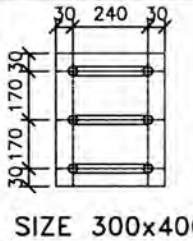
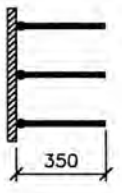
15.	R8a	12	12		
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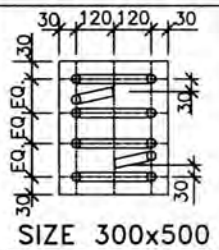
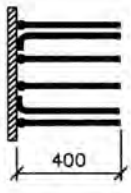
16.	R9a	12	12		
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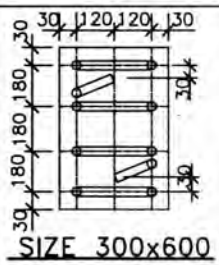
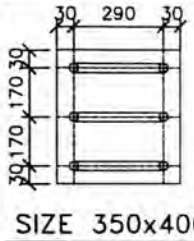
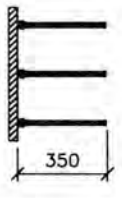
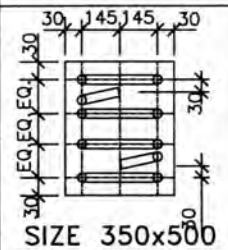
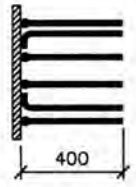
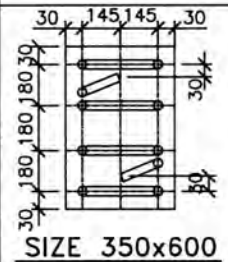
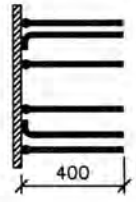
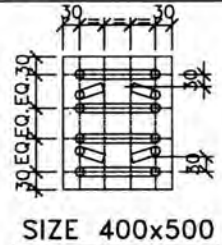
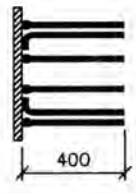
17.	R10a	12	12		
	R10b	16	16		
18.	R11a	12	12		
	R11b	16	16		

S. NO.	TYPE OF INSERT	DIA OF LUGS	THK. OF INSERT	DETAILS OF INSERT PLATE	
				PLAN	CROSS SECTION
19.	R12a	12	12		
	R12b	16	16		
20.	R13a	12	12		
	R13b	16	16		
21.	R14a	12	12		
	R14b	16	16		

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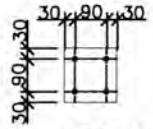
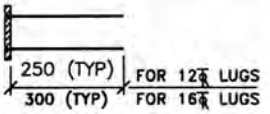
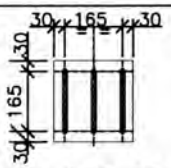
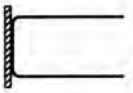
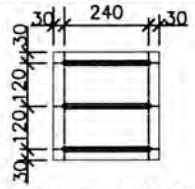
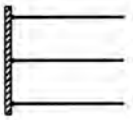
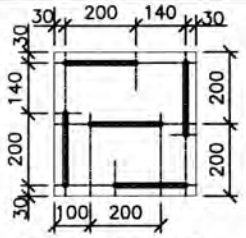
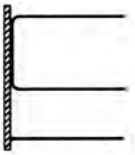
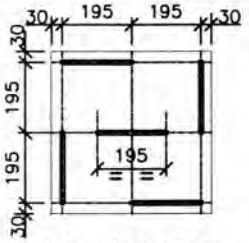
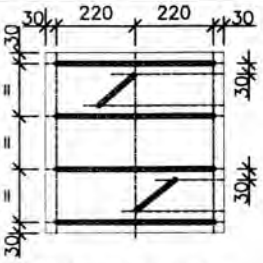
PS DESIGNATES

S.NO.	TYPE OF INSERT	DIA OF LUGS	THK. OF INSERT	DETAILS OF INSERT PLATE	
				PLAN	CROSS SECTION
1.	PS1	12	12	 SIZE 150x150	
	PS2	16	16		
2.	PS3	12	12	 SIZE 225x225	
	PS4	16	16		
3.	PS5	12	12	 SIZE 300x300	
	PS6	16	16		
4.	PS7	12	12	 SIZE 400x400	
	PS8	16	16		
5.	PS9	12	12	 SIZE 450x450	
	PS10	16	16		
6.	PS11	12	12	 SIZE 500x500	
	PS12	16	16		

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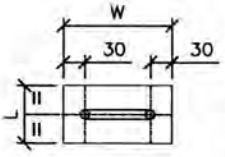
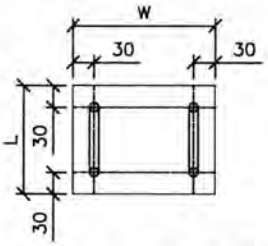
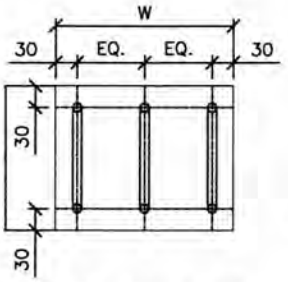
T DESIGNATES



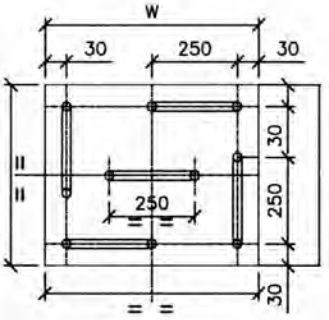
TYPE T1



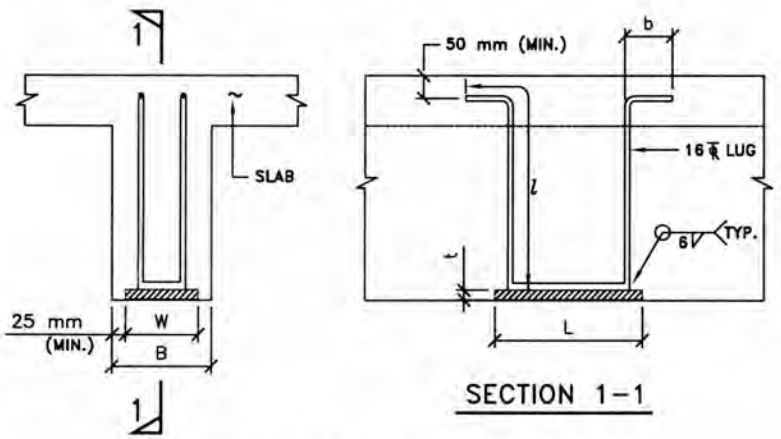
TYPE T2, T3 & T4



TYPE T5 & T6



TYPE T7



SECTION 1–1

TYPICAL FIXING DETAIL

S.NO.	TYPE OF INSERT	WIDTH OF BEAM 'B' (mm)	MAXIMUM WIDTH OF PLATE 'W' (mm)	LENGTH OF PLATE 'L' (mm)	MAXIMUM 'b' (mm)	THICKNESS OF PLATE 't' (mm)	TOTAL ANCHORAGE LENGTH 'l' (mm)
1.	T1	230	180	180	110	16	350
2.	T2	300	220	250	110	20	350
3.	T3	350	270	250	110	20	350
4.	T4	400	320	250	110	20	350
5.	T5	450	370	300	110	32	350
6.	T6	500	420	300	110	32	350
7.	T7	500	420	400	110	32	350

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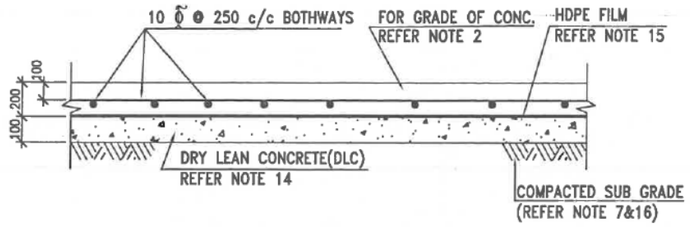
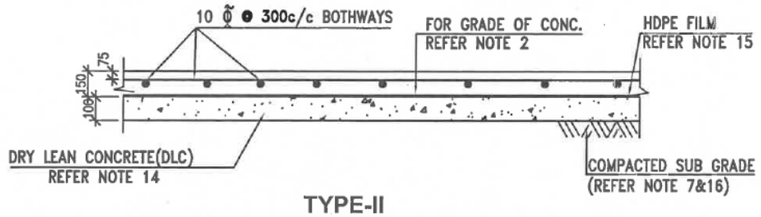
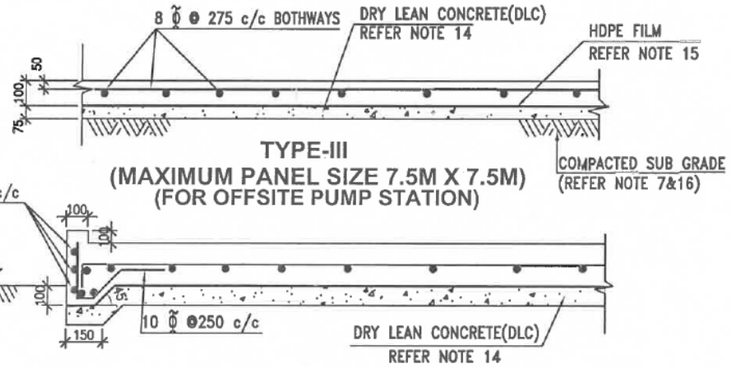


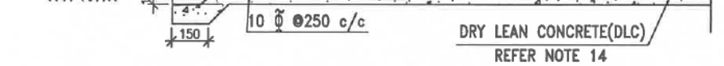
TYPE-I
(MAXIMUM PANEL SIZE 14M X 14M)
(FOR VEHICULAR MOVEMENT AREA)



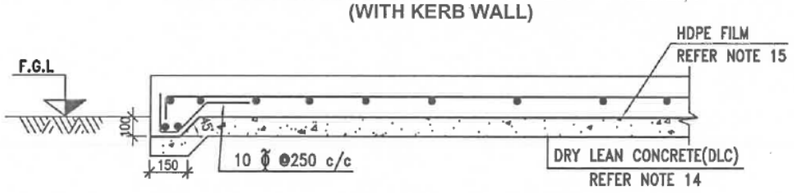
TYPE-II
(MAXIMUM PANEL SIZE 13M X 13M)
(FOR UNIT PAVEMENT)



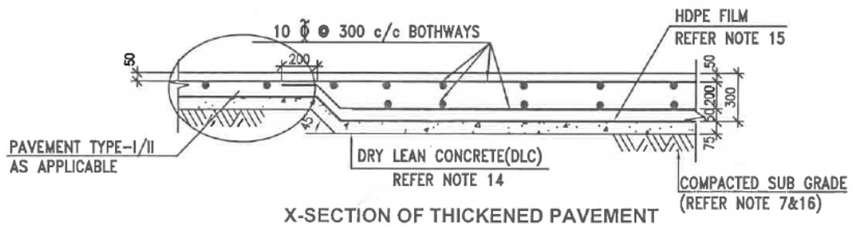
TYPE-III
(MAXIMUM PANEL SIZE 7.5M X 7.5M)
(FOR OFFSITE PUMP STATION)



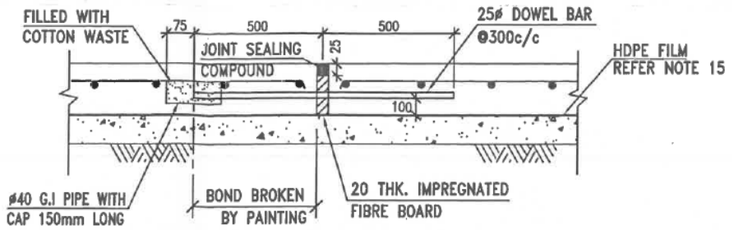
TYP. EDGE DETAIL DEPENDING ON TYPE OF PAVEMENT
(WITH KERB WALL)



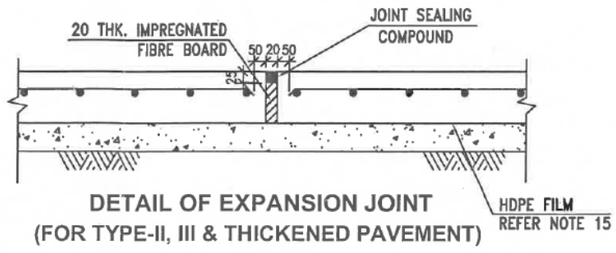
TYP. EDGE DETAIL DEPENDING ON TYPE OF PAVEMENT
(WITHOUT KERB WALL)



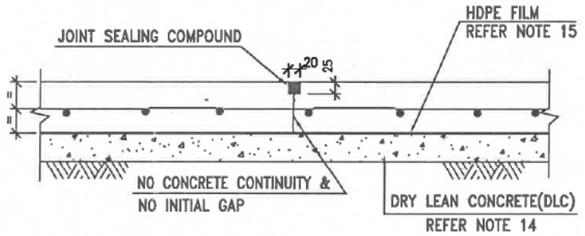
X-SECTION OF THICKENED PAVEMENT



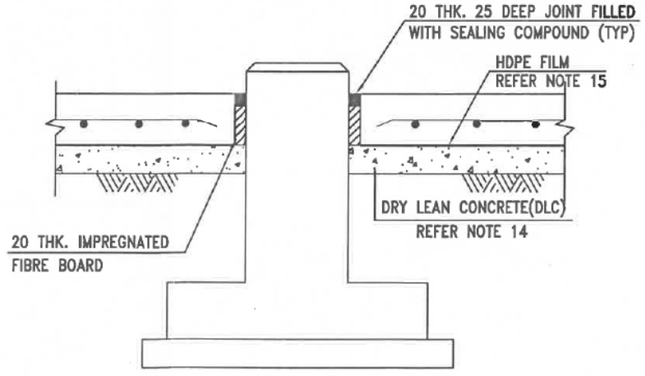
DETAIL OF EXPANSION JOINT
(FOR TYPE-I PAVEMENT)
(REFER NOTE-8 & 9)



DETAIL OF EXPANSION JOINT
(FOR TYPE-II, III & THICKENED PAVEMENT)



DETAIL OF CONSTRUCTION JOINT
(SEE NOTE-9 & 12)



TYP. DETAIL OF JOINT SEALING AROUND FOUNDATION

NOTES:-

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS STATED OTHERWISE.
2. THE GRADE OF CONCRETE SHALL BE AS PER ENGINEERING DESIGN BASIS (MIN. GRADE OF CONCRETE SHALL BE M30).
3. ϕ DENOTES HIGH YIELD DEFORMED BARS OF GRADE Fe-500D CONFORMING TO IS:1786 UNLESS OTHERWISE SPECIFIED. THE DOWEL BAR SHALL CONFORM TO IS:432 GRADE-1.
4. JOINT SEALING COMPOUND SHALL BE POLYSULPHIDE BASE JOINT SEALANT (COLD POURED) OF APPROVED MAKE CONFIRMING TO BS: 5212. SUITABLE PRIMER AS RECOMMENDED BY SEALANT MANUFACTURER, SHALL BE APPLIED IN ACCORDANCE WITH IRC 57.
5. EXPANSION AND SEALING JOINT FILLER MATERIAL SHALL BE PREFORMED FILLERS OF BITUMEN IMPREGENATED FIBRE BOARD, CONFORMING TO IS:1838, PART-1.
6. CONC. PAVING SHALL BE SLOPED STEEPEST TO 1:100 UNLESS OTHERWISE SHOWN IN DETAIL ENGINEERING DRAWING. SLOPE OF THE SUB GRADE SHALL BE PREPARED TO MATCH WITH THE SLOPE OF PAVEMENT.
7. SUB GRADE BELOW PAVEMENT SHALL BE THOROUGHLY COMPACTED TO 95% OF LAB DRY DENSITY AS PER IS:2720, PART VIII OR 85% RELATIVE DENSITY AS PER AS PER IS:2720, PART XIV.
8. EXPANSION JOINTS SHALL BE SPACED AT 14.0M (MAX.) FOR TYPE-I PAVEMENTS & 13M C/C (MAX.) FOR TYPE-II PAVEMENTS.
9. EXPANSION JOINTS SHALL BE SPACED AT 15 M C/C & CONSTRUCTION JOINTS SHALL BE SPACED AT 7.5M C/C (MAXIMUM) FOR TYPE-III PAVEMENTS.
10. THIS STANDARD IS NOT VALID FOR CAUSTIC HANDLING AREAS.
11. LIMITATION OF SINGLE AXLE LOAD ON RCC PAVEMENT: FOR TYPE-I PAVEMENT : MAX. UPTO 12.0 TONNE FOR TYPE-II PAVEMENT : MAX. UPTO 6.0 TONNE (FOR SMALL VEHICLES LIKE FORK LIFT)
12. CONSTRUCTION JOINTS MAY BE PROVIDED IN CASE PANEL SIZE IS LESS THAN THE REQUIREMENT OF ELASTIC JOINT, TO SUIT SITE REQUIREMENTS.
13. THICKENED PAVEMENT AS SHOWN IS SUITABLE FOR SINGLE POINT LOAD UPTO 5 TON. PIPE SUPPORT DETAILS COMING IN THICKENED PAVEMENT AREA REFER RELEVANT PIPING GAD / PIPING STANDARDS.
14. DRY LEAN CONCRETE (DLC) FOR SUB-BASE SHALL HAVE 7 DAYS COMPRESSIVE STRENGTH OF 10MPa.
15. 150 MICRON THICK HM HDPE (GRADE-I) FILM CONFORMING TO IS 10889 SHALL BE PROVIDED AS SEPARATION LAYER BETWEEN DLC AND RCC.
16. THIS STANDARD IS APPLICABLE FOR SUB GRADE WITH SOAKED CBR OF 4.0% AND ABOVE.

SUBGRADE

a) GEOTECHNICAL RECOMMENDATION SHALL BE FOLLOWED FOR SUBGRADE PREPARATION BELOW PAVEMENTS.
b) SPECIAL CARE AS PER GEOTECH RECOMMENDATION SHALL BE TAKEN IN CASE OF BLACK COTTON SOIL.

Rev. No.	Date	Purpose	Prepared by	Checked by	Stds. Committee Convenor	Stds. Bureau Chairman
					Approved by	
5	13.01.25	REVISED & ISSUED AS STANDARD	TP	GYAS	S K NASKAR	M NANDI
4	12.07.19	REVISED & ISSUED AS STANDARD	SD	GS/AK	RS	RKT

इंजीनियर्स इंडिया लिमिटेड ENGINEERS INDIA LIMITED (भारत सरकार का उपक्रम) (A Govt. of India Undertaking)

RCC PAVEMENT DETAILS

STANDARD No.
7-65-0404 Rev. 5
Page 1 of 1

Format No. 8-00-0001-F5 Rev. 0
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GRADE OF CONC.	BOLT TYPE	DIMENSIONS MM		BOLT DIA (ø) IN MM											
				10	12	16	18	20	22	24	27	30	33	36	39
M20	I & III	L		250	300	450	450	550	600	650	750	850	950	1000	1100
		E		95	115	155	170	190	210	230	255	285	315	345	370
		H	TYPE–I	280	336	498	504	610	666	722	831	940	1049	1108	1217
			TYPE–III	430	486	648	654	910	966	1022	1281	1390	1499	1558	1667
	II & IV	L		200	200	300	350	400	450	450	550	600	700	700	800
		E		150	180	240	270	300	330	380	405	450	495	540	585
		H	TYPE–II	230	236	348	404	460	516	522	631	690	799	808	917
			TYPE–IV	380	386	498	554	760	816	822	1081	1140	1249	1258	1367
M25	I & III	L		200	250	400	400	450	550	550	650	700	800	850	950
		E		95	115	155	170	190	210	230	255	285	315	345	370
		H	TYPE–I	230	286	448	454	510	616	622	731	790	899	958	1067
			TYPE–III	380	436	598	604	810	916	922	1181	1240	1349	1408	1517
	II & IV	L		150	150	250	250	300	350	350	450	500	550	600	650
		E		150	180	240	270	300	330	360	405	450	495	540	585
		H	TYPE II	180	186	298	304	360	416	422	531	590	649	708	767
			TYPE–IV	330	336	440	454	660	716	722	981	1040	1099	1158	1217
M30	I & III	L		180	220	315	335	390	445	470	550	600	680	735	815
		E		95	115	155	170	190	210	230	255	285	315	345	370
		H	TYPE–I	210	260	365	390	450	515	545	635	690	780	845	935
			TYPE–III	360	410	515	540	750	815	845	1085	1140	1230	1295	1385
	II & IV	L		150	150	200	200	250	275	300	350	375	425	450	500
		E		150	180	240	270	300	330	360	405	450	495	540	585
		H	TYPE–II	180	190	250	255	310	345	375	435	465	525	560	620
			TYPE–IV	330	340	400	405	610	645	675	885	915	975	1010	1070

Rev. No.	Date	Purpose	Prepared by	Checked by	Stds. Committee Convenor	Stds. Bureau Chairman
9	06.06.24	REVISED AND ISSUED AS STANDARD	ANNU AHUJA	VIKRAM GUPTA	ANURAG SINHA	MANAK NANDI
8	27.03.19	REVISED AND ISSUED AS STANDARD	JITENDER GUPTA	AMARJEET	RAJANJI SRIVASTAVA	R.K.TRIVEDI
7	26.11.13	REVISED AND ISSUED AS STANDARD	A.K. SHARMA	AMARJEET	P.K.MITTAL	S.CHANDA

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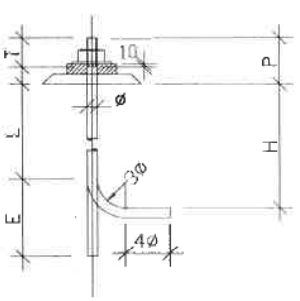
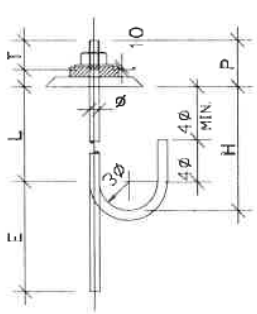
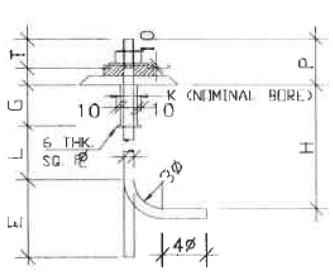
GRADE OF CONC.	BOLT TYPE	DIMENSIONS MM		BOLT DIA (ø) IN MM											
				10	12	16	18	20	22	24	27	30	33	36	39
M35	I & III	L		160	190	275	295	340	390	410	480	525	595	640	710
		E		95	115	155	170	190	210	230	255	285	315	345	370
		H	TYPE-I	190	230	325	350	400	460	485	565	615	695	750	830
			TYPE-III	340	380	475	500	700	760	785	1015	1065	1145	1200	1280
	II & IV	L		150	150	150	150	180	225	225	275	300	350	350	400
		E		150	180	240	270	300	330	360	405	450	495	540	585
		H	TYPE-II	180	190	200	205	240	290	300	360	390	450	460	520
			TYPE-IV	330	340	350	355	540	590	600	810	840	900	910	970
M40	I & III	L		150	170	240	255	300	340	360	425	460	525	565	625
		E		95	115	155	170	190	210	230	255	285	315	345	370
		H	TYPE-I	180	210	290	310	360	410	435	510	550	625	675	745
			TYPE-III	330	360	440	460	660	710	735	960	1000	1075	1125	1195
	II & IV	L		150	150	150	150	175	200	200	225	250	275	300	325
		E		150	180	240	270	300	330	360	405	450	495	540	585
		H	TYPE-II	180	190	200	205	235	270	275	310	340	375	410	445
			TYPE-IV	330	340	350	355	535	570	575	760	790	825	860	895



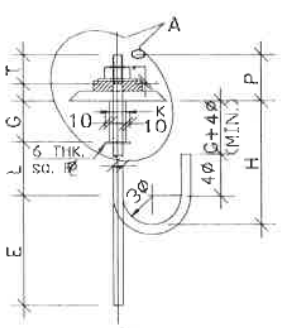
TYPE – I



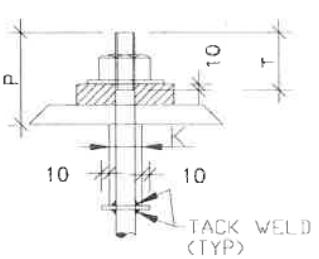
TYPE – II



TYPE – III



TYPE – IV



DETAIL–A (TYP)

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GRADE OF CONC.	BOLT TYPE	DIMENSIONS MM			BOLT DIA (ø) IN MM																										
					10	12	16	18	20	22	24	27	30	33	36	39	42	45	48	52	56	60	64								
M20,M25, M30,M35 & M40	III & IV	SLEEVE	G		150	150	150	150	300	300	300	450	450	450	450	450															
			K		50	50	50	50	50	80	80	80	80	80	80	100															
	I TO IV IX & XII	THREADED (T) LENGTH	SINGLE NUT		40	45	55	60	60	65	70	75	80	90	95	100															
			DOUBLE NUT		50	60	70	75	80	90	95	105	110	120	130	140															
M20 & M25	V		G		150	150	150	200	300	300	300	450	450	450	450	550	600	650	700	750	800	900	900								
			H		210	222	234	291	398	410	417	580	585	598	608	722	786	841	905	975	1035	1150	1171								
	V & VI		W		80	80	90	100	100	130	130	140	150	170	180	200	210	220	230	260	270	290	320								
			t3		10	12	16	16	20	20	25	25	25	28	32	36	36	36	40	45	45	50	56								
	VII		L						350	400	400	500	550	600	750	950	1050	1100	1200	1350	1500	1750	1900								
	VIII		L												350	400	450	500	550	600	650	700	750								
			C												160	200	200	200	240	240	240	260	280								
M30	V		G		150	150	150	200	300	300	300	450	450	450	450	500	500	550	600	650	750	800	800								
			H		210	225	235	290	400	410	415	580	585	600	610	675	690	745	805	875	985	1050	1075								
	V & VI		W		80	80	90	100	100	100	100	110	110	140	160	200	210	220	230	260	270	290	320								
			t3		10	12	16	16	20	20	20	25	25	28	32	36	36	36	40	45	45	50	56								
	VII		L						275	325	325	375	425	500	600	750	850	975	1000	1075	1225	1375	1525								
	VIII		L												300	350	400	450	500	550	600	650	700								
			C												125	160	160	160	185	185	200	240	240								

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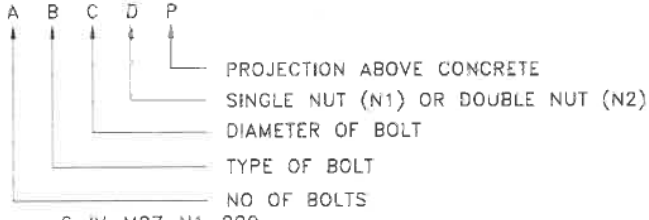
GRADE OF CONC.	BOLT TYPE	DIMENSIONS MM		BOLT DIA (ø) IN MM																		
				10	12	16	18	20	22	24	27	30	33	36	39	42	45	48	52	56	60	64
M35 & M40	V	G		150	150	150	200	300	300	300	450	450	450	450	450	500	550	600	600	700	750	750
		H		210	225	235	290	400	410	415	580	585	600	610	625	690	745	805	825	935	1000	1025
	V & VI	W		80	80	90	100	100	100	100	110	110	140	160	200	210	220	230	260	270	290	320
		t3		10	12	16	16	20	20	20	25	25	28	32	36	36	36	40	45	45	50	56
	VII	L						250	275	300	350	400	450	550	675	775	875	900	975	1100	1250	1375
	VIII	L												300	350	400	450	500	550	600	650	700
		C												125	160	160	160	185	185	200	240	240
M20, M25, M30, M35, & M40	V & VI	E		50	60	70	75	80	90	95	105	110	120	130	140	150	155	165	180	190	200	215
	V , VI , VII & VIII	K		50	50	50	50	50	80	80	80	80	80	80	100	100	100	100	125	125	125	150
		THREADED (T) LENGTH	SINGLE NUT	40	45	55	60	60	65	70	75	80	90	95	100	105	110	120	125	135	140	150
			DOUBLE NUT	50	60	70	75	80	90	95	105	110	120	130	140	150	155	165	180	190	200	215
	VII	t3						16	16	16	16	16	16	16	16	16	16	20	20	20	20	20
	VIII	t3												16	20	20	20	25	25	25	28	32
	VII & VIII	G		150	150	150	150	300	300	300	450	450	450	450	450	450	450	450	450	450	450	600
	IX	L		80	100	150	170	200														
M20&25	XII	L		185	220	310	335	385	435	460	535	590	660	720								
M30		L		150	150	200	225	250	275	300	350	375	425	450								
M35&M40		L		150	150	175	200	225	250	275	300	350	375	400								

NOTES :-

1. BOLTS SHALL BE MARKED ON THE DRAWING AS UNDER :



e.g.6-IV-M27-N1-200

2. BOLTS SHALL BE TURNED FROM M.S. ROUNDS CONFORMING TO IS:2062 GRADE-E250 QUALITY A/BR/BO.
3. NUTS AND WASHERS SHALL CONFORM TO IS:1363.
4. THREADING SHALL BE COARSE CONFORMING TO IS:1367 AND IS:4218.
5. ANCHOR BOLTS SHALL BE SET ACCURATELY AND HELD IN POSITION BY TEMPLATE BEFORE CONCRETING.
6. 6 THK. SQ. PLATE AT THE BOTTOM OF SLEEVE SHALL BE TACK WELDED WITH BOLT AND SLEEVE FOR BOLT TYPE III, IV, VII AND VIII.
7. SLEEVE SHALL BE M.S. TUBES (MEDIUM) AS PER IS:1239.
8. REFER DESIGN DRAWINGS FOR PROJECTION (P) OF BOLT ABOVE TOP OF ROUGH CONCRETE AND NUMBER (A) OF BOLTS.
9. ANCHOR BOLTS SHALL BE TEMPERED BEFORE MACHINING IF MADE BY FORGING. THE FORGING TEMPERATURE SHALL BE ABOVE 900° C BUT LOWER THAN SUPER HEATING TEMPERATURE.

M.S. ANCHOR BOLT ASSEMBLIES

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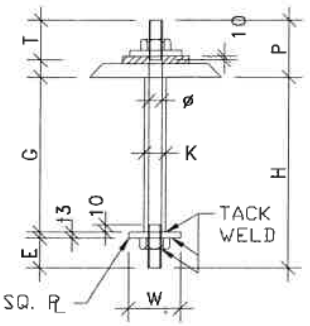
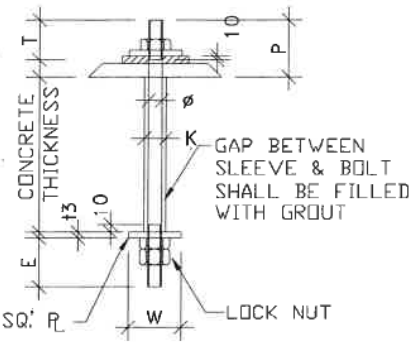
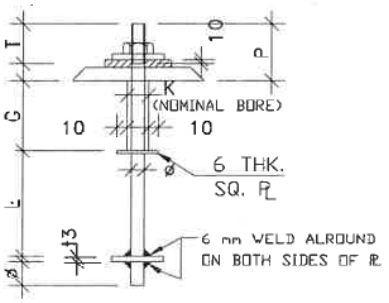
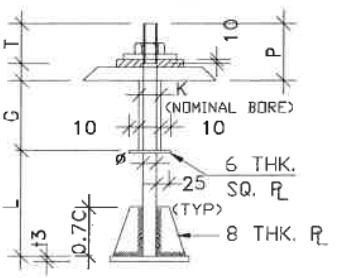


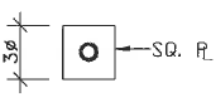
TYPE – V



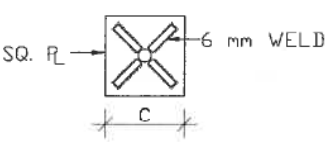
TYPE – VI



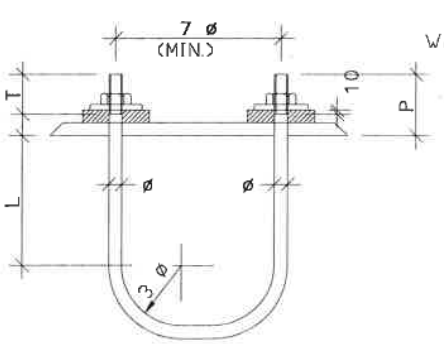




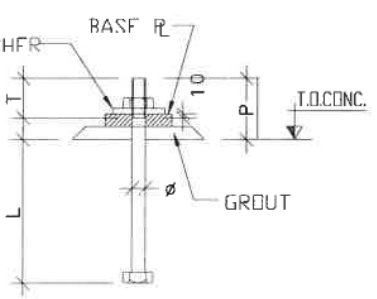
TYPE – VII



TYPE – VIII



TYPE – IX



TYPE – XII

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GRADE OF CONC.	BOLT TYPE	DIMENSIONS MM		BOLT DIA (ø) IN MM																				
				20	22	24	27	30	33	36	39	42	45	48	52	56	60	64						
M20, M25, M30, M35 & M40	X	a		150	160	180	200	220	240	260	280	300												
		b		250	290	310	330	370	390	460	480	500												
		L		600	700	800	900	1000	1100	1200	1300	1400												
		E		220	220	240	270	300	330	360	390	420												
		H		640	744	848	954	1060	1166	1272	1378	1484												
		ISA		100x100 X10	130X130X10			150X150X12		200X200X16														
		THREADED LENGTH (T)	SINGLE NUT	60	65	70	75	80	90	95	100	105												
			DOUBLE NUT	80	90	95	105	110	120	130	140	150												
	XI	h				18		20		25		30		30		30		30						
		k				18		22		25		30		35		40		50						
		c				24		30		36		42		48		56		64						
		q				65		75		85		95		110		125		140						
		r				1.6		1.6		2.0		2.0		2.0		3.0		3.0						
		f				140		150		170		190		210		220		240						
		e				30		35		42		50		58		65		75						
		L				800		1000		1200		1400		1600		1800		2000						
		ISMC				75x40		75x40		100x50		125x65		150x75		150x75		175x75						
		THREADED LENGTH (T)	SINGLE NUT			70		80		95		105		120		135		150						
			DOUBLE NUT			95		110		130		150		165		190		215						

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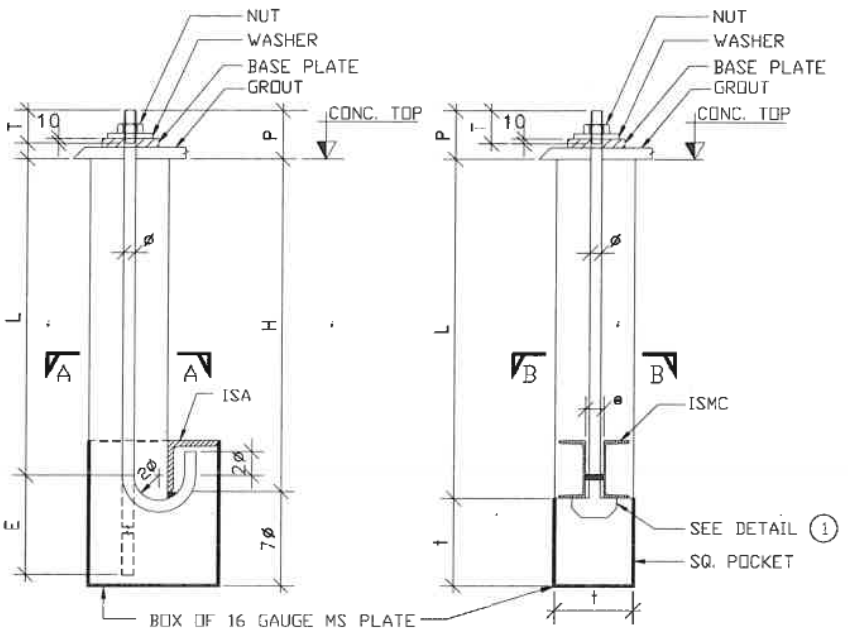
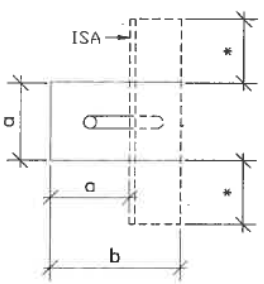
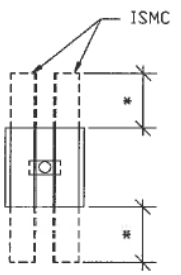




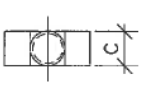
VIEW A – A

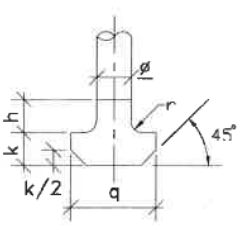
TYPE – X

(* AS PER DESIGN REQUIREMENT)



VIEW B – B





DETAIL – (1)

(FOR FORGED BOLT HEAD)

TYPE – XI

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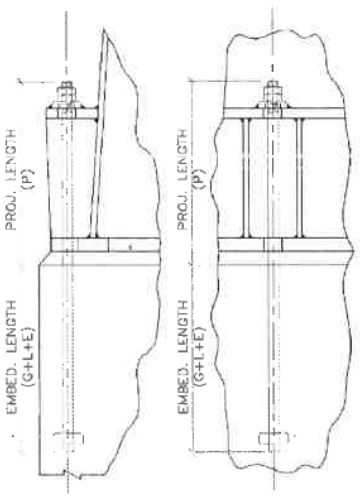

FIGURE 1: ANCHOR BOLT WITH ANCHOR CHAIR
(VERTICAL VESSELS ON SKIRT, STORAGE TANKS, ETC.)

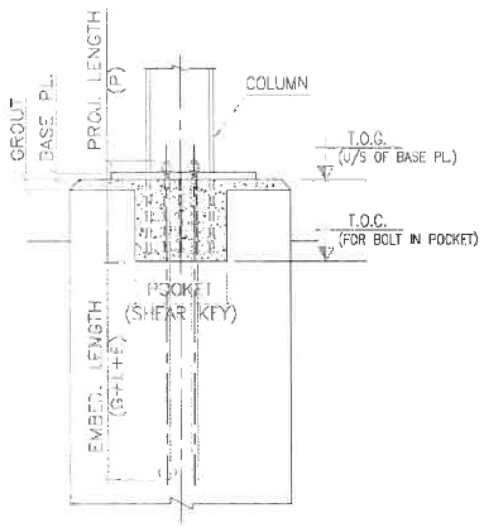

FIGURE 2: ANCHOR BOLT WITH POCKET IN PEDESTAL

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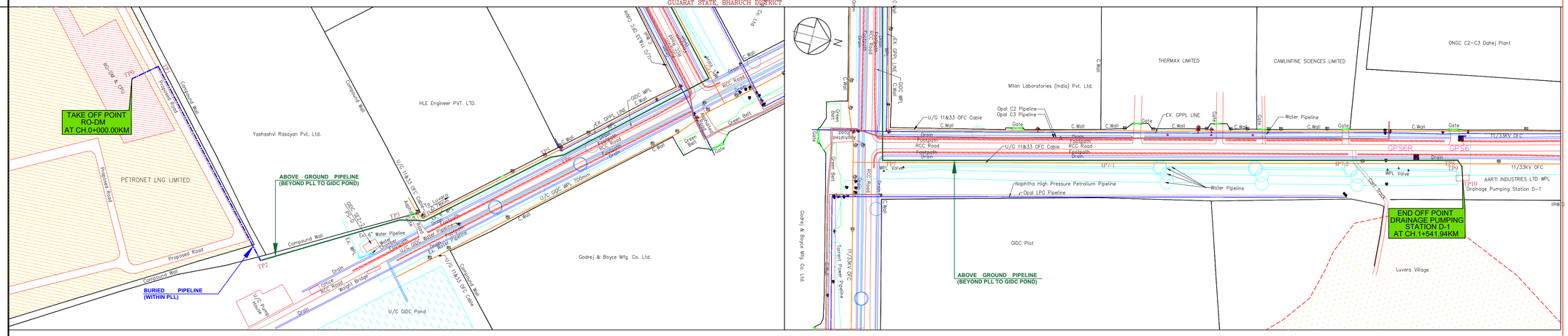
B862-000-83-44-10001

INTERSECTION POINTS (IP/TP)	TP0 TP1		TP2		TP3 TP4		TP5TP6		TP7		IP7/1		IP7/2		TP8TP10 TP9
DEFLECTION ANGLE		87°56'27"R		78°53'36"L		18°12'56"R 28°45'45"L		17°52'18"R 18°53'7"L		99°2'29"L				56°35'12"R 30°13'2"R	
DISTANCE BETWEEN IPs / TPs (m)	20.50	252.36		183.87	28.40	163.97	14.67	190.84	0.00	262.33		281.52		123.20	3.75 11.49
STATE, DISTRICT AND TALUKA	GUJARAT STATE, BHARUCH DISTRICT														

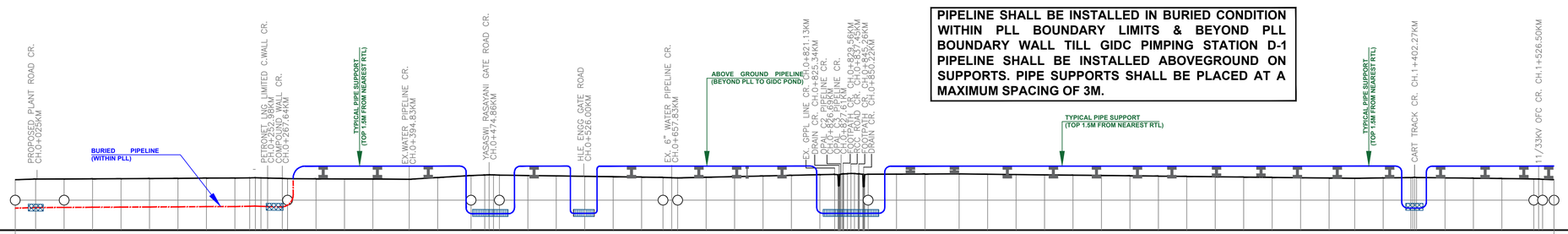
PLANIMETRY



GROUND PROFILE

SCALE :
HORIZONTAL 1:2500
VERTICAL 1:250

DATUM - 280.0m



PIPELINE SHALL BE INSTALLED IN BURIED CONDITION WITHIN PLL BOUNDARY LIMITS & BEYOND PLL BOUNDARY WALL TILL GIDC PIMPING STATION D-1 PIPELINE SHALL BE INSTALLED ABOVEGROUND ON SUPPORTS. PIPE SUPPORTS SHALL BE PLACED AT A MAXIMUM SPACING OF 3M.

| | | | | | | | | | | | | | | |