Appendices

Appendix 1

LIST OF IRC PUBLICATIONS REFERRED TO IN THE SPECIFICATIONS

Number Designation	Title
IRC : 2-1968	Route Marker Signs for National Highways (First Revision)
IRC : 5-1998	Standard Specifications & Code of Practice for Road Bridges, Section I - General Features of Design (Seventh Revision)
IRC : 6-2000	Standard Specifications & Code of Practice for Road Bridges, Section II - Loads and Stresses (Fourth Revision)
IRC : 8-1980	Type Designs for Highway Kilometre Stones (Second Revision)
IRC : 10-1961	Recommended Practice for Borrowpits for Road Embankments Constructed by Manual Operation
IRC : 14-1977	Recommended Practice for 2 cm Thick Bitumen and Tar Carpets (Second Revision)
IRC : 16-1989	Specification for Priming of Base Course with Bituminous Primers (First Revision)
IRC : 17-1965	Tentative Specification for Single Coat Bituminous Surface Dressing
IRC : 18-2000	Design Criteria for Prestressed Concrete Road Bridges (Post-Tensioned Concrete) (Third Revision)
IRC : 19-1977	Standard Specification and Code of Practice for Water Bound Macadam (Second Revision)
IRC : 20-1966	Recommended Practice for Bituminous Penetration Macadam (Full Grout)
IRC : 21-2000	Standard Specifications and Code of Practice for Road Bridges, Section III - Cement Concrete (Plain and Reinforced) (Third Revision)
IRC : 22-1986	Standard Specifications and Code of Practice for Road Bridges, Section VI - Composite Construction for Road Bridges (First Revision)
IRC : 23-1966	Tentative Specification for Two Coat Bituminous Surface Dressing
IRC : 24-2001	Standard Specifications and Code of Practice for Road Bridges, Section V - Steel Road Bridges (Second Revision)
IRC : 25-1967	Type Designs for Boundary Stones
IRC : 26-1967	Type Designs for 200-Metre Stones
IRC : 27-1967	Tentative Specifications for Bituminous Macadam (Base & Binder Course)
IRC : 29-1988	Specification for Bituminous Concrete (Asphaltic Concrete) for Road Pavement (First Revision)
IRC : 30-1968	Standard Letters and Numerals of Different Heights for Use on Highway Signs

Number Designation	Title
IRC : 35-1997	Code of Practice for Road Markings (with Paints) (First Revision)
IRC : 36-1970	Recommended Practice for the Construction of Earth Embankments for Road Works
IRC : 37-2001	Guidelines for the Design of Flexible Pavements (Second Revision)
IRC : 40-1970	Standard Specifications and Code of Practice for Road Bridges, Section IV - (Brick, Stone and Block Masonry) (First Revision)
IRC : 45-1972	Recommendations for Estimating the Resistance of Soil below the Maximum Scour Level in the Design of Well Foundations of Bridges
IRC : 47-1972	Tentative Specification for Built-up Spray Grout
IRC : 48-1972	Tentative Specification for Bituminous Surface Dressing Using Precoated Aggregates
IRC : 49-1973	Recommended Practice for the Pulverization of Black Cotton Soils for Lime Stabilisation
IRC : 50-1973	Recommended Design Criteria for the Use of Cement Modified Soil in Road Construction
IRC : 51-1992	Guidelines for the Use of Soil Lime Mixes in Road Construction (First Revision)
IRC : 56-1974	Recommended Practice for Treatment of Embankment Slopes for Erosion Control
IRC : 63-1976	Tentative Guidelines for the Use of Low Grade Aggregates and Soil Aggregate Mixtures in Road Pavement Construction
IRC : 67-2001	Code of Practice for Road Signs (First Revision)
IRC : 72-1978	Recommended Practice for Use and Upkeep of Equipment, Tools and Appliances for Bituminous Pavement Construction
IRC : 75-1979	Guidelines for the Design of High Embankments
IRC : 78-2000	Standard Specifications and Code of Practice for Road Bridges, Section VII - Foundation & Substructure (Second Revision)
IRC : 79-1981	Recommended Practice for Road Delineators
IRC : 82-1982	Code of Practice for Maintenance of Bituminous Surface of Highways
IRC : 83-1999	Standard Specifications and Code of Practice for Road Bridges, Section IX - Bearings, Part I: Metallic Bearings (First Revision)
IRC : 83-1987 (Part-II)	Standard Specifications and Code of Practice for Road Bridges, Section IX - Bearings, Part II: Elastomeric Bearings
IRC : 87-1984	Guidelines for the Design & Erection of False Work for Road Bridges
IRC : 89-1997	Guidelines for Design & Construction of River Training and Control Works for Road Bridges (First Revision)
IRC : 90-1985	Guidelines of Selection, Operation and Maintenance of Bituminous Hot Mix Plant

Number Designation	Title
IRC : 93-1985	Guidelines on Design and Installation of Road Traffic Signals
IRC : 94-1986	Specifications for Dense Bituminous Macadam
IRC : SP:11-1988	Handbook of Quality Control for Construction of Roads and Runways (Second Revision)
IRC : SP:31-1992	New Traffic Signs
	Ministry of Shipping & Transport (Roads Wing) Handbook on Road Construction Machinery (1985)
IRC : HRB : Special Report 11, 1992	IRC Highway Research Board, State of Art: Granular and Bound Bases and Sub-Bases

LIST OF INDIAN AND FOREIGN STANDARDS REFERRED TO IN THE SPECIFICATIONS

Number Designation	Title
	(A) INDIAN STANDARDS
IS:5-1994	Colour for ready mixed paints and enamels (fourth revision)
IS:73-1992	Paving Bitumen-Specification (second revision)
IS:164-1981	Ready mixed paints, brushing, for road marking, to Indian Standard Colour No. 356 Golden yellow, white and black
IS:210-1993	Grey iron castings (fourth revision)
IS:215-1995	Road tar specification (third revision)
IS:217-1988	Cutback Bitumen-Specification (second revision)
IS:269-1989	33 grade ordinary portland cement (fourth revision)
IS:278-1978	Galvanized steel barbed wire for fencing (third revision)
IS:280-1978	Mild steel wire for general engineering purposes (third revision)
IS:334-1982	Glossary of terms relating to bitumen and tar (second revision)
IS:383-1970	Coarse and fine aggregates from natural sources for concrete (second revision)
IS:432-1982	Mild steel and medium tensile steel bars and hard-drawn steel wire for concrete reinforcement
(Part I)	Mild steel and medium tensile steel bars (third revision)
(Part II)	Hard-drawn steel wire (third revision)
IS:443-1975	Methods of sampling and test for rubber hoses (second revision)
IS:454-1994	Cutback Bitumen from Waxy Crude-Specification (second revision)
IS:455-1989	Portland stag cement (fourth revision)
IS:456-2000	Code of practice for plain and reinforced concrete (fourth revision)
IS:458-1988	Precast Concrete pipes (with and without reinforcement) (third revision)
IS:460-1985	Test sieves
IS:508-1987	Specification grease graphited (fourth revision)
IS:516-1959	Methods of test for strength of concrete
IS:702-1988	Industrial bitumen (second revision)
IS:736-1986	Wrought aluminium and aluminium alloys, plates for general engineering purposes (third revision)
IS:814-1991	Covered electrodes for manual metal arc welding of carbon and carbon manganese steel (fifth revision)
IS:1030-1998	Carbon steel castings for general engineering purposes (fifth revision)
IS:1077-1992	Common burnt clay building bricks (fifth revision)

Number Designation	Title
IS:1124-1974	Method of test for water absorption apparent specific gravity and porosity of natural building stones (first revision)
IS:1129-1972	Dressing of natural building stones (first revision)
IS:1148-1982	Hot rolled rivet bars (upto 40 mm dia) for structural purposes (third revision)
IS:1149-1982	High tensile rivet bars for structural purposes (third revision)
IS:1195-1978	Bitumen mastic for flowing (second revision)
IS:1199-1959	Method of sampling and analysis of concrete
IS:1201 to 1220-1978	Indian standard methods for testing tar and bituminous materials
IS:1203-1978	Determination of penetration (first revision)
IS:1205-1978	Determination of softening point (first revision)
IS:1206-1978 (Part 1 to 3)	Determination of viscosity (first revision)
IS:1208-1978	Determination of ductility (first revision)
IS:1209-1978	Determination of flash point and fire point (first revision)
IS:1212-1978	Determination of loss of heating (first revision)
IS:1216-1978	Determination of solubility in carbon disulphide or carbon tetrachlorate or trichoroethylene (first revision)
IS:1217-1978	Determination of mineral matter (ash) (first revision)
IS:1239-1990 (Part 1)	Mild steel tubes (fifth revision)
IS:1239-1992 (Part 2)	Mild steel tubular and other wrought steel pipe fittings (third revision)
IS:1364-1992 (Part I to V)	Hexagon head bolts, screws and nuts of product grades A and B. - Part I : Hexagon head bolts (size range M1.6 to M64) (third revision)
IS:1367-1997 (Part I to XX)	Technical supply conditions for threaded steel fastners
IS:1387-1993	General requirements for the supply of metallurgical materials (second revision)
IS:1398-1982	Packing paper, waterproof, bitumen-laminated (second revision)
IS:1448	Method of tests for petroleum and its products
IS:1477	Code of practice for painting of ferrous metals in buildings
(Part 1)-1971	Pretreatment (first revision)
(Part 2)-1971	Painting (first revision)
IS:1489-1991	Portland-pozzolana cement
(Part 1)	Flyash based (third revision)
(Part 2)	Calcined clay based (third revision)

Number Designation	Title
IS:1498-1970	Classification and identification of soils for general engineering purposes (first revision)
IS:1514-1990	Methods of sampling and test for quick lime and hydrated lime (first revision)
IS:1732-1989	Dimensions for round and square steel bars for structural and general engineering purposes (second revision)
IS:1785	Plain hard-drawn steel wire for prestressed concrete
(Part I)-1983	Cold-draws stress relieved wire (second revision)
IS:1786-1985	High strength deformed steel bars and wires for concrete reinforcement (third revision)
IS:1838	Preformed filler for expansion joint in concrete pavement and structures (non extruding and resilient type)
(Part I)-1983	Bitumen impregnated fibre (first revision)
IS:1888-1982	Method of load tests on soils (second revision)
IS:2004-1991	Carbon steel forging for general engineering purposes (third revision)
IS:2062-1999	Steel to general structural purpose (fifth revision)
IS:2116-1980	Sand for masonry mortars (first revision)
IS:2131-1981	Methods for standard penetration test for soils (first revision)
IS:2250-1981	Code of practice for preparation and use of masonry mortars (first revision)
IS:2386-1963	Methods of test for aggregates for concrete
(Part 1)	Particle size and shape
(Part 2)	Estimation of deleterious materials and organic impurities
(Part 3)	Specific gravity, density, voids, absorption and bulking
(Part 4)	Mechanical properties
(Part 5)	Soundness
(Part 6)	Measuring mortar making properties of fine aggregates
(Part 7)	Alkali - Aggregate reactivity
(Part 8)	Petrographic examination
IS:2720	Methods of test for soils
(Part 2)-1973	Determination of water content (second revision)
(Part 3)-1980	Determination of specific gravity (first revision)
Section I	Fine grained soils
Section II	Medium and coarse grained soils
(Part 4)-1985	Grain size analysis (second revision)
(Part 5)-1985	Determination of liquid and plastic limits (second revision)
(Part 7)-1980	Determination of moisture content/dry density relation using light compaction (second revision)

Number Designation	Title
(Part 8)-1983	Determination of water content-dry density relation using heavy compaction (second revision)
(Part 10)-1991	Determination of unconfined compressive strength (second revision)
(Part 13)-1986	Direct shear test (second revision)
(Part 14)-1983	Determination of density index (relative density) of cohesionless soils (first revision)
(Part 16)-1987	Laboratory determination of CBR (second revision)
(Part 27)-1977	Determination of total soluble sulphates (first revision)
(Part 28)-1974	Determination of dry density of soils in-place by the sand replacement method (first revision)
(Part 29)-1975	Determination of dry density of soils in-place by core cutter method (first revision)
(Part 37)-1976	Determination of sand equivalent values of soils and fine aggregates
(Part 40)-1977	Determination of free swell index of soils
IS:3117-1965	Specification for bitumen emulsion for roads (anionic type)
IS:3466-1988	Masonry cement (second revision)
IS:3764-1992	Code of safety for excavation work (first revision)
IS:4138-1977	Safety code for working in compressed air (first revision)
IS:4332	Method of test for stabilized soils
(Part 1)-1967	Methods of sampling and preparation of stabilized soils for testing
(Part 3)-1967	Test for determination of moisture content-dry density relation for stabilized soil mixtures
(Part 4)-1968	Wetting and drying and, freezing and thawing tests for compacted soil-cement mixtures
(Part 5)-1970	Determination of unconfined compressive strength of stabilized soil
(Part 7)-1973	Determination of cement content of cement stabilized soils
(Part 8)-1969	Determination of lime content of lime stabilized soils
IS:4434-1978	Code of practice for in-situ vane shear test for soils (first revision)
IS:4826-1979	Hot dipped galvanised coating on round steel wires (first revision)
IS:5317-1987	Specification for bitumen mastic for bridge decking and roads (first revision)
IS:5435-1987	General requirements for cold asphalt macadam mixing plants (first revision)
IS:5640-1970	Method for determining the aggregate impact value of soft coarse aggregate
IS:6006-1983	Uncoated stress relieved strands for prestressed concrete (first revision)
IS:6241-1971	Methods of test for determination of stripping value of road aggregates

Number Designation	Title
IS:6909-1990	Supersulphated cement
IS:6925-1973	Methods of test for determination of water soluble chlorides in concrete admixtures
IS:7537-1974	Road traffic signals
IS:7623:1993	Specification for li thium base grease for industrial purposes (second revision)
IS:8041-1990	Rapid hardening portland cement (second revision)
IS:8112-1989	43 grade ordinary portland cement (first revision)
IS:8500-1991	Structural steel - microalloyed (medium and high strength qualities) (first revision)
IS:8887-1995	Bitumen emulsion for roads (cationic type)-specification (first revision)
IS:9103-1999	Admixtures for concrete (first revision)
IS:9381-1979	Methods of testing tar and bituminous materials: determination of fraass breaking point of bitumen
IS:9382-1979	Methods of testing tar and bituminous materials: determination of effect of heat and air by thin film oven tests
IS:10262-1982	Guidelines for concrete mix design
IS:12269-1987	Specification for 53 grade ordinary portland cement
IS:12330-1988	Specification for sulphate resisting portland cement
IS:13321 (Part I)-1992	Glossary of terms for geosynthetics, part I: terms used in materials and properties
IS:13325-1992	Determination of tensile properties of extruded polymer geogrids using the wide strip-test method
IS:13326 (Part I)-1992	Evaluation of interface friction between geosynthetics and soil-method of test, part I : modified direct shear technique
IS:SP 23-1982	Handbook on concrete mixes (based on Indian standards)
	(B) FOREIGN STANDARDS
ASTM : D-36	Thermoplastic material
ASTM : D-395	Compression test of vulcanized rubber
ASTM : D-412	Tension testing of vulcanized rubber
ASTM : D-429	Adhesion of vulcanized rubber to metal
ASTM : D-573	Accelerated aging of vulcanized rubber by the oven method
ASTM : D-624	Tear resistance of vulcanized rubber
ASTM : D-664	Test method for neutralisation number for potentiometric titration
ASTM : D-797	Young's modulus in flexure of elastomer at normal and subnormal temperature
ASTM : D977-91	Standard specification for emulsified asphalt

Number Designation	Title
ASTM : D979-89	Standard practice for sampling bituminous paving mixtures
ASTM : D-1075	Effect of water on cohesion of compacted bituminous mixtures
ASTM : D-1149	Accelerated ozone cracking of vulcanized rubber
ASTM : D-1559	Test for resistance to plastic flow of bituminous mixtures using Marshall apparatus
ASTM : D2026-72 (Reapproved 1993)	Standard specification for cutback asphalt (slow-curing type)
ASTM : D2027-76 (Reapproved 1992)	Standard specification for cutback asphalt (medium-curing type)
ASTM : D2041-95	Standard test method for theoretical maximum specific gravity and density of bituminous paving mixtures
ASTM : D2172-95	Standard test methods for quantitative extraction of bitumen from bituminous paving mixtures
ASTM : D-2240	Indentation hardness of rubber and plastic by means of a Durometer
ASTM : D2397-94	Standard specification of cationic emulsified asphalt
ASTM : D3203-94	Standard test method for per cent air voids in compacted dense and open bituminous paving mixtures
ASTM : D-3625	Test method for effect of water on bitumen coated aggregate using boiling water
ASTM : D3910-90 (Reapproved 1995)	Standard practice for design, testing and construction of slurry seal
ASTM : D-4533	Test method for trapezoid tearing strength of geotextiles
ASTM : D5976-96	Standard specification for type I polymer modified asphalt cement for use in pavement construction
ASTM : E-11	Specification for wire cloth sieves for testing purposes
ASTM : E-810	Test method for coefficient of retro-reflection or retro-reflection sheeting
AASHTO : DM 283	Coarse aggregate for highway and airport construction
AASHTO : DM 294-70	Fine aggregate for bituminous paving mixtures
AASHTO : DM 288-82	Geotextiles used for subsurface drainage purposes
AASHTO : DM 17-77	Mineral filler for bituminous paving mixtures
AASHTO : DR 5-80	Selection and use of emulsified asphalts
AASHTO : DM 81-75	Cut-back asphalt (rapid-curing type)
AASHTO : DM 82-75	Cut-back asphalt (medium-curing type)
AASHTO : DM 140-80	Emulsified asphalt
AASHTO : DM 57-80	Materials for embankments and subgrades
AASHTO : DM 147-65 (1980)	Materials for aggregate and soil-aggregate sub-base, base and surface courses

Number Designation	Title
AASHTO : DM 216-68	Lime for stabilisation
AASHTO : DM 249-79	White and yellow reflective thermoplastic stripping materials (solid form)
AASHTO : DM 268-77	Weatherometer
AASHTO : DM 282-80	Joint sealants, hot poured, elastomeric type, (or ASTM : D 3406) for portland cement concrete pavements
AASHTO : M82	Equivalent to ASTM:D2027-76 or ASTM:D2026-72
AASHTO : M140	Equivalent to ASTM:D977-91
AASHTO : M208	Equivalent to ASTM:D2397-94
AASHTO : T182-84	Coating and stripping of bitumen aggregate mixtures
AASHTO : T283-89	Resistance of compacted bituminous mixture to moisture induced damage
BS : 410-1969	Test sieves
BS : 434	Bitumen road emulsions (anionic and cationic)
- Part 2:1984	Specification for bitumen road emulsion
- Part 2:1984	Code of practice for use of bitumen road emulsions
BS : 598	Sampling and examination of bituminous mixtures for roads and other paved areas
- Part 104:1987	Methods of test for the determination of the density and compaction
- Part 107:1990	Method of test for the determination of the composition of design wearing course rolled asphalt
BS : 729-1971	Hot dip galvanized coating on iron and steel articles
BS : 812-1975	Testing aggregates
- Part 2	Methods for determination of physical properties
- Part 3	Methods for determination of mechanical properties
- Part 111	Method for determination of ten per cent fines value (TFV)
- Part 114-1989	Method for determination of the polished-stone value
BS : 1047-1952	Air-cooled blastfurnace slag coarse aggregate for concrete
BS : 1154-1970	Vulcanized natural rubber compounds
BS : 1377-1975	Methods of test for soils for civil engineering purposes
BS : 1447-1973	Mastic asphalt (limestone fine aggregates) for roads and footways
BS : 1449-1956	Steel plate, sheet and strip
- Part 1-1972	Carbon steel plate, sheet and strip
- Part 2-1967	Stainless and heat resisting plate, sheet and strip
BS : 1470-1972	Wrought aluminium and aluminium alloys for general engineering purposes - plate, sheet and strip

Number Designation	Title
BS : 2000	Methods of test for petroleum and its products
- Part 397:1995	Recovery of bitumen binders-dichloromethane extraction rotary film evaporator method
BS : 2630	Preformed joint filler
BS : 2870	Rolled copper and copper alloys : sheet, strip and foil
BS : 3262	Hot-applied thermoplastic road marking materials
Part-1	Specification for constituent materials and mixtures
Part-2	Specification for road performance
Part-3	Specification for application of material to road surface
BS : 5212, Part 2-1975	Cold poured joint sealants for concrete pavements
BS : 6044	Specification for pavement marking paints
BS : 6088	Specification for solid glass beads for use with road marking compounds and for other industrial uses
BS : 6906	Methods of test for geotextiles
Part 1	Determination of the tensile properties using a wide width strip
Part 2	Determination of the apparent pore size distribution by dry sieving
Part 3	Determination of water flow normal to the plane of the geotextile under a constant head
Part 4	Determination of the puncture resistance (CBR puncture test)
Part 7	Determination of in-plane waterflow
BS : 7542	Method of test curing compound for concrete
CRRI & IOC, New Delhi	Bituminous road construction hand book
BS : DD232-1996	Method for determination of the maximum binder content of bituminous mixtures without excessive binder drainage
Asphalt Institute	The asphalt handbook, manual series No.4 (MS-4) 1989 edition
	Manual series No.2 (MS-2) - mix design methods for asphalt concrete and other hot-mix types
	Manual series No.14 (MS-14) - asphalt cold mix manual
GRI-GG1	Geogrid rib tensile strength
GRI-GG2	Geogrid junction strength
GRI-GG3	Tensile creep testing of geogrids

(GRI denotes standards for test prepared by Geosynthetic Research Institute at Drexel University, Philadelphia, USA)

(Clause 402.3.2 and 403.3.2)

METHOD OF SIEVING FOR WET SOILS TO DETERMINE THE DEGREE OF PULVERISATION

1. A sample of pulverised soil approximately 1 kg in weight should be taken and weighed (W_1).
2. It should be spread on the sieve and shaken gently, care being taken to break the lumps of soils as little as possible. Weight of soil retained on the sieve should be recorded (W_2). Lumps of finer soils in the retained material should be broken until all the individual particulars finer than the aperture size of the sieve are separated.
3. The soil should again be placed on the sieve and shaken until sieving is complete. The retained material should be weighed (W_3).
4. Weight of soil by per cent passing the sieve can than be calculated from the expression:

$$\frac{(W_1 - W_2) \times 100}{(W_1 - W_3)}$$

Appendix 4

GUIDELINES ON SELECTION OF THE GRADE OF BITUMEN

(**Source** : Bituminous Road Construction Handbook, Indian Oil Corporation and Central Road Research Institute)

A For bituminous premix carpet, choice is governed by climatic conditions and intensity of traffic.

(i) Grade 30/40 for areas where difference between maximum and minimum atmospheric temperatures is less than 25° C and traffic intensity is greater than 1500 commercial vehicles per day. For traffic intensity less than 1500 commercial vehicles per day, Grade 50/60 is preferred.

(ii) Where the difference between maximum and minimum atmospheric temperature is more than 25° C and traffic intensity is greater than 1500 commercial vehicles per day, Grade 50/60 may be used. For traffic intensity of less than 1500 commercial vehicles per day, Grade 80/100 may be used. For roads with very heavy traffic greater than 4500 commercial vehicles per day, such as metropolitan city roads, Grade 30/40 is preferred.

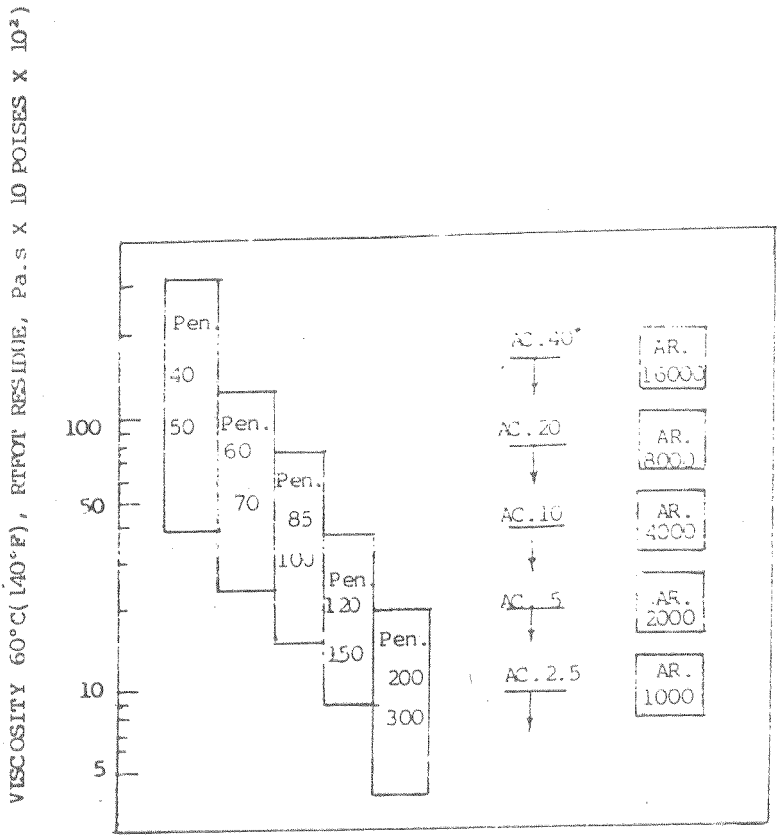
(iii) Grade 80/100 may be used in high altitude and snow-bound regions, irrespective of traffic intensity consideration.

B For bituminous macadam and penetration macadam as also built-up spray grout, Grade 30/40 (for hot climates) and 60/70 or 80/100 for other climates are suggested.

C For a dense-graded bituminous concrete, a more viscous grade like 60/70 can withstand stresses of heavier wheel loads better than a less viscous grade of 80/100. Similarly paving bitumen grade 60/70 is more advantageous for roads with large number of repetitions of wheel loads like expressways, urban roads, factory roads etc. High stability requirement cannot be met effectively by less viscous bitumen.

D A more viscous grade of bitumen is advantageous in reducing stripping of bitumen film from aggregates in the presence of water.

E With rounded river shingles, a more viscous grade of bitumen compensates to some extent for poor mechanical interlock. A comparison of penetration grades and viscosity grades (AC-2.5 to AC-40) of asphalt cement and AR grades (based on Rolling Thin Film Oven Test residue) is shown below.



Comparision of penetration grades and viscosity grades of bitumen

Appendix 5

ANTI-STRIPPING AGENTS USED FOR BITUMINOUS MATERIALS AND MIXES

1. Scope

1.1. Anti-stripping agents are used for bituminous materials and mixes to ensure adhesion between aggregates (hydrophilic in nature) and bitumen, even under submergence in water. Prior approval of the Engineer shall be taken in respect of both qualitative and quantitative use of a particular product.

2. Materials

2.1. The anti-stripping agents shall be fatty acid amines having a long hydrocarbon chain.

2.2. Physical and Chemical Requirements : The anti-stripping agents shall conform to the physical and chemical requirements as detailed in Table A5-1.

2.3. Storage and Handling : Anti-stripping agents shall be properly stored in closed containers made of steel or aluminium. Containers made of zinc, copper, polythene PVC and most types of rubber are not suitable for use. As most of the anti-stripping agents cause irritation when in contact with human skin and are also irritating to the eyes, protective gloves for hands and goggles for the eyes shall be used while handling them, specially in case of liquid anti-stripping agents.

3. Use in Sprayed Work

3.1. Additive Dosage: The dosage shall be determined depending on the nature (stripping value) of the aggregate and the size of aggregate. While the recommended minimum dose of anti-stripping agent for sprayed work is given in Table A5-2, the actual dosage shall be determined in the laboratory as directed by the Engineer.

3.2. Mixing Procedure During Construction: The anti-stripping agent supplied in liquid, solid or concentrate form shall be thoroughly mixed with liquid bituminous material or with straight run bitumen. When used with straight run bitumen, the correct dose of antistripping agent shall be mixed in a hot bitumen tank boiler.

The two constituents shall be agitated till the anti-stripping agent is thoroughly mixed. The dose of anti-stripping agent shall suitably be increased if the binder is to remain in bitumen boiler for a longer period.

4. Use in Premix Work

4.1. Additive Dosage: The dosage shall be determined depending on the nature (stripping value) of the aggregate and the per cent voids in the mix. While the recommended minimum doses for different types of bituminous premix materials in terms of voids content are given in Table A5-3, the actual dosage shall be determined in the laboratory as directed by the Engineer.

TABLE A5-1. SPECIFICATION FOR ANTISTRIPPING COMPOUND

S.No.	Test	Method	Limit
1.	Appearance	Visual	Liquid/Solid
2.	Odour	Smelling	Agreeable
3.	Specific gravity 27°C	IS : 1202-1978	0.860-1.03
4.	Pour point °C Maximum	IS : 1448	42
5.	Flash point ° (COC) Minimum	IS : 1448	150
6.	Water Content per cent Vol. Maximum	IS : 1448	1.0
7.	Solubility in diesel oil (HDO or LDO) in the ratio of 2:98 at 50°C	As given at the end of Appendix	Complete
8.	Total base value mg KOH/g minimum	ASTM D 664	200
9.	Nitrogen content per cent Wt. minimum	Elemental Analyser	7.0
10.	Stripping value with bitumen containing 1 per cent Wt. antistripping compound at 40° C 24 hours	IS : 6241 As given at the end of Appendix	No stripping
11.	Under water coating test	- do -	Complete Coating
12.	Thermal stability at 163°C 5 hours	- do -	Should not lose its efficacy
13.	Boiling water test per cent minimum coating	ASTM D 3625	95
14.	Retained Marshall Stability per cent minimum	As given at the end of appendix	75

TABLE A5-2. TENTATIVE RECOMMENDED MINIMUM DOSE OF ANTISTRIPPING AGENT FOR SPRAYED WORK

Aggregate stripping value	Dose of antistripping agent in per cent by weight of bitumen			
	Surface dressing with precoated aggregate	Penetration Macadam/ Built up spray grout	Surface Dressing with uncoated aggregate	Liquid seal coat
0-25	0.5	0.6	0.7	0.8
25-50	0.6	0.7	0.8	1.0
50-100	0.75	1.0	1.0	1.0

4.2. Mixing Procedure During Construction : The required dose of the anti-stripping agent shall be poured into the hot bitumen tank and allowed 15 to 30 minutes of circulation or stirred to ensure a homogeneous mix. It is necessary to use a stable antistripping agent or increase the dose according to expected degradation. Alternatively, the correct dose shall be injected into the bitumen line by means of a pump. The agent is fed into the bitumen first before it is sprayed on the aggregate in the mix; thus, no separate mixing time for mixing the agent with bitumen is required. In rolled asphalt and bitumen mastic surfacing works, precoated chippings are pressed into the hard surface while the mix is still hot to make the newly laid surface skid resistant. These chippings shall be precoated with bitumen treated with antistripping compound.

TABLE A5-3. TENTATIVE RECOMMENDED MINIMUM DOSE OF ANTISTRIPPING COMPOUND IN BITUMEN PREMIX WORKS

Stripping value of aggregate	Dose of antistripping agent in per cent by weight of bitumen		
	Voids content 3-5 per cent	Voids content 5-10 per cent	Voids content 10-15 per cent
0-25	0.3	0.4	0.5
25-50	0.4	0.5	0.6
50-100	0.6	0.8	1.0

Annexure to the Appendix 5

TESTING PROCEDURE FOR SOLUBILITY OF ANTISTRIPPING AGENT IN DIESEL OIL

Procedure: 98ml of diesel oil (HDO or LDO) and 2 ml of antistripping agent shall be taken in a measuring cylinder with stopper. The cylinder along with its contents shall be kept in water bath, maintained at 50°+ 1° C for half an hour. It shall then be taken out from water bath and shaken vigorously for 10 minutes. The stopper shall be removed and the cylinder kept in water bath for half an hour and examined for separation or settlement.

Reporting of results: An antistripping agent is reported to be completely soluble in diesel oil if no separation or settlement is observed for half an hour.

TESTING STRIPPING VALUE OF AGGREGATES USING BITUMEN WITH VARYING PERCENTAGES OF ANTISTRIPPING AGENT.

Procedure: Coarse aggregate passing 19 mm sieve and retained on 13.2 mm sieve shall be washed and dried in an oven for 24 hours at 110° C. Such dried 200 gms of coarse aggregates shall be heated at 149° C and then mixed with 80/100 penetration grade bitumen 5 per cent by weight of coarse aggregate heated upto 163° C. The mixture shall be mixed thoroughly for uniform coating of aggregates by bitumen. The mix shall then be transferred to a 500 ml beaker and allowed to cool to room temperature. Distilled water shall be added in the beaker, which shall be placed in a water bath maintained at 40° ± 1° C for 24 hours. The percentage degree of stripping shall be assessed visually. The test shall also be conducted with water containing 1 per cent Sodium Chloride, as a precautionary measure to eliminate water contamination. The test is repeated using bitumen containing upto one per cent of antistripping agent in stages of 0.25 per cent.

TESTING EFFICACY OF ANTISTRIPPING AGENT TO COAT AGGREGATES WITH BITUMEN IN PRESENCE OF WATER

Procedure: The antistripping agent shall be added in per cent contents of 0.0, 0.25, 0.50., 0.75, 1.00 and 1.25 to cutback bitumen MC 3 (4 parts of bitumen 80/100 and 1 part of kerosene oil). The blends shall be used for testing their ability to coat the road aggregates under water.

(a) 100gm of clean and dry stone dust conforming to following gradation shall be taken:

Sieve Size	per cent passing
2.36 mm	100
1.18 mm	80
600 mic.	75
300 mic.	45

The bottle shall be filled to 3/4 of its volume with distilled water at 40° C. The bitumen-antistripping agent blend shall be added in the bottle at the rate of 7.5 per cent by weight of stone dust. The stopper shall be replaced and the bottle shall be vigorously shaken for two minutes. The water shall be then drained off and the stone dust shall be transferred to a piece of paper and examined visually for satisfying complete coating. The minimum per cent content of antistripping agent at which the stone dust sample is thoroughly coated shall be recorded. The test shall be repeated at 60°C in water as well as 1 per cent solution of Sodium Chloride in water for both the testing temperatures.

(b) The under water coating test shall further be conducted with coarse aggregate, passing 19 mm sieve and retained on 13.2 mm sieve. In this case the per cent content of the cutback-antistripping agent blend shall be kept at 5 per cent by weight of coarse aggregate. In order to take care of contamination in water, the test shall also be carried out in the 1 per cent Sodium Chloride in water.

The minimum per cent content of antistripping agent at which stone dust/coarse aggregate is thoroughly coated as per (a) and (b) shall be taken as the dose of antistripping agent.

TESTING FOR THERMAL STABILITY OF ANTISTRIPPING AGENT

Procedure: Blends of antistripping agent and bitumen of 80/100 grade shall be prepared with 0.00, 0.25, 0.50, 0.75 and 1.00 per cent contents of antistripping agent and kept in oven at 163° C for five hours. After the heat exposure, the blend samples are fluxed with kerosene oil to obtain the consistency of MC 3 and tested for under water coating test.

Reporting of test results: An antistripping agent shall be deemed to be heat resistant if the dose requirement before and after heat exposure remains unchanged.

QUANTITATIVE EVALUATION OF RETAINED MARSHALL STABILITY VALUES AFTER IMMERSION IN WATER

Procedure: For quantitative evaluation, the tests shall be carried out as stipulated in ASTM D1075 (Effect of Water on Cohesion of Compacted Bituminous Mixtures). The gradation of aggregates shall be such as to give sufficient voids in the compacted bituminous mix to bring out the effects of stripping. The gradation of aggregates shall be as under:

Sieve Size	per cent Passing
19.00 mm	100
13.20 mm	75-100
9.50 mm	60-80
4.75 mm	35-55
2.36 mm	20-35
600 mic	10-22
300 mic	6-16
150 mic	4-12
75 mic	2-8

The Marshall test specimens shall be prepared using 5 per cent bitumen of 80/100 grade by weight of aggregates blended with varying percentages of antistripping agents from 0 to 1 per cent in steps of 0.25 per cent. The test samples shall give a void content of about 6 per cent. At least 8 standard Marshall specimens for each of the varying antistripping agent percentages shall be prepared. Each set of 8 test specimens shall be sorted out in two groups of 4 each so that the average specific gravity of the specimen in group I shall be essentially the same as in group II. Group-I shall be tested for Marshall Stability in the usual procedure ASTM D1559. Group-II specimens shall be immersed in water for 24 hours at 60°C $\pm$1°C. and then shall be tested immediately for Marshall stability as per ASTM D 1559.

Calculation: The numerical index of resistance of bituminous mixtures to the detrimental effect of water shall be expressed as the index of retained stability :

$$\frac{\text{Average Marshall Stability of Group-II}}{\text{Average Marshall Stability of Group-I}} \times 100 \text{ per cent}$$

Requirement for acceptance: A minimum of 75 per cent of retained Marshall strength shall be required for acceptance.

Appendix 1000-1

DRAFT DOCUMENT ON IS : 9077-1979 CODE OF PRACTICE FOR CORROSION PROTECTION OF STEEL REINFORCEMENT IN RB AND RCC CONSTRUCTION (REVISED)

FOREWORD

This Indian Standard has been revised taking into consideration the experience gained over the years, developments those have taken place subsequently and also considering the need for evolving suitable acceptance tests for quality control. In this regard, the electrochemical tests developed at the Central Electrochemical Research Institute, Karaikudi, and also the tests specified in ASTMA775/A775 M-90 for powder epoxy coating have been considered.

This revised standard supersedes earlier standard namely IS:9077-1979. While revising this standard, it was decided to cover the various test procedures required to ensure the quality of individual product as well as the finished products. It was also decided that this standard should include very stringent test procedures particularly for finished products so that these procedures can be used to evaluate not only the corrosion resistance of a particular finished product covered by this standard but also any other finished product such as galvanising, powder epoxy etc.

1. SCOPE

1.1. This standard (revised) specifies the recommended practice for surface preparation, surface pretreatment and anti-corrosive treatment based on inhibited and sealed cement slurry as an in-situ process for corrosion protection of mild steel reinforcement / HYSD bars in conventional reinforced concrete structures and conventional reinforced brickwork. constructions. This practice is also applicable for non-prestressing steels (mild steel reinforcement/HYSD bars) used in prestressed Concrete structure.

1.2. This standard applies only for in-situ corrosion protection of mild steel reinforcement/ HYSD bars after all bending and shaping operations are completed. However, this does not preclude the possibility of using this practice as a factory process.

2. ANTICORROSIVE TREATMENT PROCESS SEQUENCES

The anticorrosive treatment should necessarily include the following sequential steps:

(a) Surface preparation (de-rusting)

Since presence of oil, grease, dirt, heavy scale and rust will adversely affect the performance of any anticorrosive treatment, it is essential to adopt suitable surface preparation technique. Surface preparation can be either by acid pickling or by sand blasting.

(b) Surface pretreatment

Surface preparation should be immediately followed by a surface treatment step to ensure temporary protection during the time lag between the de-rusting and finish coating. This pretreatment should not adversely affect either the adhesion of the finish coat or corrosion performance.

(c) Inhibited Cement Slurry coating

A minimum of 2 coats should be applied to ensure full coverage.

(d) Sealing treatment

Sealing treatment should make the coating harder and less permeable

A typical flow diagram is shown in Fig. 1000/1.

3. PROCEDURE FOR SURFACE PREPARATION

3.1. Sand Blasting

Sand blasting of the steel surface to SAE 2 1/2 standards can be done

3.2. De-rusting by Pickling

The pickling weld should be preferably based on hydrochloric acid and should include an efficient inhibitor to prevent base metal attack.

A typical de-rusting solution should have the following characteristics:

(a) inhibitor efficiency should not be less than 97 per cent.

(b) weight loss of a polished standard mild steel reinforcement / HYSD bars specimen when dipped in the solution for 10 minutes should not be more than 2 g per sq. metre.

(c) Specific gravity when tested using a standard specific gravity bottle should be around 1.12.

4. PROCEDURE FOR SURFACE PRE-TREATMENT

De-rusted surface should be immediately converted by using phosphating treatment. It should be ensured by a suitable rinsing process that no residual acid is remaining on the surface at the time of phosphating. A typical phosphating composition of brushable consistency should have the following characteristics :

(a) Coating weight when tested as per test procedure A given hereunder should be around 4.5 gms./sq.m.

(b) Density of the product should be in the range of 1.22 to 1.4 kg/litre.

(c) Presence of fungicide shall be tested by dissolving the jelly in deionized water, the resulting solution shall be yellow in colour.

(d) Presence of phosphating chemical in jelly shall be ensured with ammonia molybdate test.

(e) pH of the composition when tested in a standard specific gravity bottle should be around 2.5 $\pm$0.1

(f) Nail scratch test should clearly leave a mark on the specimen. This indicates the existence of the coating.

5. PROCEDURE FOR INHIBITED CEMENT SLURRY COATING

5.1. A typical inhibitor admixture used should have the following characteristics:-

(i) It should in liquid form ready for mixing with the ordinary portland cement.

(ii) Specific gravity when tested using a standard specific gravity bottle should be 1.04 $\pm$0.02

(iii) pH when tested using a pH meter should be 12.75 $\pm$0.25

(iv) Tolerable limit for chloride in inhibitor - admixture when tested using anodic polarisation technique (as per test procedure B) should be 300 $\pm$ 25 ppm

5.2. Ordinary Portland Cement

This should conform to IS:269 and should be sieved to pass through 75 microns IS sieve.

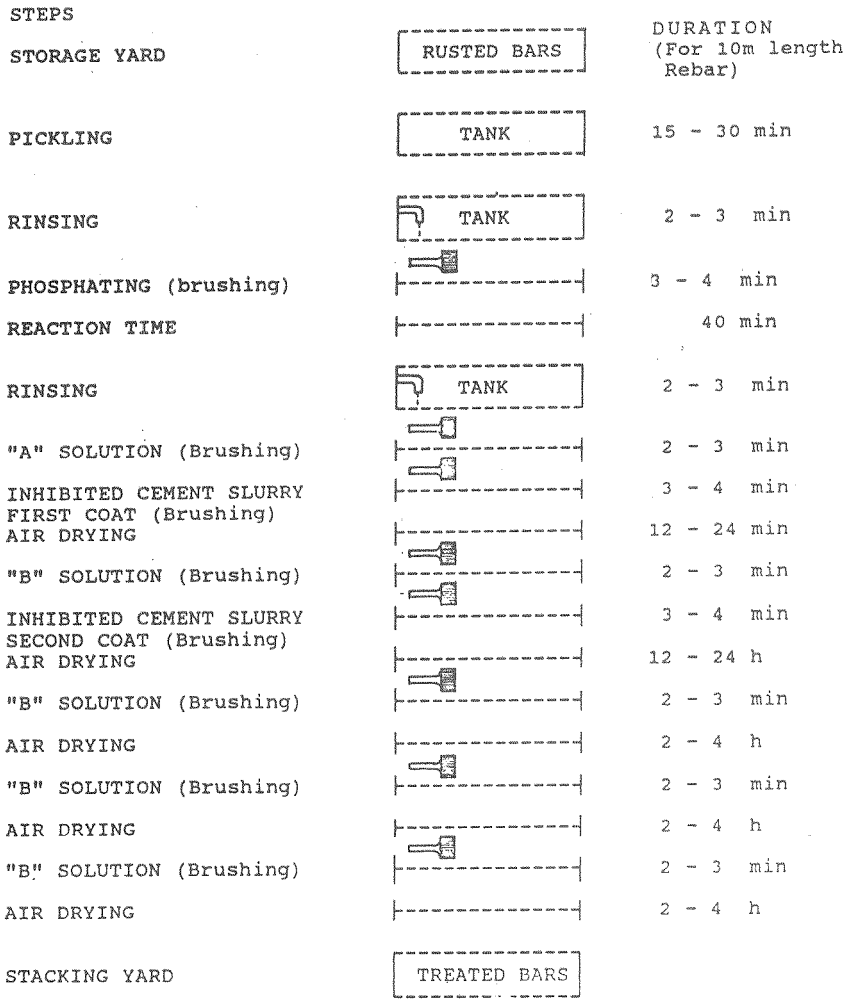


Fig. 1000/1 : Flow Diagram for Anti-Corrosive Treatment of Reinforcement Bars

5.3. Cement and inhibitor admixture should be mixed in specified proportion to have suitable consistency. Coating should be applied preferably by brushing. However, under specific circumstances spraying or dipping is also allowable.

5.4. Sufficient time lag should be allowed in between successive coatings to ensure final setting of the undercoat. A minimum of 6 to 12 hours may be necessary.

5.5 A minimum of two coats with sufficient time lag in between should be applied.

6. SEALING TREATMENT

The sealing treatment should be performed over the coated surface immediately after final setting of the top coat. Sealing treatment can be applied by brushing, spraying or dipping.

6.1. A typical sealing solution should have the following characteristics:-

(a) Specific gravity when tested using a standard specific gravity bottle should be 1.09 $\pm$0.02

(b) pH when measured using a pH meter should be 12.25 $\pm$0.25

(c) Tolerable limit for chloride in sealing solution using anodic polarisation technique should be 450 $\pm$25 ppm (as per test procedure B).

7. SPECIFICATIONS FOR FINISHED END PRODUCT

7.1. Finished coating when visually examined should be fairly uniform in thickness and should be devoid of any defects such as cracks, pinholes, peeling, bulging etc. No surface area should be left uncoated. No rust spot should be visible to the naked eye.

7.2. Thickness of the Coating

The minimum thickness of the coating shall be 200 microns. Preferable range is 200 to 400 microns.

7.3. Bond Strength of the Coated Rebar

The bond strength of the coated rebar and concrete shall not be less than that specified in IS:456 as per clause No. 0, 2, 5, 11 and 44.1.2 and tested as per IS:2770 (Part 1).

7.4. Hardness of the coating when measured using a pencil hardness tester shall be around 5 H to 7 H.

7.5. Tolerable limit for chloride in 0.04 Normal NaOH medium using anodic polarisation technique (as per test procedure B) shall be around 4500 to 5000 ppm.

7.6. No film failure as evidenced by evolution of hydrogen gas at the cathode or appearance of corrosion products at the anode shall take place during one hour of testing (as per test procedure C).

8. GENERAL REMARKS:

It is advisable that severely rusted and heavily pitted reinforcements are not accepted for treatment.

TEST PROCEDURE A

Determination of phosphate coating weight

7.5 cm x 2.5 cm or 7.5 cm x 5 cm mild steel polished and degreased specimens are to be used for this test. First the blank loss of unphosphated specimen is to be found out. For this, the initial weight (W_1) is accurately weighed. The specimen is kept immersed in the Clark's solution or patented inhibited de-rusting solution for 1 minute. The specimen is removed, rinsed

in distilled water and dried using hot air blower. The specimen is immediately weighed (W_2) The difference between W_1 and W_2 is termed as blank loss.

Another specimen (polished and degreased) is brushed with phosphating jelly and kept for 45 minutes. Then the specimen is washed free of jelly, rinsed in clean water and dried using hot air blower. The phosphated specimen (W_3) is accurately weighed. After weighing, the specimen is kept immersed in Clark's solution or patented inhibited de-rusting solution for one minute. Then the specimen is removed, rinsed in distilled water and dried using hot air blower. The specimen is immediately weighed (W_4). Coating weight = W3 - W4 - blank loss.

TEST PROCEDURE B

Anodic Polarisation Technique

Mild steel reinforcement / HYSD Bar test specimens of size 10 mm in dia and 100 mm in length with stems of size 5 mm in dia and 50 mm in length is polished, degreased and sealed at bottom edge and at the stem with suitable sealers like wax, lacquer. Then test specimen is kept immersed in test solution and potential is monitored using high impedance multimeter against suitable reference electrode such as saturated calomel electrode/ copper-copper sulphate electrode. After getting stabilised potential using appropriate current regulator (0-100 mA), the test specimen is anodically polarised at a constant current density of 290 μA cm using a platinum/ stainless steel/ TSIA/ polished mild steel reinforcement/HYSD Bar as cathode. Potential with time is followed for 5 minutes after current is applied. The maximum chloride concentration upto which the potential remains constant for 5 minutes is taken as a measure of tolerable limit.

TEST PROCEDURE C

Resistance to Applied.Voltage Test

Two mild steel reinforcement / HYSD bars of size not less than 10 mm in dia and 800 mm in length shall be given anti-corrosive treatment as per specified procedure. The end of the rebars shall be soldered with insulated copper electrical connecting wire (14 gauge) to serve as electrical contact point. Coated rebars at the two ends shall be sealed with an insulating material to a length of 25 mm at each end. Test area shall be the area between the edge of the bottom sealed end and immersion line which shall not be less than 250 mm in this case.

The coated rebars shall be suspended vertically in a non-conductive plastic container of size not less than 150 mm x 150 mm square and 850 mm high. The rebars shall be so suspended as to have a clearance of 25 mm at bottom, 45 mm at the sides and 40 mm in between the rods.

The container shall then be filled to a height of 800 mm with an aqueous solution of 7 per cent NaCl. A potential of 2 V in between the coated rods shall be impressed for a period of 60 minutes using a high resistance volt meter for direct current having an internal resistance of not less than 10 mega Ohms and having a range upto 5 V (minimum). Storage batteries may be used for impressing the voltage.

During this 60 minutes of testing, there shall not be any coating failure as evidenced by evolution of hydrogen gas at the cathode or by appearance of corrosion products of iron at the anode.