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SECTION TS 12. EPOXY RESINS

SECTION TS 12. EPOXY RESINS

12.1 SCOPE

This Specification covers the supply and application of epoxy resins as coatings, adhesives and structural systems in the construction, maintenance and repair of concrete structures.

12.2 GENERAL

The Contractor shall employ, or seek the advice of, personnel experienced in the use and application of epoxy materials in the construction of the works, and shall provide the Engineer with evidence of such experience before of commenced.

Epoxy resins may be modified by the use of flexibilisers, plasticisers, dilutants, filters, and pigments, subject to the consent of the Engineer. The choice of the proper system for a given application shall be based on the modulus of elasticity, creep characteristic, rate of heat development, and quantity of head developed during curing. The Contractor shall seek the manufacturer's guidance as to the most suitable system for the required application and shall abide by the manufacturer's recommendations as to properties of the materials to be used.

Adverse environmental conditions will severely affect the performance of the epoxy resin, and the Contractor shall schedule his work to coincide with suitable environmental, conditions or provide a favourable artificial environment at his expense.

The Contractor shall be solely responsible for the performance of the epoxy resin and its compliance with the requirements of this Specification and the Drawings.

12.3 MATERIAL

12.3.1 General

Epoxy Resins shall, unless otherwise shown on the Drawings or consented to by the Engineer, comply with the requirements of ASTM C 881 Type 1, 2 or 3 as appropriate.

The epoxy resin used for a particular job shall have properties suited for the job application as recommended by the manufacturer.

12.3.2 Definitions

For the purpose of this Specification the following definitions will apply :

Adhesive	An adhesive is a substance capable of holding solid materials together by surface attachment.
Epoxy Resin	A resinous polymer containing more than one epoxide group per molecule and which is capable of being converted to a useful thermoset form by reaction with a second component called a hardener. The converted materials are also referred to as epoxy resin.

Hardener	Chemicals resinous in form capable of reacting with epoxy groups in epoxy resins to produce a cross-linked polymer. They usually contain amine or amide groups.
Flexibilisers and Plasticisers	These are usually long chain liquid compounds added to the epoxy resin. Some react during curing to impact a degree of resilience and toughness to a normally rather rigid system. Other are non-reactive and are commonly described as plasticisers.
Fillers, extenders	These are finely divided, non-reactive inert materials added to epoxy and Pigments resins to modify certain properties such as consistency density, and colour.
Aggregates	Stable, non-reactive minerals of specified size grading, which have adequate hardness and strength. Aggregates and sands used for Portland cement concrete are usually satisfactory, but must be dust free and oven dry.

12.3.3 Physical Requirements

The epoxy resin shall not react chemically with the environment in which it is placed and shall remain stable. The curing period of the epoxy shall be such as to allowed adequate time to complete the required operations at the maximum operation temperature.

12.3.4 Sampling and Testing

Epoxy resins shall generally comply with the requirements of AASHTO M 235 'Epoxy Resin Adhesive' and/or ASTM C 881 as applicable.

At least eight weeks prior using and epoxy resin, and on request at any time during the Contract period, the Contractor shall make available an amount of epoxy material sufficient to carry out tests as determined by the Engineer. No epoxy materials shall be used until the results of the tests on samples are known and/or the Engineer gives his consent to proceed.

The Engineer may, at his discretion, arrange to take samples from each separate batch of the delivered epoxy resin. These samples shall be submitted to such test as are deemed to be necessary by the Engineer to prove their conformity with the manufacturer's advance samples and with the details given in the manufacturer's product data sheets.

12.3.5 Information to be Provided by the Contractor

- mixing directions for the base/hardener components of the system
- surface preparation needed or other conditions for use
- minimum and maximum application temperature in degrees Celsius
- curing conditions including maximum and minimum curing temperature in degrees Celsius and curing time
- percentage by mass of volatile material in the mixed resin system
- modulus of elasticity of the cured epoxy resin

- viscosity
- batch number and date of manufacture
- pot or working time for various air temperature between 5 degrees Celsius and 30 degrees Celsius
- safety precautions
- storage temperature of epoxy resin
- shelf life

12.3.6 Rejection and Replacement

If, in the opinion of the Engineer, the samples taken from the epoxy resin delivered to the work are of inferior quality to the advance samples, the Engineer may reject all material delivered to the work which, in this opinion, is represented by the samples. Rejected material shall be replaced by the Contractor at his own cost, or the Engineer may cancel the order for further supplies for the epoxy resin.

12.3.7 Test Methods

The basic procedures of the epoxy resin shall be assessed in accordance with the following Test Methods which are attached as Appendix 'A' and are an integral part of this Specification.

- Preparation of Epoxy Concrete
- Making and curing Epoxy Concrete Test Specimens for determining Compressive Strength and Flexural Strength
- Inspection and capping of Epoxy Concrete Compressive Test Specimens
- Composite Cylinder test for Evaluation of Wet-to-dry concrete adhesive
- Tensile Bond Strength of Epoxy Concrete
- Compressive strength of Epoxy Concrete.

12.3.8 Properties Prior to Curing

a. Shelf Life

The two part epoxy components shall comply with all properties specified for a minimum period of 18 months after delivery. The expiry date of the shelf shall be marked on each container.

b. Work Time

Unless otherwise consented to by the Engineer, after blending of both component parts of a 4 litre mix at 30 degrees Celsius ± 2 degrees Celsius, the viscosity of the mixture shall remain within a workable range for at least 30 minutes.

c. Hardening Time

When mixed in the proportions recommended for a project, the compressive strength of epoxy resin mortar or concrete at 24 hours after mixing and curing at 30 degrees Celsius shall be not less than 75 percent of the strength developed in 7 days at 23 degrees Celsius ± 2 degrees Celsius.

12.3.9 Properties in the Cured State

Adhesion. When tested in accordance with Test Method No. 5 the strength of the composite cylinder shall be at least 90 percent of the control specimens at 14 days.

Compressive Strength. When tested in accordance with Test Method No. 7 the compressive strength shall be not less than 70 MPa (700 kg/cm^2) at 7 days.

12.3.10 Supply

The materials shall be packed in standard commercial containers so constructed as to protect the product from contamination. The quantities of resin and hardener packed in their separate containers shall be such that when the contents of the containers are mixed the epoxy materials shall be in their required reacting ratio.

12.3.11 Safety Precautions

All personnel shall be fully instructed in the potential hazards of the material, correct use of equipment, protective clothing washing procedures, washing materials and barrier creams.

Particular care shall be taken to prevent the material from coming into contact with the skin. Before using the epoxy compound, the manufacturer's technical data shall be read with particular reference to information on protective measures.

Personnel shall be informed that toxic fumes may be emitted from epoxy compounds and adequate provision shall be made for ventilation if conditions so dictate.

12.3.12 Storage

Component of epoxy resin shall be stored at a temperature recommended by the manufacturer. Components shall not be kept for more than 18 months and shall be checked before use for signs of crystallisation.

12.4 SURFACE PREPARATION

When removal of concrete is required the removal of dust, scale, oil, grease, dirt or any foreign matter shall be achieved by grinding, abrasive blasting, jack-hammering, hand chipping, compressed air and water, or high pressure water jet. The use of hydrochloric acid may be consented to by the Engineer for selected applications.

The Contractor shall submit to the Engineer for his consent the proposed method of surface preparation. The method shall be in accordance with the relevant methods A to H inclusive of this Specification and with the consent of the Engineer. References shall also be made to AS 1627 'Metal Finishing-Preparation and pretreatment of surfaces'.

The Contractor shall be wholly responsible for adequate surface preparation prior to the application of epoxy resin.

12.4.1 Method 'A' Solvent Cleaning- Refer to AS 1627

This method shall be to remove oil, grease, wax, tar and other solvent soluble contaminants from the surface of non-porous materials. Large

quantities of contamination shall be removed by hand or power tools prior to solvent cleaning.

Suitable solvents are Petroleum Solvents, Aromatic Solvents or Chlorinated Solvents except that petrol, Benzol or Carbon Tetrachloride shall not be used due to their flammable and toxic nature.

Surfaces may be cleaned by solvents using several techniques :

- immersion in the solvent
- spraying with the solvent
- swabbing with rags or cloths
- immersion in boiling solvent vapour
- trichloroethylene using suitable equipment

Except for the last method repeated cleaning using fresh solvent shall be done for a completely clean surface.

The use of this method alone is subject to the consent of the Engineer who will usually direct that it be used in conjunction with another of the methods below.

12.4.2 Method 'B' Abrasive Blast Cleaning

Abrasive blast cleaning shall be used to prepare steel surfaces to a Class 3 standard as specified in AS 1627. Degreasing of steel surfaces shall be undertaken before abrasive blast cleaning commences. The abrasive used shall be subject to the consent of the Engineer. Abrasive blast cleaning may also be used in galvanised steel, concrete, plastics and ceramics.

Before abrasive blasting a surface, heavy rust, weld spatter or major irregularities shall be removed by mechanical means. Heavy deposits of oil, grease, wax, tar shall be removed by solvent cleaning (Method A) before abrasive blasting.

After abrasive blasting the surface shall be cleaned of any traces of any blast products by clean brushing, blowing with clean dry air or vacuum cleaning. After cleaning, the surface shall be promptly coated with the adhesive before contamination can occur.

12.4.3 Method 'C' Ferric Chloride Etching

This method shall be used to prepare copper, grass and bronze surfaces. These metals are subject to rapid surface and shall be coated with adhesive immediately after preparation.

The surface shall first be degreased by solvent washing (see Method A).

Ferric chloride solution shall be made by mixing ferric chloride, distilled water and nitric acid.

The ferric chloride shall be dissolved in the water in a glass or glazed earthenware container and then the nitric acid added with stirring.

The surface to be etched shall be immersed in the bath at 25 degrees Celsius for 1 to 2 minutes, then washed thoroughly with clean water and finally rinsed with distilled water.

12.4.4 Method 'D' Chromic Acid Etching

This method shall be used to prepare aluminium surfaces which have a tightly adherent film of inert aluminium oxide.

The aluminium shall first be degreased by solvent washing (Method A), followed by chromic acid etching.

Glass or glazed earthenware containers shall be used to hold the chromic acid solution. Eye protection and protective clothing shall be worn at all times when using chromic acid.

The Chromic Acid solution shall be made by mixing water, sodium dichromate and sulphuric acid.

The sodium dichromate shall be dissolved in the water and then the sulphuric acid added slowly with stirring. Water shall not be added to sulphuric acid as violent reaction will result.

The surface to be etched shall be immersed in the solution heated to a temperature between 60 to 70 degrees Celsius for 10 to 15 minutes. The surface shall then be washed thoroughly with clean water and finally rinsed in distilled water. After cleaning, the surface shall be promptly coated with the adhesive contamination can occur.

12.4.5 Method 'E' Hydrochloric Acid Cleaning

This method shall be used to clean sound concrete surfaces which have not been penetrated by contaminants.

If the concrete has been contaminated by oil, grease, paint, tar etc. other cleaning measures shall be adopted.

The hydrochloric acid solution of one part commercial hydrochloric acid to two parts of water by volume shall be made up in rubber, glass, glazed earthenware or plastic container. Suitable eye protection and protective clothing shall be worn when making of using this solution.

The acid shall be added to the water while constantly stirring.

The solution shall be applied to the surface of the concrete at the rate of 1 litre per square metre. When frothing ceases the surface shall be washed with water using a high pressure hose. If thorough hosing is not possible the surface shall be neutralised by washing with a weak solution of ammonia.

12.4.6 Method 'F' Preparation of Rubber Surfaces

This method shall be used to prepare rubber and neoprene surfaces.

Oil and bloom shall be removed from the surface with toluol to produce a uniform jet black appearance, then buffed with 80 grit emery paper or cloth to give a matt finish. All dust shall be removed and the adhesive applied in a uniform layer.

12.4.7 Method 'G' Preparation of Timber Surfaces

The surfaces to be joined shall be dry, sound and free from contamination by oil, grease, tars or old paint. Surface contamination and roughness shall be removed by planning and sanding. All dust shall removed.

12.4.8 Method 'H' Preparation of Bridge Decks

New bituminous road surfaces generally do not need preparation before mixing ceramic road markers. However, old surfaces which are uneven or contaminated with oil shall be prepared by one (or more) of the following methods :

• Grinding	A grinding wheel may be used to removed surface irregularities
• Burning	A burner may be used to remove oily residues
• Detergent	This mild but effective method may be used to remove
• Oily washing	Residues from bituminous surface. Neat detergent and a stiff bristle brush shall be used to clean the road surface then wash thoroughly with clean water.

12.5 MIXING

12.5.1 Mixing Equipment

All equipment and materials required for mixing of epoxy components shall be to the approval of the Engineer. All equipment shall be clean and free from harmful residue or foreign particles.

12.5.2 Mixing

Mixing shall be done in accordance with the manufacturer's directions.

The mixing of epoxy components shall in strict accordance with the manufacturer's instructions. Before any mixing is carried out, the correct proportions of components as recommended by the manufacturer shall be arranged into separate batches. All materials shall be conditioned to the temperature recommended by the manufacturer before mixing, usually 20 to 30 degrees Celsius. The base resin shall be stirred by a mixer for 10 seconds or until homogeneous prior to adding the hardener. The hardener shall then be added gradually to the base resin with constant mixing until the components are uniformly mixed.

Mixing shall be performed in a manner which will prevent frothing or air entrainment as this will considerably reduce the strength of the finished product. Mechanical mixing is preferable to hand mixing. The minimum time of mixing is five minutes.

The minimum time of mixing is five minutes.

Only small quantities (less than 1 litre) will be approved fir hand mixing.

When preparing epoxy mortars or epoxy concretes, aggregates shall be added after the epoxy components have been mixed thoroughly mixed prior to adding the next larger grade. Mixing shall then continue until a uniform mixture is produced.

All mixing shall occur as near as possible to the place of application. Mixing time shall not exceed five minutes. Part mixes will not be permitted.

12.6 METHODS OF APPLICATION

12.6.1 General

An epoxy resin shall not be applied over an epoxy application which has already hardened. No epoxy resin shall be applied until the consent of the Engineer has been obtained as to surface preparation and method of application.

12.6.2 Bonding

The epoxy resin shall be applied to the prepared surface by brush, roller, broom, squeegee, rubber gloves or spray equipment.

The epoxy resin shall be applied at a thickness to fill, with slight excess, the gap between substrate and the element to be bonded. Unless the date is available from the manufacturer the Contractor shall determine on the basis of trial joints an approximate applied rate of epoxy resin per square metre. The Contractor shall monitor the consumption of epoxy resin during the application to ascertain if significant variations occur which may indicate that either too much or too little epoxy is being applied.

Elements to be bonded shall be positioned within the contact time of the epoxy resin, as recommended by the manufacturer. If the movement of the element to be bonded is likely, the element shall be temporarily stressed or shored, within the contact time. The joint shall be checked to ensure uniform bearing and fit. Temporary fastenings or shores shall not be removed without permission of the Engineer. The joint shall not be disturbed until the epoxy resin has set.

Around cable ducts a distance of 25 mm should be kept free of epoxy resin to minimise flow into the ducts.

The Contractor shall have an experienced supervisor on site at all times during jointing operations.

Where it becomes necessary to stop work on joint after the application of epoxy resin has commenced, the Contractor shall scrape off as much of the epoxy resin as possible before it sets. The remaining hardened epoxy resin shall be removed by abrasive blasting and surface prepared according to Clause 18.4

12.6.3 Repair of Damaged Concrete

Repair of Damaged concrete shall conform to the requirements of clause 16 of this Specification.

12.6.4 Date To Be Recorded

The Contractor shall keep records of all jointing operations which shall be made available to Engineer if required.

The information recorded shall include :

- Joint number
- date and time
- weather conditions
- shade temperature
- maximum temperature of mix
- time between adding components and initial application

- time between initial application and temporary stressing of elements to be bonded, or final application of surface coatings and fillers
- volume material used

12.6.5 Environmental Restrictions

The Contractor shall comply with the manufacture's recommendations as to environmental conditions under which the epoxy resin may be applied.

Epoxy resins shall not be applied when rains falling unless a non-moisture sensitive epoxy resin used. If rain falls on applied epoxy resin before the surfaces are brought together the application shall be stopped. If it become necessary to stop work on a joint the Contractor shall scrape off as much applied epoxy resin as possible before the material sets, and prepare the surface according to Clause 18.4 before re-applying epoxy resin.

12.6.6 Temperature

When the surface and atmospheric temperatures exceed 32 degrees Celsius difficulties may be experienced in mixing and application. Work shall scheduled when the temperature is generally lower, as in the early morning hours, or the work area should be shaded from direct sunlight prior to, and during the application.

12.6.7 Clean-up

The Contractor shall protect surface beyond the limits of surface receiving the epoxy application from spillage. Any epoxy spilled or applied beyond the desired area of application shall be immediately removed, and the area affected shall be cleaned with material recommended by the manufacturer. The Contractor shall avoid contaminating the work area with the clean-up materials.

All tools and equipment should be cleaned immediately after completion of the application.

12.7 MEASUREMENT AND PAYMENT

Measurement and Payment for Epoxy Resins will not be made exclusively and all costs incurred by the Contractor in complying with the requirement of this clause shall be deemed to be included in the rates and lump sum prices entered in the priced Bill of Quantities for works which incorporate the requirements of Epoxy Resins. These shall include the entire cost of completing the work including materials, labour, equipment, transportation and any other associated costs.

SECTION TS 13. Deleted

SECTION TS 14. Deleted

SECTION TS 15. Deleted

SECTION TS 16. Deleted

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SECTION TS 17. STONE MASONRY

SECTION TS 17. STONE MASONRY

17.1 GENERAL

This section covers the general and specific requirements for the construction of the following type of masonry work:

- Wet stone masonry in retaining walls, bridge parapets, building construction, and other structures included in the Works and in places where shown on the Drawings or directed in writing by the Engineer.

17.2 MATERIALS

17.2.1 Stone

Stone for all classes of masonry shall be clean, hard, and durable. Adobe blocks shall not be used unless specified or consented to by the Engineer.

Samples of stone proposed for use in masonry construction shall be submitted to the Engineer for his consent.

Stones shall be of the sizes shown on the Drawings or appropriate for the particular application. Unless otherwise shown on the Drawings, stones shall have thickness of not less than 150 mm, widths of not less than one and a half times their respective thicknesses, and lengths of not less than one and a half times their respective widths. Each stone shall be free of depressions and projections that would prevent it from being properly bedded.

Stone shall be dressed to remove any thin or weak portions. Face stone shall be dressed to provide bed and joints lines that do not vary more than 20 mm from true lines and to ensure the meeting of bed and joints lines without the rounding of the corners of the stones in excess of 30 mm in radius. Bed surfaces of face stones shall be normal to the faces of the stones for 80 mm and from this point may depart from a normal plane by an angle which is not to exceed 50 mm in 300 mm.

Face stones shall be pitched to line along all beds and joints. The maximum projections of rock faces beyond the pitch lines shall not be more than 50 mm.

Stones shall increase in thickness from bottom to top of wall.

17.2.2 Mortar

Cement mortar shall be composed of one part of cement to three parts of fine aggregate by volume, or such other proportions as shall be directed by the Engineer, or as shown on the Drawings mixed with water so that the water-cement ratio does not exceed 0.45 by weight.

Hydrated lime may be added in an amount not exceeding ten (10) percent of the cement by weight. The hydrated lime shall comply with the requirements for type "N" lime in ASTM C 207 "Hydrated Lime".

17.3 CONSTRUCTION

17.3.1 Wet Stone Masonry Walls

17.3.1.1 General

This clause refers to the construction of wet stone masonry walls including, but not limited to, retaining walls and parapet walls.

17.3.1.2 Selection and Placing

When the masonry is to be placed on a prepared foundation bed, the bed shall be firm and normal to, or in steps normal to, the face of the wall, and shall have been approved by the Engineer before any stone is placed.

Care shall be taken to prevent the bunching of small stones or stones of the same size large stones shall be used for the bottom courses and large, selected stones shall be used in the corners.

All stones shall be cleaned thoroughly and wetted immediately before being set, and the bed which is to receive them shall be cleaned and moistened before the mortar is spread. They shall be laid with their longest faces horizontal in full beds of mortar, and the joint shall be flushed with mortar.

The exposed faces of individual stones shall be parallel to the faces of the walls in which the stones are set.

The stones shall be so handled as not to jar or displace the stones already set. Suitable equipment shall be provided for setting stones larger than those that can be handled by two men. Rolling or turning stones on the walls will not be permitted. If a stone is loosened after the mortar has taken initial set, it shall be removed, the mortar cleaned off, and the stone relaid with fresh mortar.

17.3.1.3 Beds and Joints

Beds for face stones may vary from 20 mm and to 50 mm in thickness. They shall not extend in an unbroken line through more than five stones. Joints may vary from 20 mm to 50 mm in thickness. They shall not extend in unbroken line through than two stones. They may be at angles with the vertical from 0 to 45 degrees. Face stone shall bond at least 150 mm longitudinally and 50 mm vertically. At no place shall corners of four stones be adjacent to each other.

Beds for vertical faced walls shall be level, and battered walls may vary from level to normal to the batter line of the face of the wall.

17.3.1.4 Headers

Headers shall be distributed uniformly throughout the walls of structures so as to form at least one fifth of the exposed faces. They shall be of such lengths as to extend from the front face of the wall into the backing at least 300 m. When a wall is 450 mm or less in thickness, the headers shall extend entirely from front to back face.

17.3.1.5 Backing

The backing shall be built with greater than 75 percent of stones having a minimum dimension of 200 mm. The individual stones composing the backing and hearting shall be well bonded with the stones in the face wall

and with each other. All openings and interstices in the backing shall be filled completely with mortar or with spalls surrounded completely by mortar.

17.3.1.6 Pointing

Joints not pointed at the time the stone is laid shall be thoroughly wet with clean water and filled with mortar. The mortar shall be well driven into the joints and finished with an approved pointing tool. The wall shall be kept wet while pointing is being done and in hot or dry weather the pointed masonry shall be protected from the sun and kept wet for a period of at least 3 days after completion.

After the pointing is completed and the mortar set, the wall shall be thoroughly cleaned and left in a neat and workmanlike condition.

17.3.1.7 Plastering

Plaster, if called for, shall of the same mix proportions as for mortar. Before plastering commences the surface to be plastered shall be cleaned of any dirt, grease, organic matter or any other deleterious substance. The surface shall then be wet with water. Plaster shall be applied so as to firmly key into the surface being treated. The finished surface shall be uniform in texture and regular in appearance. Flat surface shall be flat to a tolerance of 10 mm measured with a 2 m long straight edge.

17.3.1.8 Coping

Copings, if called for, shall be as shown on the Drawings. Where copings are not called for, the top of the wall shall be finished with stones wide enough to cover the top of the wall from 450 mm to 1 metre in length, and of random heights, with a minimum height of 150 mm. Stone shall be laid in such a manner that the top course is an integral part of the wall. The tops of the top courses of stone shall be pitched to line in both vertical and horizontal planes.

17.3.1.9 Weep Holes

All walls and abutments shall be provided with weep holes. Unless otherwise shown on the Drawings or directed by the Engineer, the weep holes shall be placed at the lowest points where free outlets for water can be obtained and shall be spaced not more than 2 metres centre to centre.

Weep holes shall be constructed in accordance with the requirements of Section TS 19 of the Technical Specification, Weep Holes.

17.3.1.10 Cleaning Exposed Faces

Immediately after being laid, and while the mortar is fresh, all faces stones shall be thoroughly cleaned of mortar stains and shall be kept clean until the work is completed.

17.3.1.11 Curing

The masonry shall be satisfactorily protected from the sun and shall be kept wet for a period of at least three days after completion.

17.4 MEASUREMENT AND PAYMENT

Measurement will be made of the volume of stone masonry or wet stone masonry reconstruction as the case may be, complete, in place and accepted. Projections extending beyond the faces of the walls will not be included. In computing the quantity for payment, the dimensions used shall be those shown on the Drawings or ordered in writing by the Engineer. No deductions shall be made for weep holes, drain pipe, pipe, or other openings of less than 0.01 square metres in area.

Payment will be made at the unit price entered in the priced Bill of Quantities which shall include full payment for providing all labour, materials, tools, equipment and any other works incidental to the completion of stone masonry.

Categories of work to be paid under this clause are as follows:

Description	Unit of Measurement
Wet Stone Masonry	m^3
Wet Stone Masonry Reconstruction	

SECTION TS 18. Deleted

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SECTION 19. WEEP HOLES

SECTION TS 19. WEEP HOLES

19.1 SCOPE

This section of the Technical Specification covers the general and specific requirements of Weep Holes. It shall apply wherever Weep Holes are used in the Works, such as in revetments, wall, wet stone masonry or other applications, as shown on the Drawings or specified in this and other Technical Specification clauses.

19.2 MATERIAL

Pipe:

Material for weep holes shall be 50 mm nominal diameter, black, Unplasticised Poly-Vinyl-Chloride (uPVC) conforming to the requirements of JIS K 6741. Pipe for weep holes shall be approved in writing by the Engineer before any purchase orders are placed.

Palm Fibre:

Palm fibre shall be fresh palm fibre to the Engineer's approval.

Filter Cloth

Filter cloth shall be a polyester, staple fibre, needle punched felt with a minimum mass of 250 gm/m^2 and shall comply with ASTHMA M 288 'Geotextiles used for Subsurface Drainage Purposes'.

19.3 CONSTRUCTION

Pipes for weep holes shall be cut to the required lengths as shown on the Drawings and the inner end shall be surrounded by a ball of palm fibre not less than 150 mm diameter wrapped in filter cloth. The filter cloth shall be tied firmly to the pipe with nylon twine so as to ensure that all water which will enter the pipes must pass trough the filter cloth and palm fibre filters.

Assembled units shall be placed in the work at the levels, positions and slopes shown on the Drawings taking care to ensure that filter constructed as described above remains intact and that the exposed ends on the face of the work are flush with the face of the structure through which the weep hole passes. Gravel backfill shall be carefully hand placed around inner ends of the filters ensuring that that the filter remains intact.

19.4 MEASUREMENT AND PAYMENT

Measurement will be made of the number of weep holes of the various lengths completed in accordance with the Drawings, the Specification and to the approval of the Engineer.

Payment will be made at the rate entered in the Bill of Quantities and shall include the entire cost of completing the work including materials, labour, equipment, transportation and any other associated costs.

Categories of work to be paid under this clause are as follows

Description	Unit of Measurement
Weep Hole, Dia.50mm	No.

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SECTION TS 20. ROADS AND PAVEMENTS

SECTION TS 20. ROADS AND PAVEMENTS

20.1 GENERAL

This section covers the construction of the following:

- Approach roads to the Goa Kreo Bridge,
- Paving on the deck of the Goa Kreo Bridge
- Any other roads shown in the Drawings

Owing to the small quantities of roadworks for this contract, at the sole discretion of the Engineer, manual placement of road materials may be permitted in lieu of the mechanical methods specified hereunder.

20.2 PREPARATION OF SUBGRADE

20.2.1 General

This clause specifies the requirements for the preparation of the surface on which roads are to be constructed.

20.2.2 Testing and Preparation

Where the inspection road is to be constructed on a subgrade of natural material (i.e. not on embankment), the Contractor shall check and visually inspect the subgrade for soft spots which shall be removed and replaced with suitable approved, compacted granular material. The Contractor shall check the in-situ density of the subgrade to ensure that it complies with the acceptance criteria shown below.

The acceptance criteria for the subgrade shall be :

(a) No visible soft areas and;

(b) No discernible movement during rolling with a 6 to 8 ton roller and;

(c) Compaction 90% of the maximum dry density determined according to AASHTO T 99.

No measurement or additional payment shall be made for the testing and preparation of subgrade described herein and the cost of complying with this clause shall be deemed to be included in the rates and lump sum prices in the priced Bill of Quantities.

20.3 SUB-BASE COURSE

This item comprises the supply and placement of gravel in accordance with the requirements of clause TS 2.4

20.4 BITUMINOUS PRIME COAT

20.4.1 General

This work shall consist of furnishing and applying bituminous material to a bridge deck and to the portion of the approach road to be surfaced with

asphalt concrete in accordance with this Clause and/or as directed by the Engineer.

20.4.2 Material for Prime Coat

Asphalt for the prime coat shall be cutback asphalt MC-70 conforming to the requirements of AASHTO M82 or equivalent.

20.4.3 Surface Preparation before Prime Coating

Prime coat shall be applied to the concrete deck slab of the bridge and to the road to be paved with asphaltic concrete. No application shall be made during wet weather.

20.4.4 Application of Prime Coat

(a) Immediately before applying the prime coat, the Contractor shall sweep the full width of surface to be treated to remove all dirt and other objectionable material. Asphaltic materials shall be applied at a temperature between 40.5°C and 85°C.

(a) The rate of application of the liquid asphalt shall be from 0.8 to 2.5 litre per square meter, but the exact rate shall be as directed by the Engineer.

(b) The prime coat shall be left undisturbed for at least 24 hours and shall not be opened to traffic until the prime coat has penetrated and cured sufficiently so that it will not be picked up by the wheels of passing vehicles. The primed area shall be maintained until the next course is applied. Care shall be taken that the application of bituminous material is not in excess of the specified amount; any excess shall be blotted with sand or removed as directed.

(c) All areas inaccessible to the distributor shall be sprayed manually using the device for hand spraying from the distributor.

(d) Structures and trees adjacent to the area being treated shall be protected to prevent their being spattered or marred.

20.5 ASPHALTIC CONCRETE SURFACE COURSE

20.5.1 Aggregates for Asphaltic Concrete Surface Course

(a) Coarse and fine aggregates shall be clean, hard, tough, sound particles free from decomposed material, organic matters and other deleterious substances.

(b) Coarse aggregates, which is material retained on the 2.36 mm sieve, shall consist of crushed rock, crushed gravel or a mixture of natural and crushed gravel. Not less than fifty percent (50%) by weight of the coarse aggregates retained on the 4.75 mm sieve shall have at least one fractured face.

(c) Fine aggregates, which is material passing the 2.36 mm sieve, shall consist of gravel, sand, stone screenings or a mixture thereof. Not less than fifty percent (50%) by weight of the fine aggregates shall be crushed particles. The combined aggregate shall conform to the grading shown in the following table.

Grading of Aggregates for Asphaltic Concrete

ASTM Standard Sieve	Percentage Passing by Mass			
	Coarse Aggregate	Fine Aggregate	Filler	Composite Aggregate
3/4 inch	100			100
1/2 inch	80 - 100	-	-	85 - 100
No. 4	5 - 30	100	-	40 - 60
No. 10	0 - 8	-	100	25 - 45
No. 40	-	-	90 - 100	15 - 30
No. 200	-	0 – 8	50 - 100	4 - 10

(d) When the combined grading of the coarse and fine aggregates is deficient in material passing the No. 200 sieve, additional filler material shall be added. The filler material shall consist of finely divided rock dust, hydrated lime, hydraulic cement or other suitable mineral matter and shall conform to the grading shown in the following table.

Grading of Filler

ASTM Standard Sieve	Percentage Passing by Mass
No. 30 (0.6 mm)	100
No. 50 (0.3 mm)	95 - 100
No. 200 (0.075 mm)	70 - 100

(e) The coarse and fine aggregates shall meet the following requirements:

Required Properties of Aggregate for Asphaltic Concrete

Property	Requirement	Standard
Wear by the Los Angeles Abrasion test	< 40%	AASHTO T96
Loss when subjected to five cycles of the Sodium Sulfate Soundness Test	< 12%	AASHTO T104
Sand Equivalent after all processing except for addition of asphalt cement	> 35	AASHTO T176
Liquid Limit	≤ 25	AASHTO T89
Plasticity Index	≤ 6	AASHTO T90
Amount of thin and elongated aggregates by weight	< 5%	

(f) Asphalt binder to be mixed with the aggregate shall be paving asphalt penetration grade 85-100 and shall meet the requirements of AASHTO M226, Penetration Graded Asphalt Cement.

20.5.2 Preparatory Works

Bituminous surface course shall be laid after the Engineer has approved the primed area.

20.5.3 Equipment

The equipment shall be either a batch plant or continuous mix plant of adequate capacity, co-ordinated and operated to produce a mixture which complies with the requirements of this Clause.

(a) Asphaltic Concrete Control Unit: Satisfactory means shall be provided for:

(i) Weighing, metering, or volumetric measurement of ingredients. All measuring devices shall have an accuracy of 2%.

(ii) Checking the quantity or rate of flow of asphalt concrete ingredients into the mixer.

(iii) Maintaining the specified temperature of the asphalt concrete by steam jacketing or other insulation.

(b) Control of Mixing Time: The plant shall be equipped with positive means to govern the time of mixing, which shall be the interval between the time the asphalt is spread on the aggregate and the time the same aggregate is discharged from the mixer.

(c) Preparation of Aggregates: Before being fed to the dryer, aggregates shall be separated into two or more sizes and stored separately. One storage unit shall contain aggregate of such size that eighty percent (80%) will pass Sieve No. 4 and the other unit shall contain aggregate of such size that eighty percent (80%) will be retained on Sieve No.4.

(i) Should the Contractor choose to use natural fine material, a separate storage unit for such material shall be provided in addition to the two units mentioned above. If filler is used as a separate component, it shall also be stored and measured separately and accurately before being fed into the mixer.

(ii) In placing the materials in storage or in moving them from storage to the mixer, any method which cause segregation or uncontrolled combination of materials of different grading shall be discontinued and the segregated or degraded materials:

(iii) shall be re-screened and, if necessary, passed through the dryer before being mixed; or

(iv) shall be totally wasted.

(v) Fine and coarse aggregates shall be fed into the dryer at a uniform rate and the rate of feed shall be maintained within ten percent (10%) of the amount set. Coarse and fine aggregates shall be dried and heated so that when delivered to the mixer they shall be at a temperature of ±17° C of the temperature of the asphalt being used, or as directed.

20.5.4 Job Mix Formula

The Engineer will, together with the Contractor, determine a Job Mix Formula for the asphalt concrete mixture, established among other things on

the basis of ASTM D1559, Marshall Tests, made with specified aggregates and asphalt to be used. Modifications of the Job Mix Formula shall only be made with the approval of the Engineer.

20.5.5 Preparation and Composition of the Mixture

The components shall be combined so as to produce a mixture conforming to the following tabulated composition by weight. The exact percentage of asphalt in the mix shall be based on the Job Mix Formula.

Composition of Mixture for Bituminous Surface Course

(i)Total aggregate (including filler)	92 - 95%
(ii)Asphalt	5 - 8%

20.5.6 Requirements for the Mixture

When tested according to the Marshall Method, the bituminous mixture shall conform to the requirements in the following table.

Required Properties of Bituminous Mixture

Property	Value
Minimum stability	550 kg
2.5 mm Flow	8 – 16%
Voids in total mix	5 – 7%
Aggregates voids filled with Asphalt cement	70 – 80%
Minimum dry compressive strength	1.4 MPa (14.3 kgf/cm^2)
Maximum loss in Marshall stability by submerging specimens in water at 60°C for 24 hours as compared to the stability measured after submerging in water at 60°C for 20 minutes	25%

20.5.7 Spreading and Compacting

(a) The mixture shall be spread at a temperature of not less than 107°C and all initial rolling shall be done immediately after spreading. The mixture shall not be placed on any wet surface or when weather conditions will otherwise prevent its proper handling and finishing.

The equipment used for spreading and compacting shall be subject to the approval of the Engineer and to the extent practicable considering the constricted nature of the bridge and approach road, shall be mechanical equipment.

(b) Where a course previously laid is joined to a course to be laid later, the first course shall be cut back and painted with asphalt as directed.

(c) The mix shall be compacted immediately after placing. Initial rolling with a tandem steel roller or a three-wheeled steel roller shall follow the paver as closely as possible. Immediately following the sealing of the longitudinal joints, rolling shall commence at the outside edges and progress towards the centerline. Rolling with a pneumatic-tired roller shall be done immediately behind the initial rolling. In areas too small

for the roller, a vibrating plate compactor or hand tamper shall be used to achieve thorough compaction.

(d) Rolling shall continue as long as required to attain a minimum compaction of ninety-seven percent (97%) of the Marshall density of the approved Job Mix.

Asphalt pavement shall be laid and compacted to the designated level and traverse slopes as shown on the Drawings.

20.5.8 Required Density

(a) The density after compaction shall be determined by taking cores from the various courses and testing them in accordance with either:

(vi) ASTM Method of Test D1188, "Bulk Specific Gravity of Compacted Bituminous Mixtures Using Paraffin-Coated Specimens"; or

(vii) ASTM Method of Test D2726, "Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surfaces Dry Specimen", whichever is applicable.

(b) The compacted pavement shall have a density of not less than ninety percent (90%) of the density of a laboratory specimen prepared in accordance with the Marshall Test.

20.5.9 Tolerances

Tolerances for Asphalt Pavement

Feature	Tolerance
Permitted variation from thickness of layer	± 5 mm
Permitted variation from design level of surface	+ 5 mm - 5 mm
Permitted surface irregularity measured by 3-m straightedge	± 6 mm
Permitted variation from design crossfall or camber	± 0.2%

20.6 MEASUREMENT AND PAYMENT

Subgrade Preparation

Measurement and payment is not applicable to this item. All costs for complying with the specification for subgrade preparation shall be deemed to be included in other rates in the priced Bill of Quantities.

Sub-Base Course (Gravel)

Gravel shall be measured and paid for under section TS 2

Bituminous Prime Coat

Measurement and payment is not applicable to this item. All costs for complying with the specification for bituminous prime coat shall be deemed to be included in the rate for asphaltic concrete.

Asphaltic Concrete

Measurement will be made of the mass in tonne (1 tonne = 1000 kg mass) of asphaltic concrete surface course placed to the lines, grades and dimensions as shown on the Drawings or directed by the Engineer and

approved by the Engineer. Materials placed outside the design limits shown on the Drawings shall not be measured for payment.

Payment shall be made at the rate entered in the priced Bill of Quantities which shall be full compensation for the cost of materials labour, tools, equipment and incidental items (including the cost of bituminous prime coat where asphalt concrete) necessary to complete the Works in accordance with the Specifications and instructions by the Engineer.

Categories of work to be paid under this clause are as follows:

Description	Unit of Measurement
Asphaltic Concrete	tonne

SECTION TS 21. Deleted

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SECTION TS 22. MINOR METAL WORK ITEM

SECTION TS 22. MINOR METALWORK ITEMS

22.1 GENERAL

22.1.1 Scope

This section covers the designing, manufacturing, transporting, installing, coating and other common requirements incidental to all metal works to be furnished under the Contract. The metal works herein specified shall mean steel works such as handrails, bridge expansion joints, etc., as shown on the Drawings or as directed by the Engineer.

22.1.2 Submittals

The Contractor shall prepare shop drawings showing complete details, sections and plans of all parts, assemblies, materials lists, components, connections and supports, and relations to the structures based on the Drawings. The shop drawings are subject to approval by the Engineer in accordance with Clause 1.4.3. of the General Specification

22.1.3 Standards

Unless otherwise specifically provided in this Specification, the metal works shall be manufactured, fabricated and installed in accordance with the latest provisions of JIS, or other equivalent standards approved by the Engineer.

All materials to be furnished by the Contractor shall be new and shall have the best quality of their respective kinds.

Unless otherwise specified in this Specification, all materials and methods of fabrication shall conform to the standards listed in the following table.

Standards for Metalwork

Item	Standard
Structural Steel	ASTM A36, JIS G3101 or JIS G3106
Structural Steel Pipe	ASTM 122 or JIS G3444
Steel Pipe	JIS G3452
Bolt and Nut	ASTM A307 Grade A or JIS B1180
Arc Welding Electrode	AWS, JIS Z3211

22.2 FABRICATION AND CONSTRUCTION

22.2.1 General

The Contractor shall be responsible for the correctness and completeness of the shop drawings and for shop fit and field connections. The work shall be shop-fitted and shop-assembled as practicable as possible, conforming to the details on the approved shop drawings.

Where necessary, metals shall be insulated to prevent electrolysis due to contact between dissimilar metals and to prevent corrosion due to contact between metals and masonry or concrete. Insulation shall be by means of bituminous paint or other approved means.

All fastening, anchors and accessories required for fabrication and erection shall be provided by the Contractor. Exposed fastenings shall be kept to an absolute minimum, evenly spaced and neatly set out. Wood plugs will not be permitted.

Workmanship in fabrication shall conform to the best modern shop and field practice. All joints and intersecting members shall be accurately fitted and all works shall be fabricated on true planes with adequate fastenings.

22.2.2 Welding

Welding shall be carried out in accordance with the requirements of the American Institute of Steel Construction (AISC) or approved equivalent and shall conform to the standard code of the American Welding Society or equivalent approved by the Engineer.

The Contractor shall submit, for approval, details of the experience and qualifications of proposed welders. The welders shall have sufficient experience and qualifications for welding work and hold certificates issued by "Balai Latihan Kerja, Departemen Tenaga Kerja (Employment Training Centre, Department of Labour)" or other training course approved by the Engineer.

All welds shall be visually inspected by the Engineer and shall be subject to his approval.

When so directed by the Engineer, welds shall be tested by radiographic tests specified in JIS 3104 or other testing method approved by the Engineer.

Field welding shall not normally be permitted. However, when expressly authorised by the Engineer it shall not be performed under adverse weather conditions of rain, temperature, moisture and wind unless the welding work is protected in a manner approved by the Engineer.

Welding electrodes shall conform to the requirements of JIS Z3211 to Z3212 or equivalent approved by the Engineer.

Welds disapproved by the Engineer shall be chipped out to sound metal, tested and repair-welded and subject to the Engineer's approval using a procedure approved by the Engineer prior to carrying out the repair

22.2.3 Protective Treatment of Metalwork

All minor metalwork shall be galvanised in accordance with the following:

All galvanizing shall be by the hot dip galvanizing process in accordance with the requirements of AASHTO M 111 (ASTM A 1230 "Zinc (Hot Galvanized) Coatings", AASHTO M 232 (ASTM A 153) "Zinc Coating (Hot-Dip) on iron and Steel Hardware" and this Clause.

Surface Preparation

Steelwork shall be pre-cleaned in accordance with the requirements of AS 1627 Part 1 or equivalent standard followed by acid pickling in accordance with the requirements of AS 1627 Part 5 or equivalent standard.

All weld spatter, slag, burrs, loose rust and mill scale and other foreign substances shall be removed by either sand or shot or grit-blasting to "Near-White metal" under "Sa 2 1/2" of Swedish Standard SIS 055900 or SSPC-SP10 of Steel Structures Painting Council Manual Volume 2.

Surface contaminants and coatings which cannot be removed by the normal

chemical cleaning process in the galvanizing operation shall be removed by abrasive blast cleaning or some other suitable method.

Galvanizing

All articles to be galvanized shall be handled in such a manner as to avoid any mechanical damage and to minimise distortion.

Galvanising parameters such as galvanizing temperature, time of immersion and withdrawal speed shall be chosen to suit the requirements of the article being galvanised.

The composition of the zinc in the galvanising bath shall be not less than 98.0% zinc.

Coating Requirements

Thickness:

The thickness of the galvanized coating shall conform with the table below:

Products	Minimum average coating on any individual tests area	
	Coating Mass (Gram/sq.m)	Equivalent Thickness (Micron)
Steel 5 mm thick and over	600	84
Steel under 5 mm thick but not less than 2 mm	450	63
Steel less than 2 mm thick	350	49
Centrifuged work	300	42

The thickness of the galvanized coatings of threaded fasteners shall conform with the table below:

Minimum Average		Minimum Individual	
Coating Mass (Gram/sq. m)	Equivalent Thickness (Micron)	Coating Mass (Gram/sq.m)	Equivalent Thickness (Micron)
375	52	300	42

Actual thicknesses shall be measured by a suitable thickness meter. Should any doubt arise, as to the quality of galvanizing, tests shall be carried out in accordance with AASHTO T 65 'Tests for Weight of Coating on Zinc-Coated (Galvanised) Iron or Steel Articles or ASTM E 376 'Measuring Coating Thickness by Magnetic Field or Eddy Current (Electromagnetic Test Methods).

Surface Finish

The galvanized coating shall be continuous, adherent, as smooth and evenly distributed as possible, and free from any defect that is detrimental to the stated and use of the coated article. On silicon killed steels, the coating may be dull grey, provided that the coating is sound and continuous.

The integrity of the coating shall be determined by visual inspection and coating thickness measurements.

Where slip factors are required to enable high strength friction grip bolting where shown, these shall be obtained after galvanizing by suitable mechanical treatment of the mating surfaces.

Where a paint finish is to be applied to the galvanized coating, all spikes shall be removed and all edges shall be free from lumps and runs.

Adhesion

The galvanized coating shall be sufficiently adherent to withstand normal handling during transport and erection. The Engineer may test the adhesion in accordance with AASHTO M 111 (ASTM A 123).

Passivation

Galvanized reinforcing bars and ferrules shall be passivated in a 2% sodium dichromate solution applied by the galvanizer.

Transport and Storage

Galvanized components shall, wherever possible, be transported and stored under dry, well ventilated conditions to prevent the formation of wet storage staining.

A chromate passivation treatment after galvanizing may be used to minimise the wet storage staining which may occur on articles unable to be stored in dry, well ventilated conditions.

Any wet storage staining shall be removed by the galvanizer if formed prior to leaving the galvanizer's plant. Provided that the coating thickness complies with the requirements of AASHTO M 111 (ASTM A 123), no further remedial action shall be required to the stained areas.

22.2.4 Check Sheets

At least seven (7) days before placing concrete in any structure or installing any metal work, the Contractor shall submit, for approval, three (3) copies of an approved checkout sheet detailing all items of metalwork to be installed including unit masses and dimensions for materials to be furnished and installed and receipted invoices or other approved documentary evidence detailing the mass of any item which has been furnished and installed.

22.2.5 Installation

Metal works to be embedded in concrete shall be embedded when the concrete is being placed or, if shown on the Drawings or directed by the Engineer, recesses or blockouts shall be made in the concrete and the metalwork shall be grouted in place using cement or embedded in second-stage concrete.

The surfaces of all metal works to be in contact with concrete shall be thoroughly cleaned immediately before the grout or concrete is placed.

Metal works shall be accurately positioned and aligned in the locations as shown on the Drawings, and shall be held securely in the correct position during placing and setting of the concrete.

Where it is impracticable to place anchors or anchor bolts required for the installation of metal work when the concrete is placed, holes shall be drilled into the concrete after the concrete has set for 28 days and expansion bolts, adhesive anchor bolts, or other approved anchors shall be installed.

Field welding, cutting or drilling of prefabricated galvanised metalwork items shall not be permitted without the written approval of the Engineer.

22.3 MEASUREMENT AND PAYMENT

22.3.1 Handrails

Measurement shall be made of the mass of steel handrails completed and installed and approved by the Engineer.

Payment shall be made at the rate entered in the priced Bill of Quantities which shall be full compensation for the cost of all materials, labour, equipment and incidental costs for completing the handrail in accordance with the Drawings and the Specification.

Categories of work to be paid under this clause are as follows:

Description	Unit of Measurement
Hand Rail	kg

22.3.2 Expansion Joint

Measurement shall be made of the length of expansion joint installed and approved by the Engineer.

Payment shall be made at the rate entered in the priced Bill of Quantities which shall be full compensation for the cost of all materials, labour, equipment and incidental costs for completing the expansion joint in accordance with the Drawings and the Specification.

Categories of work to be paid under this clause are as follows:

Description	Unit of Measurement
Expansion Joint	m