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SECTION TS 15. STEEL SHEET PILES

SECTION TS 15. STEEL SHEET PILES

15.1 GENERAL

This section covers the supply and driving of steel sheet piles

The handling and driving of steel sheet piles shall be in accordance with the requirements of Section TS 13 of this Specification except as modified hereunder.

The steel sheet piles to be furnished and driven in this contract are for seepage control and are not required to be driven to criteria based on bearing capacity.

15.2 MATERIALS

Steel sheet pile shall be of U-shape type with a yield point strength of 30 kgf/mm^2 or more as specified in JIS A5528 or equivalent approved by the Engineer. Type and sectional properties of steel sheet pile shall be as tabulated below. The material used for sheet pile shall be Type II as shown on the Drawings or directed by the Engineer.

Type of Steel Sheet Pile

Type	Width (mm)	Height (mm)	Thickness (mm)	Section Modules (cm^3)
Type I	400	85	8.0	88
Type II	400	100	10.5	152
Type III	400	125	13.0	223
Type IV	400	170	15.5	362
Type V	400	200	24.3	520

All piles shall be supplied by the Contractor

15.3 HANDLING, TRANSPORT AND STORAGE

Handling, transport and storage shall be as specified in Section TS 13

15.4 DRIVING OF PILES

15.4.1 General

Piles shall be driven generally in accordance with the requirements of Section TS 13 of this Specification except as modified below.

Only piles which have been inspected and passed by the Engineer shall be driven. Any pile which shows any defect which, in the opinion of the Engineer, would affect the driveability or durability of the pile will be rejected and shall not be used anywhere in the work.

15.4.2 Test Piles

Test piles are not required for steel sheet piles.

15.4.3 Driving Steel Sheet Piles

Steel sheet piles be pitched and driven accurately in the positions shown on the Drawings and to the required depths as directed by the Engineer.

The piles shall be pitched inside a braced template and carefully aligned and positioned before driving. Particular care shall be taken to ensure the interlocking of adjacent sheet piles. The piles shall then be driven to the required penetration in such a manner as to ensure that the vertically of the piles is maintained. In the event of any misalignment developed during driving, the Contractor shall take appropriate action to correct the condition during driving.

Piles driven in excess of 10 mm, per meter of pile length or damaged during driving may be rejected, if, in the opinion of the Engineer, the improperly aligned or damaged pile adversely affects the structure. The Contractor shall propose the corrective measures to be taken for approval by the Engineer. All corrective measures shall be at the Contractor's own expense. Rejected piles shall be expected, re-driven or placed or cut-off at all a level approved by the Engineer.

Pile shall be extended by full penetration butt welds in accordance with clause 13.4.7 of the Technical Specification.

15.5 MEASUREMENT AND PAYMENT

Measurement shall be made of the length of steel sheet piles in place and accepted by the Engineer. The length measured shall include the length of any portion cut off as the result of the specified length of pile not being driven to the toe elevation as shown on the Drawings following a directive of the Engineer to cease driving for whatsoever reason.

Payment for steel sheet piles will be made at the rate entered in the priced Bill of Quantities which shall be full compensation for materials, labour, tools, equipment including furnishing, handling, pitching, driving and cutting and all other items for completing the work in accordance with the specification.

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

Description	Unit of Measurement
Furnishing and Driving Steel Sheet Pile, Type II	m

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SECTION TS 16. TIMBER PILES

SECTION TS 16. TIMBER PILES

16.1 GENERAL

This section covers the requirements for timber log piles to be driven as part of foundations in various parts of the Works.

16.2 MATERIALS

Timber piles shall be cylindrical logs cut from timber with recognised qualities of durability and suitability for installation as piles in wet conditions. The Contractor shall propose timber of a type or species for the Engineer's approval prior to procuring timber pile material. Logs shall be straight to a tolerance of 20 mm over their full length and shall be free of branches. The diameter of the thinnest part of any pile shall not be less than 150 mm and not shorter than the length specified on the drawings. All logs shall be treated with creosote using a method subject to the Engineer's approval. Any log not complying with the above requirements shall be removed from the site.

16.2 HANDLING

Timber piles shall be kept in neat stacks on site until ready for use. Handling shall be conducted in such a manner so as not to damage the integrity and strength of the piles.

16.3 DRIVING

Timber piles shall be pitched and driven accurately in the position and at the location shown on the Drawings and to the required depths as directed by the Engineer. During driving operations, timber pile heads shall be protected and held in position by use of a combination creation-driving head and pilot.

Timber piles shall be fresh-head and square and, when directed by the Engineer, the pile heads shall be protected by means of heavy steel or wrought iron rings. The driving head shall closely fit the top of the timber pile and shall extend down the sides of the pile at least 75 mm. During driving operations, each pile shall be restrained from lateral movement and the pile shall be kept moving by continuous operation of the hammer. If the specified penetration has not yet been reached when the energy required to continue driving is endangering the pile integrity the driving may be discontinued with the approval of the Engineer. Piles driven materially out of line and position as indicated on the Drawing shall be pulled and replaced. Deviations in the excess of 200 mm out of position and 2 percent out of plumbness or batter indicated on the Drawings shall be cause for rejection.

Cutting off and trimming of timber piles shall be done at the designated elevations. Splicing of timber piles shall not be permitted except when approved by the Engineer in writing. Piles inaccurately cut off shall be replaced. The sawn heads of all treated piles which are not embedded in concrete shall be brush-coated with 3 applications of hot creosote and covered with hot roofing pitch. The sawn heads of all treated piles to be encased in concrete need not to be treated further.

16.4 MEASUREMENT AND PAYMENT

A count shall be made of the number of timber piles of each designated length, in place and installed in accordance with the specification then that total multiplied by the nominal length of pile specified on the Drawings.

Payment for timber piles will be made at the rates entered in the priced Bill of Quantities which shall be full compensation for materials, labour, tools, equipment including furnishing, handling, pitching, driving and cutting and all other items for completing the work in accordance with the Specification.

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

Description	Unit of Measurement
Log Pile, Dia. 150 mm L=2.0 m	m
Log Pile, Dia.150 mm, L=3.0m	m
Log Pile, Dia. 150mm, L=4m	m

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SECTION TS 17. STONE MASONRY

SECTION 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 flood walls, revetment construction of various types, retaining walls, ground sills, channels, dikes, drainage structures, stairways and other structures included in the Works and in places where shown on the Drawings or directed in writing by the Engineer.
- Stone facing in revetments.
- Rip Rap.

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 to be used in wet stone masonry revetments shall be regular is size and their thickness shall be approximately 200 mm.

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

17.3.2.1 General

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

17.3.2.2 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.

17.3.2.3 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.

17.3.2.4 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.

17.3.2.5 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.

17.3.2.6 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.

17.3.2.7 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.

17.3.2.8 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.

17.3.2.9 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 18 of the Technical Specification, Weep Holes.

17.3.2.10 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.

17.3.2.11 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.

17.3.2 Wet Stone Masonry for Revetment Facing

17.3.2.1 General

This clause refers to the use of wet stone masonry for surface protection construction in revetments or where otherwise required to complete the Works.

17.3.2.2 Preparation

The gravel bed shall be completed to the approval of the Engineer prior to placing wet stone masonry.

All concrete work around the perimeter of the intended wet stone masonry work shall be completed to the satisfaction of the Engineer prior to commencing wet stone masonry.

17.3.2.3 Selection and Placing

All stones shall be cleaned thoroughly and wetted immediately before being set, and the gravel 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 revetment face in which the stones are set and the pattern shall be regular.

The stones shall be so handled as not to jar or displace the stones already set.

17.3.2.4 Beds and Joints

Beds for stones may vary from 20 mm and to 50 mm in thickness. At no place shall corners of four stones be adjacent to each other.

17.3.2.5 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 gaps between stones with a pointing tool. Stones shall be proud of the pointed mortar by approximately 30 mm. 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.

17.3.2.6 Weep Holes

Weep holes shall be constructed at the locations as shown on the Drawings or as directed by the Engineer in accordance with the requirements of Section 18, Weep Holes.

17.3.2.7 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.

17.3.2.8 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.

17.3.3 Chipping of Existing Masonry

17.3.3.1 General

This clause refers to the chipping back of the surface of existing plastered masonry walls in order to prepare them for joining new masonry to the old.

17.3.3.2 Method of Execution

All plastering shall be chipped back as shown on the Drawings in order to expose clean stonework of the existing masonry structure.

The chipped surfaces of existing masonry against which new masonry is to be placed shall be brushed clean, and wetted with water . New masonry shall not be placed until the prepared surface of the existing masonry has been inspected and approved by the Engineer.

Masonry extensions to prepared surfaces shall be laid in accordance with the specification for new stone masonry above.

17.4 MEASUREMENT AND PAYMENT

Wet Stone Masonry

Measurement will be made of the volume of stone masonry 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.

Pointing

Measurement will be made of the area of the surface of wet stone masonry in which the mortar has been pointed and accepted. The area measured will be the gross area which includes stone and pointed mortar. No deduction shall be made for the areas occupied by stone, weep holes or openings less than 0.01 square metres.

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 pointing.

Cement Mortar Plastering

Measurement will be made of the area of the surface of wet stone masonry which has been plastered and accepted. No deduction shall be made for the areas occupied by stone, weep holes or openings less than 0.01 square metres.

Payment will be made at the rate 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 plastering.

Chipping of Existing Dike Surface

Measurement will be made of the area of plaster and mortar chipped from the surface of existing dike surface in accordance with the specification.

Payment will be made at the rate 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 completing plastering of the work.

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

Description	Unit of Measurement
Wet Stone Masonry	m3
Pointing	m2
Pointing	m2
Chipping of Existing Dike Surface	m2

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SECTION TS 18. GABIONS AND MATTRESSES

SECTION TS 18. GABIONS AND MATTRESSES

18.1 GENERAL

This section of the Technical Specification covers the requirements for Gabions and Gabion Mattresses (also known as reno mattresses).

Gabions shall be flexible galvanised wire boxes of the size stated in the Drawings, fabricated of wire mesh of the type and size, and selvedged as specified as specified below. Each gabion shall be divided by diaphragms into cells whose length shall not be greater than the width of the gabion plus 100 mm except in the case of reno mattresses where the diaphragms shall have a maximum spacing of 600mm.

18.2 MATERIAL REQUIREMENTS

18.2.1 Gabion Wire Mesh Baskets

Wire

Wire used in the fabrication of gabions and in the wiring operations during construction shall conform to AASHTO M 279 (ASTM A 116) having a tensile strength of not less than 350 MPa (3500 kg/cm^2). The minimum weight of zinc coating shall be 250 g/m^2.

The adhesion of the zinc coating to the wire shall be such that when the wire is wrapped six turns around a mandrel of four times the diameter of the wire, it shall not crack to such an extent that any zinc can be removed by rubbing with the bare fingers.

Where shown in the Drawings or shown in the Bill of Quantities, wire, galvanized as specified above, shall be coated with PVC in accordance with the manufacturer's recommendations.

Manufacture

The mesh shall be hexagonal woven mesh wherein the joints are formed by twisting each pair of wires through three half turns. The diameter of the wire shall be as shown on the drawings but not less than 3 mm for body wire, 3.9 mm for perimeter wire and 2.4 mm for tying and connecting wire.

The undisturbed size of the mesh shall be as shown on the drawings but shall not be greater than 80 mm by 100 mm. The tightness of the twisted joints shall be such that a force of not less than 1.75 kN pulling on one wire is required to separate it from the other wire when each wire is prevented from turning and the wires and the applied force are in the same plane.

The wire mesh shall have elastic properties sufficient to permit elongation of the mesh equivalent to a minimum of 10% of the length of the section of mesh under test without reducing the gauge or tensile strength of individual wire strands to values less than those for a similar wire one gauge smaller in diameter.

All edges of the gabions, diaphragms and end-panels except as stated below shall be selvedged with a wire of which the diameter is 25% greater than that of the wire used to form the mesh. Where the selvedge is not woven integrally with the mesh but has to be fastened to the cut ends of the mesh, it shall be attached by binding the cut ends of the mesh, so that a force of not less that 8.5 kN applied in the same plane as the mesh, at a

point on the selvedge of a mesh sample of length one (1) metre is required to separate it from the mesh.

The diaphragms and end-panels shall be selvedged on the top and vertical sides only. The end panels shall be attached by twisting the cut ends of the mesh at the bottom of the panel about the selvedge on the base of the gabions. Similarly, the diaphragms shall be attached by twisting the cut ends of the mesh to the twisted joins of the mesh of the gabions. In each case the force required to separate the panels from the base shall not be less than that required to break the mesh over the same length.

Sufficient binding and connecting wire shall be supplied with the gabions to perform all the wiring operations to be carried out in the construction of the gabion work as stated below. The diameter of the binding wire shall not be less than 2.20 mm.

Tolerances

A tolerance on the diameters of all wire of + or – 2.5 % shall be permitted. The length of the gabions is subject to a tolerance of + or – 3 % and the width of gabions to a tolerance of + or – 25 mm. All other gabion dimensions are subject to a tolerance of + or – 3% of the sizes shown on the Drawings.

18.2.2 Stone Fill

Stone fill material shall consist of hard, durable stone of minimum dimension 100 mm and maximum dimension of 250 mm.

18.3 CONSTRUCTION

Gabions and Gabion Mattresses

Prior to constructing gabions the bed on which they are to be placed shall be cut to the lines and profiles as shown on the Drawings.

The placement of the gabion boxes shall be carried out in an orderly manner so that a face of incomplete work is maintained.

At least two rows of empty boxes shall be wired together at the face of uncompleted work prior to filling the box closest to the completed work. Prior to filling any box, one end or side of the box shall be secured to completed works or to stakes driven into the ground at the corners or in any other approved manner and the opposite end, side or corner shall be stretched with crow bars and secured to and bottom in a suitable manner.

Stone fill material shall be placed carefully in order to ensure that it is tightly packed with a minimum of voids. The boxes shall be filled to between 25 mm and 50 mm above their tops. The top layer of material shall consist of selected small stone not less than 100 mm minimum dimension.

18.4 MEASUREMENT AND PAYMENT

Gabion Mattresses

Measurement shall be made of the volume of gabion mattresses in place and accepted by the Engineer.

Payment shall be made at the rate entered it the priced Bill of Quantities which shall be full compensation for the cost of materials labour, tools, equipment and incidental items necessary to complete the Works in accordance with the Drawings, the Specification and instructions by the Engineer.

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

Description	Unit of Measurement
Gabion Mattress t=500mm (Galvanized)	m^3

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SECTION TS 19. WEEP HOLES

SECTION 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 20. ROADS AND PAVEMENTS

20.1 GENERAL

This section covers the construction of pavements for the following categories of roads:

Inspection Roads

Where inspection roads are constructed in new areas they shall consist of concrete paving blocks on sand bedding with concrete kerbs and with sub-base and base course as shown on the Drawings.

Where Inspection roads are constructed over existing pavements they shall consist of concrete paving blocks on sand bedding with concrete kerbs as shown on the Drawings.

Other Roads

Other roads shall be constructed as shown on the Drawings and shall have asphalt surfacing

Bridge decks shall have asphalt concrete surfacing

20.2 PREPARATION OF SUBGRADE

20.2.1 General

This clause specifies the requirements for the preparation of the surface on which inspection 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 :

i) No visible soft areas and;

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

iii) 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 granular sub-base material in accordance with the following:

20.3.1 Materials

Aggregates for sub-base shall consist of hard, durable particles or fragments of crushed stone, crushed slag, or crushed or natural gravel and filler of natural or crushed sand or other finely divided mineral matters. The composite material shall be free from organic matters and lumps or balls of clay, and shall be of such nature that can be compacted readily to form a firm, stable sub-base.

Materials for sub-base shall conform to the requirements for Class B sub-base as specified below or directed by the Engineer.

Grading Requirements of Sub-Base Course Class B

AASHTO Designation No.	Percentage Passing by Weight
2 inch	100
1 1/2 inch	70 - 100
1 inch	55 - 85
3/4 inch	50 - 80
3/8 inch	40 - 70
No. 4 (5 mm)	30 - 60
No. 10 (2 mm)	20 - 50
No. 40 (0.4 mm)	10 - 30
No. 200 (0.074 mm)	5 - 15

The percentages passing the various sieves are subject to appropriate correction by the Engineer when aggregates of varying specific gravities are used.

Other Requirements of Sub-Base Course Class B

Liquid Limit (AASHTO T89)	25 max
Plasticity Index (AASHTO T91)	6 max.
Sand Equivalent (AASHTO T176) :	25 min.
Loss by Abrasion of particles retained on ASTM No. 12 sieve (AASHTO T96) :	40% max.
Soaked CBR at the required density (100% of the maximum dry density according to AASHTO T180) :	60% max.

20.3.2 Placing and Spreading

(a) Sub-base material shall be placed as a uniform mixture on the prepared subgrade in a quantity which will provide the required compacted thickness. When more than one layer of sub-base material base is required, each layer shall be shaped and compacted before the succeeding layer is placed. When uniformly mixed, the sub-base

material shall be spread to the required thickness as shown on the Drawings or as directed by the Engineer.

(b) Sub-base material shall be distributed in a continuous uniform layer or windrow of such size that, when spread and compacted, the finished layer shall be equal to or slightly greater than the nominal thickness of sub-base shown on the Drawings.

(c) When hauling is done over previously placed sub-base material, hauling equipment shall be dispersed uniformly over the entire surface of the previously constructed layer to minimise rutting or uneven compaction.

(d) Where the required thickness is 150 mm or less, the material may be spread and compacted in one layer. Where the required thickness is more than 150 mm, sub-base material shall be spread and compacted in two or more layers of approximately equal thickness, and the maximum compacted thickness of any one layer shall not exceed 150 mm. All subsequent layers shall be spread and compacted in a similar manner.

(e) The moisture content of sub-base material shall be adjusted before compaction by watering with approved sprinklers mounted on trucks or by drying out, as required, in order to obtain the required compaction.

20.3.3 Compacting the Sub-base

(a) Immediately after each layer of the sub-base has been spread, the full width shall be compacted by approved compaction equipment. Compaction shall progress gradually from the sides to the centre, parallel to the centreline of the road, and shall continue until the whole surface has been compacted. All irregularities or depressions that develop shall be corrected by loosening material at these places and adding or removing material until the surface is smooth and uniform. At all places not accessible to the compaction equipment, the sub-base material shall be compacted thoroughly with approved tampers or compactors.

(b) Each layer of the sub-base shall be compacted to a density of at least one hundred percent (100%) of the maximum dry density determined in accordance with AASHTO T180, Method D. In-situ density of the compacted sub-base shall be measured in accordance with AASHTO T191 at the location directed by the Engineer.

20.3.4 Tolerances

Tolerances for the sub-base course shall be as specified in the following table:

Tolerances for Sub-Base Course:

Feature	Tolerance
Permitted variation from thickness of layer	± 20 mm
Permitted variation from design level of surface	+ 10 mm - 20 mm
Permitted surface irregularity measured by 3-m straightedge	20 mm
Permitted variation from design crossfall or camber	± 0.3%
Permitted variation from design longitudinal grade over 25 m in length	± 0.1%

20.4 BASE COURSE

This item comprises the supply and placement of granular base course material in accordance with the following:

20.4.1 Materials

Aggregate for base course shall consist of hard, durable particles or fragments of stone or gravel crushed to the size and of the quality requirements of this Clause. It shall be clean and free from organic matters, lumps or balls of clay and other deleterious substances. The material shall be of such nature that it can be compacted readily to form a firm, stable base.

All base course aggregate shall conform to the following physical requirements:

Physical Requirements of Base Course Material

(i)	Toughness (ASTM D3)	6 min.
(ii)	Loss by Sodium Sulphate Soundness Test (AASHTO T104)	10% max.
(iii)	Loss by Magnesium Sulphate Soundness Test (AASHTO T104)	12% max.
(iv)	Loss by Abrasion after 100 revolutions (AASHTO T96)	10% max.
(v)	Loss by Abrasion after 500 revolutions (AASHTO T96)	40% max.
(vi)	Thin and elongated pieces, by weight (pieces larger 1 inch., with thickness less than 1/5 of length)	5% max.
(vii)	Soft fragments (AASHTO T189)	5% max.
(viii)	Clay lumps (AASHTO T112)	0.25% max.

Aggregate for base course shall conform to the requirements of Class A as specified herein. Crushed gravel or rock fragments for base course Class shall consist of the product obtained by crushing gravel or rock, which, if

percent (80%) by weight of the coarse aggregate shall be of particles having at least one fractured face.

Class A base course material shall be crushed rock or crushed gravel conforming to the following grading requirements:

Grading Requirements for Base Course Class A

AASHTO Designation No.	Percentage Passing by Weight
2 1/2 inch	100
2 inch	90 - 100
1 1/2 inch	35 - 70
1 inch	0 - 15
1/2 inch	0 - 5

Blending material for Class A base shall be quarry screenings or natural sand of suitable binding quality as approved by the Engineer. Blending material shall be free from foreign or organic matter, dirt, shale and clay lumps or other deleterious matter and shall conform to the following requirements:

Grading Requirements of Blending Materials for Base Course Class A

AASHTO Designation No.	Percentage Passing by Weight
3/8 inch	100
No. 4 (5 mm)	85 - 100
No. 100 (0.15 mm)	10 - 30
Plasticity Index (AASHTO T90)	6 max.
Sand Equivalent (AASHTO T176)	30 min.

The percentage of crushed aggregate composed of elements having at least one fractured face shall be at least eighty percent (80%) by weight of the material retained on sieve No. 4.

20.4.2 Spreading and Compacting

The course and fine components of the base course material shall be mixed in proportions as directed by the Engineer

Base course material shall be spread and compacted in the same manner as specified above for Sub-base Course.

20.4.3 Tolerances

Tolerance for the base course shall be as specified in the following table.

Tolerances for Base Course

Feature	Tolerance
Permitted variation from thickness of layer	± 10 mm
Permitted variation from design level of surface	+ 5 mm - 10 mm
Permitted surface irregularity measured by 3-m straightedge	5 mm
Permitted variation from design crossfall or camber	± 0.2%
Permitted variation from design longitudinal grade over 25 m in length	± 0.1%

20.5 BITUMINOUS PRIME COAT

20.5.1 General

This work shall consist of furnishing and applying bituminous material to a bridge deck or to other areas shown on the Drawings, in accordance with this Clause and/or as directed by the Engineer.

20.5.2 Material for Prime Coat

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

20.5.3 Surface Preparation before Prime Coating

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

20.5.4 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 by means of a pressure distributor or other equipment approved by the Engineer, at a temperature between 40.5°C and 85°C.

(b) 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.

(c) 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.

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

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

20.6 ASPHALT TREATMENT BASE

20.6.1 General

The Contractor shall construct the asphalt treatment base (ATB), to the lines, grades and dimensions shown on the Drawings or directed by the Engineer.

20.6.2 Materials

(a) The bituminous material shall be a mixture of aggregate, filler, hydrated lime, if required, and asphalt cement. The several aggregate fractions shall be uniformly graded and combined in such proportions that the resulting composite blend meets the job-mix formula and the following index of retained strength as determined in accordance with AASHTO T245, ASTM 1559:

Properties of Bituminous Materials

Stability	750 kg
Flow	2.5 to 4.0 mm
Voids in total mix	4 to 8%
Voids filled with asphalt	75 to 85%
Marshal Quotient	1.8 to 5.0 kN/mm (184 to 510 kgf/mm)

(c) The grading of the aggregate shall be as follows:

Grading of Aggregate for ATB

Sieve Designation		Percentage Passing by Weight
Metric (mm)	ASTM	
25	1 inch	100
20	3/4 inch	94 - 100
13	1/2 inch	59 - 100
10	3/8 inch	41 - 74
5	No. 4	37 - 47
2.5	No. 8	33 - 46
0.6	No. 30	10 - 44
0.15	No. 100	3 - 26
0.074	No. 200	2 - 5

(d) Before stockpiling aggregate, the Contractor shall submit a proposed job-mix formula for approval. The formula submitted shall propose definite single values for:

(i) the percentage of aggregate passing each specified sieve;

(ii) the percentage of bituminous material to be added;

(iii) the temperature of the mixture leaving the mixer;

(iv) the temperature of the mixture delivered on the road; and

(v) the grading of bituminous material.

(e) Values shall be proposed within the limits specified for the required of bituminous concrete. The Engineer will determine a job-mix formula with single value for the items mentioned above and notify the Contractor. The mixture furnished by the Contractor shall conform to this job-mix formula, within the following range of tolerances:

Tolerances for Job-Mix Formula for ATB

Aggregate passing the No. 4 and larger sieves	± 4 percent
Aggregate passing the No. 8 through No. 100 sieve	± 7 percent
Aggregate passing the No. 200 sieve	± 2 percent
Bituminous material	± 0.4 percent
Temperature leaving the mixture	± 6°C
Temperature delivered to the mixture	± 6°C

(f) Whenever test on the bituminous concrete mix indicate a variation from the approved design or when a change in sources of materials is proposed, the Contractor shall prepare a new job formula for approval and the Engineer will establish a new job-mix formula and notify the Contractor. The plant mix material shall be tested by the Contractor, at the direction of the Engineer, after blending or mixing at the plant or before final incorporation into the work.

(g) The coarse aggregate, as retained on a No. 8 sieve, shall consist of clean, hard and durable fragments free from an excess of flat, elongated, soft or disintegrated pieces and free from stone coated with dirt or other objectionable material.

(h) The percentage of wear, when tested according to the Los Angeles abrasion test by ASTM C535, JIS A1121 or AASHTO T96, shall not be more than forty percent (40%).

(i) The sodium sulphate soundness loss shall not exceed nine percent (9%) nor shall the magnesium sulphate loss exceed twelve percent (12%).

(j) When crushed gravel is used, not less than 50 percent by weight of the particles retained on the No. 4 sieve shall have at least one fracture face.

(k) The fine aggregate, defined as the fraction passing No. 8 sieve, shall have characteristics and soundness in accordance with AASHTO M29 or ASTM D1073.

(l) Mineral filler, when required, shall consist of limestone dust, Portland cement or other non-plastic mineral from an approved source. Mineral filler shall be dry, free-flowing, free from lumps and other objectionable material and, when tested by sieving, shall meet the following grading requirements.

Grading of Mineral Filler for ATB

Sieve Designation		Percentage Passing by Weight
Metric (mm)	ASTM	
0.6	No. 30	100
0.3	No. 50	95 - 100
0.074	No. 200	65 - 100

(m) Asphalt cement shall be of penetration grade 60-70 and shall conform with the requirements of AASHTO M20, ASTM D946 or JIS K2208.

(n) Prime coat shall conform with the requirements of Clause TS7.05.

20.6.3 Preparation of Sub-base

(a) Before applying the prime coat, the surface of the sub-base shall be graded and compacted to remove all irregularities and the compacted density shall not be less than ninety percent (95%) of the modified maximum dry density. The surface shall be thoroughly cleaned with brooms or other equipment.

(b) Application of the prime coat shall be performed in fine weather when the ambient temperature is 15°C or higher and wind velocity is below 16 kilometers per hour. Work shall not be performed on a wet surface nor on a day with the probability of rain.

(c) Twenty-four (24) to forty-eight (48) hours after application of the prime coat, when it has sufficiently dried, it shall be broomed. A limited amount of sand, as directed by the Engineer, may be sprinkled on the prime coat to make further work possible if it is necessary to perform further work without waiting for the prime coat to dry sufficiently. Excess sand shall be removed by brooming before spreading the asphalt treated base.

20.6.4 Preparation of the Bituminous Mixture

(a) Aggregates shall be dried and heated at the paving plant so that, when introduced into the mixer, the moisture content does not exceed 0.5%.

(b) Water in aggregates shall be removed by heating to the extent that there is no subsequent foaming in the mixture before placing and spreading. Aggregates shall be heated to the temperature designated by the job formula with the specified job tolerance, with a maximum temperature and a rate of heating that will not cause permanent damage to the mixture.

(c) Particular care shall be taken so that aggregates high in calcium or magnesium content are not damaged by overheating. The quantity of bituminous material for each batch or the calibrated amount for continuous mixer, as determined by the Engineer, shall be measured by weight and introduced into the mixer, at the specified temperature, using the lowest rate possible for adequate mixing and spreading.

(d) For batch mixers, all mineral aggregates shall be placed in the mixer before the bituminous material is added. The exact temperature within the specified range shall be as directed by the Engineer.

(e) Mixing shall continue for the time necessary to coat all particles uniformly, as directed by the Engineer. This time is dependent upon the mix design and type of mixing equipment used.

20.6.5 Transportation and Delivery of the Mixture

(a) Trucks used for hauling bituminous mixtures shall have tight, clean and smooth metal beds. To prevent mixtures from adhering, beds shall be lightly coated with a minimum amount of paraffin oil, lime solution, or other approved material. Each truck shall have a suitable cover to protect the mixture from adverse weather and an insulated bed to maintain the mixture at the specified temperature.

(b) The mixture shall generally be placed at a temperature of between 120°C to 150°C when asphalt cement is used. When the mixture is placed during warm weather and the Engineer has determined that satisfactory results can be obtained at a lower temperature, he may direct that the mixture be mixed and delivered at the lower temperature.

(c) Loads shall not be dispatched from the mixer if it is expected that spreading and compaction of the mixture cannot be completed under conditions of adequate lighting.

(d) Mixtures shall be delivered to the point of placement at a temperature within the tolerances required by the Job Mix Formula.

20.6.6 Spreading

(a) Immediately before placing the bituminous mixture, the prime coat shall be cleaned using a power sweeper equipped with a blower, supplemented with hand brooms if necessary, or by other approved means.

(b) The mixture shall be laid upon an approved surface which is thoroughly dry and in suitable condition, and only when weather conditions are fair unless otherwise directed by the Engineer.

(c) Placing shall commence at points farthest from the mixing plant and progress continuously toward the plant, unless otherwise directed by the Engineer. Traffic shall not pass over the base course until it has been thoroughly compacted as specified, and allowed to cool to atmospheric temperature.

(d) Upon arrival the mixture shall be dumped into an approved bituminous paver, immediately spread to the full width required, and struck off in a uniform layer at such thickness that, when work is completed, the layer will have the required thickness conforming to the specified grade and surface profile.

(e) The bituminous paver shall be a self-contained, power propelled unit with an activated screed or strike-off assembly heated as necessary. The paver shall be capable of spreading and finishing courses of bituminous plant mix material of the specified thickness, smoothness and grade, and shall also be equipped with an automatic line and grade controlling device.

(i) The paver shall have a receiving hopper of sufficient capacity to permit a uniform spreading operation, and the hopper shall be equipped with a distribution system to place the mixture uniformly in front of the screed.

(ii) The screed or strike-off assembly shall effectively produce a finished surface of the required evenness and texture without tearing, shoving, or gouging.

(iii) The paver shall be capable of operating at forward speeds consistent with the satisfactory laying of the mixture and the paver speed shall be regulated to eliminate pulling and tearing of bituminous material.

(f) The mixture shall be placed in strips not less than 3 meters wide. To ensure proper drainage, spreading shall begin along the pavement centerline on a crowned section, or on the high side of a pavement with a one-way slope.

(i) After the first strips has been compacted, the second strip shall be placed, finished, and compacted in the same manner as the first strip. After the second strip has been placed and rolled, a 5-meter straightedge shall be placed across the longitudinal joint to determine if the surface conforms to the grade and contour requirement.

(g) In areas where use of mechanical spreading and finishing equipment is impractical because of irregularities or unavoidable obstacles, the mixture may be hand-spread.

20.6.7 Compaction of the Mixture

(a) After spreading, the mixture shall be thoroughly and uniformly compacted with power rollers. Sufficient rollers shall be furnished and operated to handle plant output.

(b) Rolling shall begin as soon as the mixture can bear the roller without undue displacement or hair cracking, and shall start from the center of the first strip and continue toward either edge. On subsequent strips, rolling shall start from the edge adjacent to the previously laid material and continue toward the opposite edge.

(c) The speed of roller shall, at all times, be slow enough so as to avoid displacement of the hot mixture. Any displacement occurring as a result of reversing the direction of the roller, or from any other cause, shall be corrected at once by rakes and by applying fresh mixture where needed.

(d) Rolling shall continue until all roller marks are eliminated, the surface is of uniform texture and true to grade and cross section, and the in-situ density is not less than ninety-eight percent (98%) of the specified laboratory density as obtained from laboratory compacted specimens of the same materials and same proportions used in the asphalt mixture as determined by AASHTO T166. The method of sampling the mixture and the compaction of specimens shall be in accordance with AASHTO T168 and AASTHO T245, respectively. Field density tests shall be made at least twice daily.

(e) In areas not accessible to the roller the mixture shall be thoroughly compacted with hot mechanical tampers.

(f) Any mixture which becomes loose and broken, contaminated with dirt, or in any way defective shall be removed and replaced with fresh hot mixture and immediately compacted to conform to the surrounding areas, all at Contractor's expense. Skin patching will not be permitted.

20.6.8 Trimming and Clean-up

(a) Placing of the bituminous mixture shall be as continuous as possible. Rollers shall not pass over the unprotected and freshly laid mixture unless authorized by the Engineer.

(b) Transverse joints shall be formed by cutting back on the previous run to expose the full depth of the course. When so directed by the Engineer, a brush coat of bituminous material shall be used on contact surfaces of transverse joints just before additional mixture is placed against the previously rolled material.

(c) The exposed edges of the completed pavement shall be cut true to the required lines. Material trimmed from the edges and any other discarded or rejected bituminous mixture shall be removed from the roadway and disposed of in an approved manner.

20.6.9 Completion Test

(a) Surface Test : Tests for conformity with the specified crown, grade and width shall be made by the Contractor immediately after initial compaction. Any deviation shall be corrected by removal or addition of materials and continuous rolling.

(b) After completion of final rolling, the smoothness of the course shall again be tested along the whole distance. Humps or depressions that exceed the specified tolerances or that retain water on the surface shall be immediately corrected by removing defective work and replacing it with new material at the Contractor's expense.

(c) Finished surfaces shall not vary from the design elevations by more than 5 mm when tested with a crown template and a 3 m straightedge furnished by the Contractor. Tests shall be performed at 10 m intervals along the road centerline.

(d) The width shall not be less than 2.5 cm of the design section measured at 20 m intervals.

(e) Thickness Tests : The total thickness of each completed course of asphalt treated base shall be determined by cores taken by the Contractor for each completed layer at places designated by the Engineer. One core test shall be performed for every 200 m^2 of paved area. The thickness shall not be 5 mm less than the design depth for any one test, and not less than 2.5 mm for an average of 10 tests.

(f) When deficiencies in either elevation or thickness exceed the specified tolerance, the Contractor shall remove and replace the asphalt treated base with new material.

20.7 ASPHALTIC CONCRETE SURFACE COURSE

20.7.1 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.

20.7.2 Preparatory Works

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

20.7.3 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) Asphalt 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.

20.7.4 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.

20.7.5 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%

20.7.6 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.

(b) Asphalt pavers shall be self-propelled, mechanical, spreading and finishing equipment, provided with a screed or strike-off assembly capable of distributing the material to not less than the full width of a traffic lane.

(c) Screed action shall include any cutting, crowning or other practical action which is effective on the mixture without tearing, shoving or gouging, and which produces a surface texture of uniform appearance. The screed shall be adjustable to the required section and thickness. The paver shall be provided with either a full width roller or tamper or other suitable compacting device. Pavers that leave ridges,

indentations or other marks in the surface that cannot be eliminated by rolling or prevented by adjustment in operation shall not be used.

(d) 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.

(e) 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.

(f) 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.

20.7.7 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%

20.7.8 Spreading and Compacting

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

20.7.9 Required Density

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

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

(ii) 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.

20.7.10 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%

20.8 CONCRETE PAVING BLOCK PAVEMENT

20.8.1 Materials

Concrete paving blocks shall be of the dimensions shown in the Drawings and shall comply with the requirements of BS 6717: Part 1 1986, Precast Concrete Paving Blocks with no block having a compressive strength of less than 40 MPa.

Sand Bedding shall be in accordance with the requirements specified in TS 2 of the Technical Specification.

Precast Concrete Kerbs shall consist of Class D concrete complying with the requirements of TS 3 and TS 4 of the Technical Specification.

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.

20.8.2 Construction Requirements

Sand and concrete paving blocks and kerbs (curbs) shall be placed as described in Division D, TS – 0215 Unit Pavement.

Where shown on the Drawings weep holes shall be carefully placed at the edge of the sand bedding as shown on the Drawings. Materials and construction shall be in accordance with the requirements of Section TS 19, Weep Holes, of the Technical Specification.

20.9 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 (Aggregate Class B)

Measurement shall be made of the volume of aggregate class B material placed and compacted to the lines grades and dimensions shown on the drawing or as directed by the Engineer and approved by the Engineer.

20.9 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 (Aggregate Class B)

Measurement shall be made of the volume of aggregate class B material placed and compacted to the lines grades and dimensions shown on the drawing or as directed by the Engineer 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 materials labour, tools, equipment and incidental items necessary to complete the Works in accordance with the Specifications and instructions by the Engineer. The rate for aggregate class B shall also include complying with the specified requirements for subgrade preparation.

Base Course (Aggregate Class A)

Measurement shall be made of the volume of Aggregate class A material placed and compacted to the lines grades and dimensions shown on the drawing or as directed by the Engineer 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 materials labour, tools, equipment and incidental items necessary to complete the Works in accordance with the Specifications and instructions by the Engineer.

Bituminous Prime Coat

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.

Asphalt Treated Base

Measurement will be made of the mass in tonne (1 tonne = 1000 kg mass) of asphalt treated base 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 treated base is laid directly on the primed surface) necessary to complete the Works in accordance with the Specifications and instructions by the Engineer.

Asphalt Concrete

Measurement will be made of the mass in tonne (1 tonne = 1000 kg mass) of asphalt 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 is laid directly on the primed surface) necessary to

complete the Works in accordance with the Specifications and instructions by the Engineer.

Sand Bedding

Measurement shall be made of the volume of sand bedding material placed and compacted to the lines grades and dimensions shown on the drawing or as directed by the Engineer 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 materials labour, tools, equipment and incidental items necessary to complete the Works in accordance with the Specifications and instructions by the Engineer.

Concrete Block Pavement

Measurement shall be made of the area of concrete block pavement placed to the lines grades and dimensions shown on the drawing 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 materials labour, tools, equipment and incidental items necessary to complete the Works in accordance with the Specifications and instructions by the Engineer.

Concrete Kerb

Measurement shall be made of the volume of concrete kerb placed to the lines and grade as on the drawings or as directed by the Engineer 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 materials labour, tools, equipment and incidental items necessary to complete the Works in accordance with the Specifications and instructions by the Engineer.

Cement Mortar

Measurement shall be made of the volume of cement mortar placed as bedding and backing for the concrete kerb as shown on the drawings or as directed by the Engineer 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 materials labour, tools, equipment and incidental items 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
Aggregate Class A	m^3
Aggregate Class B	m^3
Asphalt Concrete	tonne
Asphalt Treated Base	tonne
Sand Bedding	m^3
Concrete Block Pavement	m^2
Concrete Kerb	m^3
Cement Mortar	m^3

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SECTION TS 21. LANDSCAPING

SECTION TS 21. LANDSCAPING

21.1 GENERAL

This section covers landscaping works comprising the planting of trees and shrubs along the banks of the Asin River as shown on the Drawings. Landscaping works inside the Asin Pumping Station Complex are specified elsewhere in this specification.

21.2 SCOPE OF WORK

The work to be competed includes the following:

- Planting of trees and shrubs of the types and in the locations and spacings as shown on the Drawings.
- Maintenance of trees and shrubs up to the end of the defects liability period.

21.3 TREE PLANTING

21.3.1 Plant Requirements

Trees to be supplied, planted and maintained shall be as specified in the following table:

Species	Height including root ball (mm)	Minimum Length of Roots (mm)	Minimum Diameter of Trunk measured 1000 mm above ground level (mm)	Ideal Spacing Interval (m)
Bottle Palm	3,000	250	100	10 m
Bougainvillaea	1,000	150	Not applicable	2.5

Branches and leaves shall be in good healthy condition

The root ball, comprising main roots, hair roots and surrounding soil shall be wrapped in a plastic or bamboo basket.

21.3.2 Method of Planting

21.3.2.1 Ground Preparation

When locations for trees to be planted has been fixed and approved by the Engineer ground preparation shall be carried out as follows:

- An area 800 mm by 800 mm by 600 mm deep shall be dug and the soil loosened and removed.
- All rocks and debris shall be removed
- The loosened red soil shall be mixed with natural fertiliser in the ratio of 1:1
- The excavation shall be half filled with the soil-fertiliser mix
- Mix enough red soil with peat moss in the ratio of 2 parts soil to 1 part peat moss to form a 100 mm thick layer.
- The soil-peat moss mix shall be placed in the hole to form the 100 mm thick layers.

- Backfill the hole with the remaining red soil and tamp down.
- The prepared ground shall be left for a minimum of 10 days before tree planing.

17.3.3.4 Planting

Planting shall be done as described below:

- A hole of sufficient size for the root ball shall be dug in the prepared ground.
- The wrapping on the root ball shall be removed and the tree planted with backfilling made with the soil-peat moss mix. The soil level shall be the same as the surrounding finished ground surface.
- Build a 100 mm high mound around the tree to form a watering saucer.
- Stake the tree with 3 60 mm dia. bamboo stakes and fasten the tree to stakes with plastic rope a t a height of two thirds of the trunk height. Note that staking is only applicable to palms.

21.4 POST-PLANTING CARE

The Contractor shall maintain all trees up until the end of the defects liability period.

Maintenance shall include regular watering as required (twice a day during the dry season), weeding around the bases of trees, propping as required and trimming as directed by the Engineer.

Any tree which dies shall be replaced by the Contractor with a tree of the same species and of similar size at his cost.

21.5 MEASUREMENT AND PAYMENT

Payment for tree planting shall be made at the lump sum price entered in the priced Bill of Quantities which shall be full compensation for the cost of all materials, labour and equipment for completing the tree planting and maintaining the trees until the end of the Defects Liability Period.

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

Description	Unit of Measurement
Tree Planting	L.S.

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SECTION TS 22. MINOR METALWORK ITEMS

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, ladders, 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 120 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 requirements of clause TS 24.1.16.9.

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
Safety Hand Rail (Type-I)	kg
Safety Hand Rail (Type-II)	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

22.3.3 Ladder

Payment shall be made at the lump sum price 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 furnishing and installation of a steel ladder in accordance with the Drawings and the Specification and to the approval of the Engineer.

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

Description	Unit of Measurement
Ladder	L.S.