

TABLE OF CONTENTS

SECTION TS 19. WEEP HOLES

19.1	SCOPE	TS 19-1
19.2	MATERIAL	TS 19-1
19.3	CONSTRUCTION	TS 19-1
19.4	MEASUREMENT AND PAYMENT	TS 19-1

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/m² and shall comply with ASTM 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 through 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 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.

TABLE OF CONTENTS

SECTION TS 20. ROADS AND PAVEMENTS

20.1	GENERAL	TS 20-1
20.2	PREPARATION OF SUBGRADE	TS 20-1
	20.2.1 General	TS 20-1
	20.2.2 Testing and Preparation	TS 20-1
20.3	SUB-BASE COURSE	TS 20-1
	20.3.1 Materials	TS 20-2
	20.3.2 Placing and Spreading	TS 20-2
	20.3.3 Compacting the Sub-base	TS 20-3
	20.3.4 Tolerances	TS 20-3
20.4	BASE COURSE	TS 20-4
	20.4.1 Materials	TS 20-4
	20.4.2 Spreading and Compacting	TS 20-5
	20.4.3 Tolerances	TS 20-5
20.5	BITUMINOUS PRIME COAT	TS 20-6
	20.5.1 General	TS 20-6
	20.5.2 Material for Prime Coat	TS 20-6
	20.5.3 Surface Preparation before Prime Coating	TS 20-6
	20.5.4 Equipment for Prime Coating	TS 20-6
	20.5.5 Application of Prime Coat	TS 20-6
20.6	ASPHALT TREATMENT BASE	TS 20-7
	20.6.1 General	TS 20-7
	20.6.2 Materials	TS 20-7
	20.6.3 Preparation of Sub-base	TS 20-9
	20.6.4 Preparation of Bituminous Mixture	TS 20-9
	20.6.5 Transportation and Delivery of the Mixture	TS 20-10
	20.6.6 Spreading	TS 20-10
	20.6.7 Compaction of the Mixture	TS 20-11
	20.6.8 Trimming and Clean-up	TS 20-12
	20.6.9 Completion Test	TS 20-12
20.7	BITUMINOUS SURFACE COURSE	TS 20-12
	20.7.1 Aggregates for Bituminous Surface Course	TS 20-12
	20.7.2 Preparatory Works	TS 20-14
	20.7.3 Equipment	TS 20-14
	20.7.4 Job Mix Formula	TS 20-15
	20.7.5 Preparation and Composition of the Mixture	TS 20-15
	20.7.6 Spreading and Compacting	TS 20-15
	20.7.7 Requirement for the Mixture	TS 20-16
	20.7.8 Spreading and Compacting	TS 20-16
	20.7.9 Required Density	TS 20-16
	20.7.10 Tolerances	TS 20-17
20.8	MEASUREMENT AND PAYMENT	TS 20-17

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 directed by the Engineer, has first been screened in such a manner that when the aggregate is produced from gravel, not less than eighty 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 splattered 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 m² 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:
- Weighing, metering, or volumetric measurement of ingredients. All measuring devices shall have an accuracy of 2%.
 - Checking the quantity or rate of flow of asphalt concrete ingredients into the mixer.
 - 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 $\pm 17^{\circ}\text{C}$ 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

TABLE OF CONTENTS

SECTION TS 21. LANDSCAPING

21.1	GENERAL	TS 21-1
21.2	SCOPE OF WORK	TS 21-1
21.3	TREE PLANTING	TS 21-1
21.3.1	Plant Requirement	TS 21-1
21.3.2	Method of Planting	TS 21-1
21.3.2.1	Ground Preparation	TS 21-1
21.3.2.2	Planting	TS 21-2
21.3.2.3	Post-Planting Care	TS 21-2
21.4	MEASUREMENT AND PAYMENT	TS 21-2

SECTION TS 21. LANDSCAPING

21.1 GENERAL

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

21.2 SCOPE OF WORK

The work to be completed includes the following:

- Planting of trees and shrubs of the types and in the locations and spacings as shown on the Drawings and as instructed by the Engineer.
- 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)	Ideal Spacing Interval (m)
Bougainvillea	1,000	150	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 600 mm by 600 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.

21.3.2.2 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.

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.

TABLE OF CONTENTS

SECTION TS 22. MINOR METALWORK ITEMS

22.1	GENERAL	TS 22-1
	22.1.1 Scope	TS 22-1
	22.1.2 Submittals	TS 22-1
	22.1.3 Standards	TS 22-1
22.2	FABRICATION AND CONSTRUCTION	TS 22-1
	22.2.1 General	TS 22-1
	22.2.2 Welding	TS 22-2
	22.2.3 Protective Treatment of Metalwork	TS 22-2
	22.2.4 Check Sheets	TS 22-2
	22.2.5 Installation	TS 22-3
22.3	MEASUREMENT AND PAYMENT	TS 22-3
	22.3.1 Handrails	TS 22-3
	22.3.2 Expansion Joint	TS 22-3
	22.3.3 Ladder	TS 22-3

• *Journal of the American Medical Association*, 2000; 284: 1039-1044

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

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 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.

TABLE OF CONTENTS

SECTION TS 23. MISCELLANEOUS WORKS

23.1 GENERAL	TS 23-1
23.2 STAFF GAUGE	TS 23-1
23.2.1 Scope of Work	TS 23-1
23.2.2 Technical Requirements	TS 23-1
23.2.3 Submitted	TS 23-1
23.2.4 Construction Requirements	TS 22-1
23.3 MEASUREMENT AND PAYMENT	TS 23-1

SECTION TS 23. MISCELLANEOUS WORKS

23.1 GENERAL

This Section of the Technical Specification covers the requirements for works not specified elsewhere including the following :

- Staff Gauge

23.2 STAFF GAUGE

23.2.1 Scope of Work

The work includes the furnishing and installation of a vertical staff gauge for the visual observation of water depth.

23.2.2 Technical Requirements

The staff gauge shall be of painted steel or anodised aluminium and shall be suitably protected against corrosion for permanent use in salt water.

Figures and calibration shall be clear and crisp to enable reading in poor light conditions.

23.2.3 Submittal

The Contractor shall submit shop drawings and technical details of proposed materials, surface protection system, marking pattern etc. for the Engineer's approval.

23.2.4 Construction Requirements

The staff gauge shall be installed firmly and plumb in the location shown in the location shown on the Drawings or as directed by the Engineer.

23.3 MEASUREMENT AND PAYMENT

Payment for the staff gauge shall be made following completion of installation, inspection and approval by the Engineer in accordance with 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 all other associated costs.

Categories of work to be paid under this clause :

Item	Units of Measurement
Staff Gauge	L.S

DIVISION C

**TECHNICAL SPECIFICATION
MECHANICAL AND ELECTRICAL WORKS**

TABLE OF CONTENTS

SECTION TS 24. MECHANICAL WORKS

24.1	GENERAL REQUIREMENTS	TS 24-1
24.1.1	General	TS 24-1
24.1.2	Scope of Mechanical Works	TS 24-1
24.1.3	Operating Philosophy of Baru Pumping Station	TS 24-2
24.1.4	Data Sheets	TS 24-2
24.1.5	Standards.....	TS 24-2
24.1.6	Standard Products	TS 24-3
24.1.7	Alternative Design or Specification.....	TS 24-3
24.1.8	Shop Drawings and Calculation Sheets	TS 24-3
24.1.9	Spare Parts	TS 24-4
24.1.10	Maintenance Tools.....	TS 24-4
24.1.11	Installation, Operation and Maintenance Instructions	TS 24-4
24.1.12	Work Schedule.....	TS 24-4
24.1.13	Name Plates.....	TS 24-5
24.1.14	Inspections, Testing and Commissioning.....	TS 24-5
	24.1.14.1 Inspections, Testing and Commissioning Manual	
	TS 24-5
	24.1.14.2 Test and Inspections	TS 24-5
24.1.15	Welding	TS 24-7
24.1.16	Protective Treatment of Metalwork.....	TS 24-7
	24.1.16.1 General	TS 24-7
	24.1.16.2 Painting Manual	TS 24-7
	24.1.16.3 Cleaning and Preparation	TS 24-7
	24.1.16.4 Paint Application	TS 24-8
	24.1.16.5 Colours.....	TS 24-9
	24.1.16.6 Paint System.....	TS 24-9
	24.1.16.7 Surfaces Not to be Painted	TS 24-9
	24.1.16.8 Paint Testing	TS 24-10
	24.1.16.9 Galvanising	TS 24-12
	24.1.16.10 Other Protective Coating Systems	TS 24-14
24.1.17	Defects Liability and Warranties.....	TS 24-14
24.2	MAIN PUMP SYSTEM	TS 24-15
24.2.1	General	TS 24-15
24.2.2	General Specification for Screw Pumps.....	TS 24-15
	24.2.2.1 Scope.....	TS 24-15
	24.2.2.2 Spiral Screw	TS 24-15
	24.2.2.3 Concrete Trough	TS 24-15
	24.2.2.4 Bearings.....	TS 24-16

24.2.2.5	Gear Box.....	TS 24-16
24.2.2.6	Flexible Coupling	TS 24-16
24.2.2.7	Diesel Motors.....	TS 24-17
24.2.2.8	V-Belt Drive.....	TS 24-17
24.2.2.9	Guards.....	TS 24-17
24.2.2.10	Anti Rotation Device	TS 24-17
24.2.2.11	Surface Protection	TS 24-17
24.2.2.12	Design Criteria and Technical Data	TS 24-17
24.2.3	Submittals.....	TS 24-18
24.2.4	Quality Control	TS 24-18
24.2.5	Fabrication and Manufacture	TS 24-18
24.2.6	Installation and Testing.....	TS 24-19
24.2.7	Spare Parts.....	TS 24-19
24.3	DIESEL ENGINE SYSTEM FOR MAIN PUMPS	TS 24-19
24.3.1	General.....	TS 24-19
24.3.2	Accessories.....	TS 24-19
24.3.3	Installation and Testing.....	TS 24-20
24.3.4	Spare Parts.....	TS 24-20
24.4	AUXILIARY EQUIPMENT FOR DIESEL ENGINES	TS 24-20
24.4.1	General.....	TS 24-20
24.4.2	Fuel Transfer Pump.....	TS 24-20
24.4.3	Fuel Storage Tank	TS 24-21
24.4.4	Fuel Service Tank.....	TS 24-21
24.4.5	Installation and Testing.....	TS 24-22
24.5	PIPING SYSTEMS	TS 24-22
24.5.1	General.....	TS 24-22
24.5.2	Requirements.....	TS 24-22
24.5.3	Installation.....	TS 24-22
24.6	AUXILIARY DRAINAGE PUMP SYSTEM	TS 24-22
24.6.1	General.....	TS 24-22
24.6.2	Requirements.....	TS 24-23
24.6.3	Installation and Testing.....	TS 24-23
24.7	OVERHEAD CRANE SYSTEM	TS 24-23
24.7.1	General.....	TS 24-23
24.7.2	Requirements.....	TS 24-23
24.7.3	Installation and Testing.....	TS 24-24
24.8	GATE WORKS	TS 24-24
24.8.1	General.....	TS 24-24
24.8.1.1	Scope of Work	TS 24-24
24.8.1.2	Standards	TS 24-25
24.8.1.3	Submittals	TS 24-25

	24.8.1.4	Materials.....	TS 24-26
24.8.2		Design Criteria	TS 24-26
	24.8.2.1	Design Stresses	TS 24-26
	24.8.2.2	Design Data	TS 24-26
	24.8.2.3	Summary of Design Criteria for Gates and Stop Logs	TS 24-27
	24.8.2.4	Design Particulars	TS 24-29
24.8.3		Manufacturing and Materials	TS 24-31
24.8.4		Method of Construction	TS 24-32
	24.8.4.1	Fabrication	TS 24-32
	24.8.4.2	Installation	TS 24-33
24.9		INSTALLATION AND TESTING	TS 24-34
	24.9.1	General	TS 24-34
	24.9.2	Installation	TS 24-34
	24.9.3	Testing	TS 24-35
	24.9.3.1	General	TS 24-35
	24.9.3.2	Tests at Site	TS 24-35
24.10		MEASUREMENT AND PAYMENT	TS 24-36
	24.10.1	Main Pump System	TS 24-36
	24.10.2	Diesel Engines for Main Pumps	TS 24-37
	24.10.3	Auxiliary Equipment for Diesel Engines	TS 24-37
	24.10.4	Piping Systems	TS 24-38
	24.10.5	Auxiliary Drainage Pump System	TS 24-38
	24.10.6	Overhead Crane.....	TS 24-39
	24.10.7	Gate Works	TS 24-39
	24.10.8	Inspection and Test.....	TS 24-40
	24.10.9	Maintenance Tools and Spares	TS 24-40

1. The first part of the document is a letter from the President of the United States to the Congress, dated January 3, 1862.

2. The second part is a report from the Secretary of the Treasury, dated January 3, 1862.

3. The third part is a report from the Secretary of the Interior, dated January 3, 1862.

4. The fourth part is a report from the Secretary of the Navy, dated January 3, 1862.

5. The fifth part is a report from the Secretary of the War, dated January 3, 1862.

6. The sixth part is a report from the Secretary of the State, dated January 3, 1862.

7. The seventh part is a report from the Secretary of the War, dated January 3, 1862.

8. The eighth part is a report from the Secretary of the Navy, dated January 3, 1862.

9. The ninth part is a report from the Secretary of the War, dated January 3, 1862.

10. The tenth part is a report from the Secretary of the Navy, dated January 3, 1862.

11. The eleventh part is a report from the Secretary of the War, dated January 3, 1862.

12. The twelfth part is a report from the Secretary of the Navy, dated January 3, 1862.

13. The thirteenth part is a report from the Secretary of the War, dated January 3, 1862.

14. The fourteenth part is a report from the Secretary of the Navy, dated January 3, 1862.

15. The fifteenth part is a report from the Secretary of the War, dated January 3, 1862.

SECTION TS 24 . MECHANICAL WORKS

24.1 GENERAL REQUIREMENTS

24.1.1 General

This section of the Technical Specification covers the general and particular requirements for that portion of the Works described as, and identified in the Bill of Quantities, as Mechanical Works. It specifies the design parameters, minimum requirements of materials, workmanship, standards, tests and finishes and for all the items of plant to be designed, manufactured, delivered and installed by the Contractor under the Contract.

All plant shall be designed, manufactured, installed and commissioned in accordance with the Drawings and the requirements of these specifications or as directed by the Engineer.

All the items of plant herein described shall be designed to endure long periods of operation without the need for substantial repair or replacement of the parts.

All plant shall be products of reputable manufacturers that have a long history and experience in the production of such plant. In addition, the subcontractor (supplier/manufacture) for the screw pumps shall have had previous experience in the design, manufacture, installation and commissioning of screw pumps of diameter of at least 2.6 m diameter.

24.1.2 Scope of Mechanical Works

The Contractor shall design, manufacture, install, test, commission and rectify defects for all of the mechanical works comprising the systems, sub-systems and supply warranties components as shown in the Drawings and described in this section of the Specification.

Each item of plant, and each sub-system and system shall be designed, installed and commissioned such that the pumping station and the gate system are complete and function in accordance with the operating philosophy for the pumping station and the specified requirements.

Electrical works associated with the mechanical systems to be provided shall be included in this scope of work unless otherwise stated and included as specific pay items in the Bill of Quantities. Requirements for electrical works are specified in the Section TS 25, Electrical Works, of the Technical Specification.

General descriptions of the main systems and elements of the scope of mechanical works are as follows:

- Main Pump System comprising 2 screw-type main pump units and gear boxes.
- Diesel Engine System for Main Pumps comprising 2 diesel engines, fuel service tank, fuel transfer pump.
- Fuel Tank and Accessories including grounding and cathodic protection.
- Auxiliary Pump System comprising 2 electrically-driven submersible pumps, a control panel and water level detectors

- Overhead Crane System comprising a manually-operated travelling crane complete with girder trolley and chain block
- Piping System comprising fuel transfer piping, overflow piping, fuel service piping, fuel intake piping and air vent piping.
- Inspection and Testing comprising factory testing and site testing
- Provision of Spare Parts for all systems
- Provision of Maintenance Tools for all systems
- Gate comprising a steel sluice gate complete with guide frame, electrical and manual hoist and stop logs
- Provision of stop logs for pump intake channels

24.1.3 Operating Philosophy of Baru Pumping Station

Pump Operation

Water level in the Baru River will be maintained at a satisfactory level as determined by the operator.

The operator will set the water levels at which the auxiliary pump system starts.

When the water level rises to the determined start level, the duty electric, submersible, auxiliary drainage pump will start automatically, powered by mains (PLN) supply.

As the water level lowers the duty auxiliary pump will automatically stop.

When the water level rises to the pre-set level as indicated by the "start pump" on the control panel the operator will perform the following tasks:

- manually start one of the diesel engines for the main pumps in the pump house
- manually start one of the main pumps

When the operator judges that one main pump is not adequate to handle the flood or when "high water" is indicated on the control panel, he will manually start the second main pump.

As the flood passes the operator will progressively shut down the main pumps until he judges that the auxiliary pump has sufficient capacity to maintain a satisfactory pond level.

Stop logs will be used when pump maintenance is required.

Gate Operation

When the water level in the retarding pond is higher than the level outside the gate, the gate may be opened by means of the electric hoist activated at a local panel, or manually.

Stop logs will be used during times of gate maintenance

24.1.4 Data Sheets

The completed data sheets M 1 to M 11 shall form part of, and shall be read in conjunction with, this section of the Technical Specification.

24.1.5 Standards

The following standards shall apply to the works specified in this specified in this section. Alternative standards may be accepted in accordance with clause 1.6 of the General Specification.

Gate:

Gate:

Refer to clause TS 24.8.2

Pumps:

JIS B 8301 – 1976 Testing Method for Screw Pumps

JIS B 8302 – 1976 Measuring Method of Pump Capacity

Diesel Engines:

JIS B 8014 – 1964 Test Code for Constant Speed Diesel Engines

Overhead Cranes:

JIS B 8801 Manual Overhead Crane

Electrical Motors:

JIS C 4004 – 1977 General Rules for Electric Rotary Machinery

JIS C 4201 – 1963 Low Voltage Three Phase Induction Motors (for General Purpose)

Electrical Generators:

JIS C 4004 – 1977 General Rules for Electric Rotary Machinery

JEC 114 – 1964

JEC 146 – 1960

24.1.6 Standard Products

The equipment to be furnished under the Contract shall be standard products which are in regular production by manufacturers regularly engaged in the production of high quality equipment of the types to be furnished. Such equipment shall be essentially duplicate equipment of that which has been in satisfactory and successful operation in flood control and drainage works for a period of at least twenty five (25) years.

24.1.7 Alternative Design or Specification

The details of mechanical works depicted in the Drawings contained in Volume 3 of the Bidding Documents are for reference only and show the anticipated dimensions and general arrangement of equipment and related piping and wiring etc. It is expected that that equipment furnished under the Contract will differ to some degree from that shown because of plant designs offered by the Contractor differing in minor details or because of modifications required for its installation or for its related wiring and piping.

At the sole discretion of the Engineer, the design and this specification may be varied to allow for alternative design details, construction methods and materials provided that the performance and durability characteristics are equal or superior to those shown on the Drawings or specified herein.

Changes to the civil and building construction details and dimensions shall not, however, be varied.

Where alternative designs have been offered they shall comply with the accepted details contained in the data sheets submitted with the bid and forming part of the Contract or as approved by the Engineer.

24.1.8 Shop Drawings and Calculation Sheets

Within three (3) months after the date of receipt of Letter of Acceptance, and prior to the manufacture of mechanical plant and equipment to be incorporated in the permanent works, the Contractor shall furnish four (4) copies of calculation sheets, shop drawings and a complete list of materials

for approval in accordance with the requirements of clauses 1.4 and 1.5 of the General Specification.

24.1.9 Spare Parts

The Contractor shall supply spare parts for maintenance purposes suitable for 5-years operation, in accordance with the approved schedule, based on the accepted recommendations of the Contractor made in completed data sheets appended to his bid for all systems for the Baru Pumping Station Mechanical Works.

24.1.10 Maintenance Tools

The Contractor shall supply maintenance tools which shall include tools required for the installation, overhauling and assembly of the equipment in accordance with the approved schedule, based on the accepted recommendations of the Contractor made in completed data sheets appended to his bid for all systems for the Baru Pumping Station Mechanical Works.

Tools for individual equipment, such as pumps, engines, cranes and gate shall be contained in separate tool boxes.

24.1.11 Installation, Operation and Maintenance Instructions

Operation and Maintenance Manuals

At least three (3) months prior to the date of site testing and commissioning of the plant, the Contractor shall submit three (3) copies of the Operation and Maintenance Manual which shall contain comprehensive data for the operation and maintenance of the entire pumping station / gate system in addition to comprehensive information for the operation and maintenance of each individual item of plant for the Engineer's review and comments. Following approval by the Engineer, ten (10) copies of the final Operation and Maintenance Manual shall be submitted by the Contractor for the Employers reference.

Contractor's Engineers

The Contractor shall assign at least one mechanical engineer and one electrical engineer full-time for the supervision during the period of the installation of the plant furnished under this Contract and for the field operational testing and commissioning plus a 2-week period following the completion of commissioning for the training of operators. In the event that commissioning is completed during the dry season, the engineers shall return for a further 2-week period during the following wet season for training and instruction of operators over all a full range of conditions of operation.

24.1.12 Work Schedule

The schedule for all mechanical and associated electrical work for each of the systems described herein shall be shown in detail in the work programme described in clause 1.5 of the General Specification. The schedule shall include details and durations of all activities including, but not limited to preparation of shop drawings and their approval, procurement of materials, manufacturing, delivery, installation, testing and commissioning.

24.1.13 Name Plates

Each plant (pump, motor, engine, crane, gate, etc.) shall have a standard name plate securely affixed thereto in a conspicuous place, showing the type of plant, serial number, date of manufacture, the name of the manufacturer and all other necessary information to complete the identification, in English characters. Detailed requirements for the name plate of each equipment shall include the following in addition to other standard information provided by the manufacturers:

- Pump: Capacity in m³/sec at rated speed, revolution per minute,
- Diesel engines: Power rating (kW) and revolution per minute.
- Electric Motors: kW, speed and electric current characteristics.
- All other equipment: Manufacturer's standard details as approved by the Engineer.

24.1.14 Inspection, Testing and Commissioning

24.1.14.1 Inspection, Testing and Commissioning Manual

The Contractor shall prepare a manual for inspection testing and commissioning for the mechanical and electrical works. The manual shall include schedules, tests/inspection to be performed, locations, witnesses to attend, comprehensive check sheets for recording and other relevant data.

The manual shall be submitted in accordance with the procedures stated in Clause 1.4 and 1.5 of the General Specifications.

24.1.14.2 Tests and Inspections

Upon completion of the manufacture of the plant and at the time indicated on the work schedule, and where indicated as required in the following table, the Contractor shall conduct operational tests at the factory under actual field operating conditions.

The Auxiliary Pumps shall be operated to cover the full range of the operating condition. Testing method shall be in accordance with the requirements of JIS B 83001 and 8302 or other internationally accepted standards approved by the Engineer.

Diesel engines shall be tested in accordance with the requirements of JIS 8014 or other internationally accepted standards approved by the Engineer. Floodgates shall be inspected and tested in accordance with the Standards of Japan Water Gate Association or other internationally accepted standards approved by the Engineer and the requirements herein described.

The results of all tests shall verify the technical particulars given in the approved documents and drawings. Operational test for screw pumps at the manufacturer's workshop shall not be required.

Mill sheets shall be submitted for materials of torque shaft and blades of the screw pumps of main drainage pumps and all other materials. Mill sheets are also required for SUS 304 material.

The Contractor shall invite one (1) mechanical inspector (the Engineer or his Representative) for two (2) man days for main drainage pumps, two (2) man days for main diesel engine, and two (2) man days for the gate respectively, i.e. a total of six (6) man days for the purpose of witnessing tests in the Contractor's workshops.

All necessary expenses for the said inspector such as round-trip air tickets, per diem living allowance and land transportation charge shall be borne by Contractor.

Factory Inspection and / or Testing Schedule

ITEM	Required Test or Inspection	Presence of Engineer or his Representative	Submission of Test Records
Main Pumps	Fabrication	0	0
	Dimension	0	0
	Material	0	0
Diesel Engines	Performance	0(at least one unit)	0
	Dimension	0 (ditto)	0
Gear Boxes	No-Load operation	X	0
	Material	X	0
	Dimension	X	0
Overhead Crane	Dimension	X	0
	Function	X	0
Tanks	Dimension	0	0
	Pressure	0	0
	Material	0	0
Gate	Material	X	0
	Assembly	X	0
	Fabrication	X	0
Stop Log	Dimension	X	0
Automatic Trash Removal Unit	Dimension	X	0
	Assembly	X	0
Belt Conveyer	Dimension	X	0
	Assembly	X	0
Small Piping, Valves and Appurtenances	Manufacturer's Certificate	X	X

Legend : 0: Required
X: Not Required

24.1.15 Welding

Unless otherwise stipulated in this Specification, only electric arc welding shall be used and shall be performed by a welders qualified for the work required.

Welding symbols conforming to JIS G 3021 or other internationally accepted standards and all necessary dimensions for welding shall be shown on the shop drawings prepared by the manufacturers.

The Contractor shall prepare a welding manual for the fabrication of all plant which involves welding for the approval of the Engineer in accordance with the submittal procedures stated in clauses 1.4 and 1.5 of the General Specification. The manual shall clearly state the procedures for qualification of welders, welding procedures including welding rods, welding positions, joint preparation, type of welding machine, weld examination by either radiographic, ultrasonic or all other applicable methods and procedures for weld repairs and the formats for recording inspections. The welding manual shall be submitted in a timely manner and shall be subject to the Engineer's approval.

The results of all welding inspections shall be recorded and submitted to the Engineer for approval.

24.1.16 Protective Treatment of Metalwork

24.1.16.1 General

This clause specifies the requirements for the protective treatment of metal surfaces for all metalwork to be furnished by the Contractor. The items covered by this clause shall include, but not be limited to, screw pumps, gates, cranes, handrails, and all other metal components included in the Works.

24.1.16.2 Painting Manual

The Contractor shall prepare a painting manual specifying his proposed protective treatment of metalwork for all steel components. The procedures proposed by the Contractor in the painting manual shall be equal to or superior to those stated in this clause TS 24.1.16.

The painting manual shall be submitted in accordance with the procedures stated in clauses 1.4 and 1.5 of the General Specification.

24.1.16.3 Cleaning and Preparation

Cleaning and preparation of surfaces for painting shall be in accordance with the following and as required according to the painting system described in clause.

Surfaces to be painted shall be cleaned before the application of paint or surface treatment. All oil, grease, dirt, rust, loose mill scale, weld spatter, slag or flux deposit, oil weathered paint, and other foreign substances shall be removed. The removal of oil and grease shall be accomplished before mechanical cleaning is started. Clean cloths and cleaning fluids shall be used to avoid leaving a thin film of greasy residue on the surfaces being cleaned. Cleaning and painting shall be so programmed that dust or spray from the cleaning process will not fall on wet, newly painted surfaces. Where required, imperfections and holes in surfaces and open joints between matching surfaces shall be filled or removed in an approved manner. Any

required wash treatment shall be carried out in accordance with the paint manufacturer's instructions.

Extreme care shall be exercised when blast cleaning is applied on structures to prevent blasting materials from entering or damaging machined surfaces and other precision parts.

All cleaning, preparation and paint application shall be carried out after the parts are completely finished and checked in the shop assembly. The parts shall be disassembled to the extent necessary to enable cleaning and painting those surfaces which are inaccessible when assembled. After the finishing coats have been applied and the paint surface hardened, parts shall be reassembled as required for shipment. Those bolts and other connections which will not be removed in erection shall be coated with the shop primer and finishing.

24.1.16.4 Paint Application

Workmanship

All work shall be done in a workmanlike manner so that the finished surfaces will be free from runs, drops, ridges, waves, laps, pinholes, and unnecessary brush marks. All coats shall be applied in such manner as to produce an even film of uniform thickness completely coating all corners and crevices. All painting shall be done by thoroughly experienced and skilled workmen. Care shall be exercised during spraying to hold the nozzle sufficiently close to the surface being painted to avoid excessive evaporation of the volatile constituents, loss of material into the air, or the bridging of crevices and corners. All surface preparation and paint application in the shop and field shall be supervised by a supervisor, approved by the Engineer, from the paint manufacturer, provided by the Contractor. The supervisor shall certify that all preparations and applications are in accordance with this Specification and the paint manufacturer's recommendations and specifications.

Equipment

All paint shall be applied using airless spray equipment unless otherwise approved. Spray equipment shall be equipped with a mechanical agitator, a pressure gauge, and a pressure regulator. Nozzles shall be of the proper size as recommended by the paint manufacturer.

Paint Properties, Mixing and Thinning

The Contractor shall submit the specification of each type of paint to be used in each system for the Works for the Engineer's approval prior to the executing any painting work.

Test certificates from the paint manufacturer shall be provided for each batch of each type of paint used in the Works.

All paint, when applied, shall provide a satisfactory film and a smooth even surface. Paint shall be thoroughly stirred, strained and kept at a uniform consistency during application. Paints may be thinned in accordance with the paint manufacturer's recommendations. Paint furnished for field touch-up work shall be delivered in containers which shall show the designated name, formula or specification number, colour, special directions, manufacturer, and date of manufacture.

Atmospheric Conditions

Paint shall be applied only to surfaces that are thoroughly dry and only under such combination of humidity and temperature of the atmosphere and surfaces to be painted as will cause evaporation rather than condensation. In no case shall any paint be applied to surfaces upon which there is moisture condensation. The temperature of the surface to be painted shall be at least 3°C above dew point. Painting shall not be carried out when the relative humidity of the surrounding air exceeds 85 percent.

Protection of Paint Surfaces

Where protection is provided for painted surfaces, such protection shall be kept in place until the paint film has properly dried. Items which have been painted shall not be handled, worked on, or otherwise disturbed until the paint coat is completely dry and hard.

Time Between Surface Preparation and Painting

Surfaces which have been cleaned, pre-treated, and/or otherwise prepared for painting shall be primed as soon as practicable after such preparation has been completed prior to deterioration of the prepared surface in accordance with the paint manufacturer's recommendations.

Coating Progress

Where painting on any type of surfaces has been commenced for any portion of the Work, the complete painting operation shall be continuous and completed as soon as practicable and without delays.

24.1.16.5 Colours

The finish colour of all structures shall be as approved by the Engineer but the Contractor shall propose a colour scheme for the work and shall submit colour strips or paint samples. A colour strip shall be included with the approved colour schedule for each type of finish to be applied at the Site shop or site.

24.1.16.6 Paint System

The paint system for use on steelworks shall be in accordance with the system for each respective application in the painting manual approved by the Engineer. Painting systems shall be equal or superior to those shown in the tables for Paint System No 1 to 9 hereunder.

Where the paint system is applied to a structure that is partly embedded in concrete, the surface preparation and paint system applied to the exposed material shall extend 100 mm beyond the edge of the concrete surround or embedment.

24.1.16.7 Surfaces Not to be Painted

Wire ropes, gear teeth, interior of hydraulic piping, corrosion-resistant metal seals, the gate skin plate and other machined surfaces shall not be painted.

On completion of cleaning, surfaces not to be painted shall be coated with an approved rust preventative coating material or an adhesive plastic film to protect the surfaces from minor mechanical damage and corrosion during transportation and storage. The coating material shall be stripped off after installation.

Unassembled fitting, pins, keys, bolts, nuts etc shall be oiled and wrapped with moisture-resistant paper or protected by other approved means.

24.1.16.8 Paint Testing

All paint applications shall be tested in accordance with the following:

- The dry film thickness of each shop primer coat and total thickness of all coats shall be measured by the Contractor in the presence of the Engineer or his representative.
- The edges, corner and the areas within 5 mm distance from them, and the surface of castings and steels forgings shall be excluded unless the Engineer has reason to doubt the thickness of the application.
- Two (2) portions shall be selected per 10 m² by the Engineer and more than four (4) arbitrary points shall be measured per portion.
- An electronic thickness measuring gauge shall be used and shall be calibrated in accordance with an approved standard.
- The mean value of each portion shall be more than the average thickness specified and the minimum thickness in all eight (8) or more points measured per 10 m² shall be more than the minimum thickness specified.
- The details of testing shall be as approved by the Engineer following the submission of the Contractor's proposal.

PAINT SYSTEM

Paint System No.	Location	Site	Process	General Name	No. of Coats	Coating Interval (at 20°C)	Dry Film Thickness (micron/coat)	
							Ave	Min
1	Ferrous Metal Continuous Immersion in Water	Shop	Surface Preparation	Commercial Blast Cleaning Sa 2 1/2				
			Primer Coat	Epoxy Zinc Rich Paint	1	3 days 6 months	20	15
			1 st Coat	Coal Tar Epoxy Resin Paint	1	24 hours 7 days	280	200
			2 nd Coat	Coal Tar Epoxy Resin Paint	1	-	280	200
		Field	Surface Preparation	Power Tool Cleaning Sa 2 1/2		Note Damaged areas and welded areas only		
			Touch-up Primer Coat	Epoxy Zinc Rich Paint	1	3 days 6 months	20	15
			Touch-up	Coal Tar Epoxy Resin Paint	2		280	200

2	Ferrous Metal Intermittent Immersion and Splash	Shop	Surface Preparation	Commercial Blast Cleaning Sa 2 1/2				
			Primer Coat	Epoxy Zinc Rich Paint	1	3 days 6 months	20	15
			1 st Coat	Epoxy Resin Paint	1	24 hours 7 days	110	80
			2 nd Coat	Epoxy Micaceous Iron Oxide Paint	1	24 hours 18 months	50	35
		Field	Surface Preparation	Power Tool Cleaning Sa 2 1/2		Note : Damage areas and welded areas only		
			Touch-up Primer Coat	Epoxy Zinc Rich Paint	1	3 days 6 months	20	15
			Touch-up	Epoxy Resin Paint	2	24 hours 7 days	110	80
			3 rd Coat	- ditto -	1	- ditto -	40	20
			4 th Coat	- ditto -	1	-	40	20
3	Ferrous Metal Atmospheric Exposure		Surface Preparation	Commercial Blast Cleaning Sa 2 1/2				
			1 st Coat	Lead Suboxide Anti-Corrosive Paint	1	24 hours 6 months		25
			2 nd Coat	- ditto -	1	- ditto -	35	25
			3 rd Coat	Phenol Micaceous Iron Oxide Paint	1	24 hours 18 months		35
		Field	Surface Preparation	Commercial Blast Cleaning Sa 2 1/2				
			Touch-up	Lead Suboxide Anti-Corrosive Paint	2	24 hours 6 months	35	25
			Touch-up	Phenol Micaceous Iron Anti-Corrosive Paint	1	24 hours 18 months	50	35
			4 th Coat	Long Oil Alkyd Resin	1	24 hours 1 month	25	20
			5 th Coat	- ditto -	1	-	25	20

4	Equipment for Temporary use	Shop	Surface Preparation	Commercial Blast Cleaning Sa 2 1/2				
			1 st Coat	Zinc Chromate Primer	1	8 hours 6 months	35	25
			2 nd Coat	- ditto -	1	-	35	25
		Field	Surface Preparation	Power Tool Cleaning (SSPC-SP3)		Note : Damage d areas and welded areas only		
			Touch-up	Zinc Chromate Primer	2	8 hours (Note:- ditto-) 6 months	35	25
5	Small Sized Steel Pipe (except Hydraulic Piping)	Shop	Surface Preparation	Solvent Wash (SSPC-SP1)				
			Coating	Hard-Drying Anti Corrosive Oil	1	Over 4 hours	50	-
6	Ferrous Metal Embedded in Soil	Shop	Surface Preparation	Blast Cleaning (SSPC-SP10)				
			1 st Coat	Zinc Chromate Primer	1	8 hours 6 months	35	25
			2 nd Coat	- ditto -	1	8 hours 6 months	35	25
			3 rd Coat	Alkyd Resin Paint	1	5 hours 6 months	20	15
			4 th Coat	- ditto -	1	-		
8	Ferrous Metal Embedded in Concrete			Clean				
9	Ferrous Metal Embedded in Soil	Shop	Surface Preparation	Commercial Blast Cleaning Sa 2 1/2				
			1 st Coat	Coal Tar Epoxy Primer	1	24 hours 5 days		
			2 nd Coat	Coal Tar Epoxy Enamel		Note: 2 nd +3 rd Coat Simultaneous Application		3000
			3 rd Coat	Glass Cloth				

24.1.16.9 Galvanising

All galvanizing specified on the Drawings 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 A 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.

Exposed covers around couplings, v-belts and other moving parts shall be pickled in sulphuric acid then hot-dip galvanised with a thickness of 80 microns.

24.1.16.10 Other Protective Coating Systems

Any other alternative systems proposed by the Contractor which are will result in superior protection to that specified herein shall be subject to the approval of the Engineer.

24.1.17 Defects Liability and Warranties

Pursuant to Clause 35 of the Conditions of Contract the Contractor shall promptly repair and make good any defect or deficiency in any item of mechanical or electrical equipment forming part of the permanent works.

Further to the Contractor's liability for rectification of defects, the Contractor shall supply written warranties guaranteeing the plant supplied under the Contract from all of the subcontractors and / or suppliers of all specialised plant for durations of two (2) years from the date of the issue of the Certificate of Completion of the Works. Such warranties shall be consistent with the warranty details entered in the data sheet for respective items of plant and shall be made out in favour of the Employer.

24.2 MAIN PUMP SYSTEM

24.2.1 General

The Contractor shall supply all labour, materials, equipment and incidentals required for the design, manufacture, installation, testing and commissioning of three Archimedian screw pumps as shown in the Drawings and as specified herein.

The pumps shall be new and of current manufacture and complete with all accessories and controls to provide a complete operational system.

The control system for the pumps shall be in accordance with the operating philosophy for the pumping station as detailed above.

The design and specification may be varied as stated in clause TS 24.1.7, above

24.2.2 General Specification for Screw Pumps

24.2.2.1 Scope

The screw pumps shall comprise the screw pump, supports for the drive unit, profile plates, gear boxes, couplings, guards, upper and lower bearing assemblies, belts, pulleys, lubrication systems, splash plates, all fastenings and any other items necessary for three (3) complete screw pump units. Diesel motors are specified elsewhere.

24.2.2.2 Spiral Screw

The spiral screw pump body shall consist of a centre tube (torque tube) constructed of 12 mm mill-certified SS 400 steel, sealed at each end with rigidly designed steel end plates of the same quality of as the centre tube. The screw shall have a rotational speed of 26.5 rpm.

Tube end plates shall be machined with registers to precisely accept the upper and lower bearing assemblies. The layout of the bolt holes in the end plates for the lower bearing assembly shall be water-tight.

End plates shall be precisely perpendicular to the torque tube centreline.

Screw flights shall be constructed of cold formed, SS 400 steel. The screw flights shall be continuously welded to the centre tube on both sides with full penetration welds. All radial welds between adjacent flight segments shall be full penetration welds. Each flight segment shall be perpendicular to the centre tube.

The outer edges of the flights shall be of the specified diameter of 2,600 mm to a tolerance of + or - 3 mm and shall be parallel to the main axis of the centre tube.

24.2.2.3 Concrete Trough

The concrete trough shall be formed as shown on the approved working drawings. The clearance between the outer edges of the flights and the inner face of the trough shall be within the limits specified in the data sheet for the screw pump. Concrete shall be class C-2 in accordance with the requirements of section 3 of the Technical Specification.

24.2.2.4 Bearings

Lower Bearing Assembly

The lower bearing assembly shall be designed as follows :

It shall allow continuous operation when fully submerged in the saline contaminated water to be pumped.

It shall remain in true axial alignment with the screw pump centreline during all operating conditions

It shall allow for free expansion of the screw pump

The lower bearing shall be an automatically grease-lubricated bearing assembly consisting of a sleeve type bearing bush of phosphor bronze, a high carbon steel shaft stuffing box and a gland plate, cast iron base and cast iron hub flange attached to the screw pump body end plate. The Lower bearing assembly shall carry radial loading only. The bearing shall be completely protected by a stationary cast iron shroud to prevent material in the incoming water to become entangled with moving parts. The shroud shall be in two halves to facilitate its removal from the bearing assembly. The bearing shaft and bush shall be bolted to the cast iron base anchorage casting and screw pump body end plate. The design of the lower bearing shall be such that it can be replaced without requiring the removal of the cast iron base anchorage or the screw pump body.

Each screw pump shall have a grease pump in accordance with the manufacturer's recommendation and in complying with that specified on the relevant data sheet in Appendix 6 of the Contractor's bid.

Upper Bearing

The upper bearing assembly shall incorporate an anti-friction bearing train consisting of a self-aligning, double-spherical roller bearing mounted in a cast iron housing designed to withstand all the thrust and radial loads of the pump under operating conditions. The bearing housing shall be designed with easily removable sections for ease of inspection and service. The design of the upper bearing shall be such that all loads shall be transmitted to the supporting reinforced concrete foundation.

The upper bearing drive shaft shall be a solid steel stub fitted with either a cast iron flange or a machine faced and gusseted steel plate flange to match the register on the screw pump centre tube end plate. The back face of the upper bearing flange shall incorporate a steel splash plate covering the opening to the screw pump.

24.2.2.5 Gear Box

Each screw pump shall be driven by a totally enclosed oil-lubricated, air cooled, foot-mounted, helical/bevel, right-angle-shaft gear box. The gears and bearings shall lubricated to suit the size and mounting orientation of the unit. The gear box shall be designed for 24-hour continuous service with a bearing life of 40,000 hours at rated power, in the angular mounting position corresponding to the inclination angle of the screw pump.

The housings of the gear boxes shall be complete with removable inspection covers, oil filler and drain and oil breather.

24.2.2.6 Flexible Coupling

The output shaft of the gear box shall be connected to the screw pump upper bearing by means of a low-speed flexible coupling.

It shall be designed to compensate for shocks, vibration and shaft misalignment. The coupling shall consist of two cast iron housings separated by flexible, non-metallic rubber or elastomeric bushes. Replacement of the flexible elements shall be possible without disassembly of the screw pump drive train.

24.2.2.7 Diesel Motors

The diesel motors which power the screw pumps are specified below.

24.2.2.8 V-Belt Drive

The diesel engine and gear box shall be connected by means of v-belts and pulleys.

24.2.2.9 Guards

Protective guards shall be provided on all moving elements of the screw pump. (i.e. V-belts and low-speed coupling). The guards shall be easily removable for inspection and maintenance purposes.

24.2.2.10 Anti Rotation Device

Screw pumps shall be fitted with anti-rotation devices to prevent back rotation of the screw pump when the pumps are stopped.

24.2.2.11 Surface Protection

All fabricated steel parts of the screw pumps shall be protected in accordance with the minimum requirements stated in clause TS 23.1.16.

24.2.2.12 Design Criteria and Technical Data

Design criteria and technical data for the screw pumps are summarised in the following table:

Type	Screw pump with concrete trough
Number of Units	Two (2)
Capacity	2,400 litre / sec, head 5.1m
Rotation Speed	26.5 rpm
Diameter of Screw	2,600 mm
Flight Pitch	Refer to relevant data sheet
Angle of Inclination	30 degrees
Number of Flights	3
Adsorbed power at motor shaft	Refer to relevant data sheet
Elevation of Filling Point	-2.50

Maximum Pumping Point	2.50
Top of Trough Elevation (Chute Point)	+1.20
Bottom of Trough Elevation (Touch Point)	-4.80
Diesel Engine Output	267 hp, 1,800 rpm
Pump Efficiency	Refer relevant data sheet
Driving Method	Diesel Engine through reduction gear box
Lower Bearing	Automatically grease lubricated
Upper Bearing	Grease lubricated
Coating System	System 1 in accordance with clause TS 24.1.16 or equal

Note: Data in the above table is subject to modification in the event of changes proposed by the Contractor in his bid being accepted.

24.2.3 Submittals

The Contractor shall submit the following items for the Engineer's approval in accordance with the requirements of clauses 1.4 and 1.5 of the General Specification:

- Shop drawings and specifications of all components and assemblies comprising the pumping systems
- Details of all materials and components surface treatment
- Welding procedures in accordance with clause TS 24.1.15.
- Quality control procedures to be used during fabrication installation and testing
- A detailed schedule for the fabrication, transportation, installation, testing and commissioning of the pumps

24.2.4 Quality Control

The Contractor shall comply with the approved quality control procedures during all stages of the works and shall document all data and inspection and test results in accordance with those procedures.

Inspection and testing shall be in accordance with the schedule manual for Inspection Testing and Commissioning referred to in Clause TS 24.1.14.

24.2.5 Fabrication and Manufacture

The screw pump shall be fabricated strictly in accordance with the approved shop drawings and procedures and to the tolerances indicated therein.

Torque tubes shall be mounted in a precision lathe to check that the circularity of the torque tube is within tolerance and accurately faced to ensure that end plates will be perpendicular to the major axis.

After flights have been welded to the torque tube the screw pump body shall be mounted in a precision lathe and the flights accurately machined to the specified diameter within the specified tolerance.

24.2.6 Installation and Testing

Refer to clause TS 24.9 for general installation and testing procedures applicable to the pump system and to the overall installation.

24.2.7 Spare Parts

Spare parts shall be interchangeable with each pump and shall be of the same materials and workmanship. The spare parts to be furnished for each pump shall be in accordance with the approved list of spare parts recommended by the Contractor in the approval data sheet M-10.

24.3 DIESEL ENGINE SYSTEM FOR MAIN PUMPS

24.3.1 General

The work comprises the supply, installation, testing and commissioning of three (3) diesel engines which drive the main pumps as part of the main pump system as specified above.

Diesel engines shall be horizontal, single acting injection, 4 stroke cycle, cold starting, radiator air-cooled diesel engines and shall be base mounted.

Main parts shall possess excellent properties against heat, pressure, corrosion, and wear. All parts shall be manufactured to ensure the highest accuracy and precision by means of limit gauges, special jigs, fixtures, etc., so that they are entirely interchangeable with each other.

The three engines shall be identical to ensure that common spare parts may be used. Materials used, manufacturing and performance shall be in accordance with applicable JIS specifications or equivalent.

Design Conditions for the diesel engines for the main pumps shall be as follows:

ITEM	REQUIREMENT
Continuous rating output	270 hp
1 hour rating output	110 %
Continuous operation speed:	1,800 rpm
Bore of Cylinders: mm	In accordance with approved data sheet
Number of Cylinders:	In accordance with approved data sheet
Specific fuel Consumption:	In accordance with approved data sheet
Starting System:	Battery powered electric starter motor
Location of Operation:	In pump house
Engine cooling system:	Radiator
Engine Lubrications System:	Forced lubrication pump mounted on engine
Fuel Oil Recommended:	Diesel heavy oil

Note: Data in the above table is subject to modification in the event of changes proposed by the Contractor in his bid being accepted.

24.3.2 Accessories

Accessories for the diesel engine to be furnished shall be as follows:

- **Gauges**
Tachometer, lubrication oil pressure, cooling water pressure, suction air pressure, fuel oil pressure, etc.
- **Thermometers**
Lubrication oil, cooling water, exhaust gas, etc.
- **Auxiliary Priming Pumps**
Wing type lubrication oil pumps
- **Strainers and Coolers**
Fuel oil strainer, lubrication oil strainer, lubrication oil cooler, suction air cooler, etc.
- **Safety Devices**
Lubrication oil pressure relay, cooling water high temperature relay, over speed relay, cooling water flow sight glass, etc.
- **Miscellaneous**
Exhaust system has turbo-supercharger, pressure indicator cock for each cylinder, flywheel and dual air reservoir tanks, flexible pipe joints, installation bolts, etc.

24.3.3 Installation and Testing

Refer to Clause TS 24.9, Installation and Testing of Main Pump System.

24.3.4 Spare Parts

Spare parts shall be interchangeable with each engine and shall be of the same material and workmanship. The spare parts to be furnished shall be in accordance with clause TS 24.1.9 of this specification.

24.4 AUXILIARY EQUIPMENT FOR DIESEL ENGINES

24.4.1 General

The Contractor shall design, supply, install, test and commission the following items of auxiliary equipment which are necessary for the complete and correct operation of the diesel engines for the main pumps and the diesel generator in accordance with the Drawings, the Specification and the directions of the Engineer.

24.4.2 Fuel Transfer Pump

The fuel transfer pump shall be installed in the location indicated in the Drawings. Its function shall be to transfer fuel from the fuel storage tank to the fuel service tank, and shall be automatically controlled by a float switch to maintain a regulated fuel level in the fuel service tank.

All necessary piping for the fuel system shall be provided and shall be in accordance with the specification for piping in clause TS 24.5. The piping provided under this item shall include piping up to all diesel engines including the diesel generator.

The type and requirements for the fuel oil transfer pump shall be as follows:

ITEM	TYPE AND REQUIREMENTS
Type:	Horizontal gear type powered by single phase, 220 V, 0.5 kW electric motor
Requirement:	Transfer capacity to be as proposed by the Contractor and entered in the relevant data sheet forming part of this specification.
Number of Units:	1
Accessories:	Gate valve, check valve, couplings, complete piping system, etc.

Note: Data in the above table is subject to modification in the event of changes proposed by the Contractor in his bid being accepted.

24.4.3 Fuel Storage Tank

The fuel service tank shall be an underground, buried tank of welded steel construction complete with an inspection opening and cover and flanged bosses for connecting pipework and other accessories, in accordance with the Drawings, the Specification and the directions of the Engineer.

The type and requirements for the fuel oil storage tank shall be as follows:

ITEM	TYPE AND REQUIREMENTS
Type:	Welded steel construction, steel to be JIS designation rolled steel (SS – 400)
Volume:	10,000 litre
Size:	Refer to approved data sheet
Number of Units:	1
Accessories:	Fuel level gauge, float switch with alarm, flanges for connecting pipework, vent pipe, grounding, cathodic protection.
Surface Protection System	System 1 in accordance with clause TS 24.1.16 or better.

Note: Data in the above table is subject to modification in the event of changes proposed by the Contractor in his bid being accepted.

24.4.4 Fuel Service Tank

The fuel service tank shall be a welded steel tank complete with steel supporting frame, level gauge, inspection opening and flanged bosses for connecting pipework in accordance with the Drawings, the Specification and the directions of the Engineer.

The type and requirements for the fuel oil storage tank shall be as follows:

ITEM	TYPE AND REQUIREMENTS
Type:	Welded steel construction, steel to be JIS designation rolled steel (SS – 400)
Volume: litre	2,000
Minimum thickness of bottom plate: mm	4
Number of Units:	1
Accessories:	Level indicator, inlet, outlet, overflow, vent pipe, drain pipe, inspection opening.

Note: Data in the above table is subject to modification in the event of changes proposed by the Contractor in his bid being accepted.

24.4.5 Installation and Testing

Refer to Clause 23.9, Installation and Testing.

24.5 PIPING SYSTEMS

24.5.1 General

The work includes the supply, fabrication, installation, testing and commissioning of piping systems for the fuel and lubrications for the following systems:

- Fuel systems for the diesel engines powering the main drainage pumps and the diesel generator.
- Discharge piping for the auxiliary pumping system

24.5.2 Requirements

Water and Oil Piping:

Water and oil piping shall be galvanised steel pipe and shall conform to the requirements of JIS G 3442.

Pipe fittings shall be galvanised and shall conform to the requirements of JIS B 2301. Piping and accessories shall be connected either by threaded or flanged connections. Flanges shall be galvanised for water lines and for oil lines. Flanges shall conform to the requirements of JIS B 2201 and B 2212.

Gates valves for water and oil service lines shall conform to the requirements of JIS B 2044. Check valves for water and oil service lines shall conform to the requirements of JIS B 2045.

Accessories such as supporting racks, frames, pipe brackets, maintaining metal bands, bolts, nuts and other attachment shall be provided together with the pump equipment and shall conform to the requirements of the applicable Japanese standard or other standard approved by the Engineer.

Surface treatment of piping shall be in accordance with clause TS 24.1.16, Surface Protection of Metalwork.

24.5.3 Installation

Testing of all pipework associated with the main pump system shall be in accordance with clause TS 24.9, Installation and Testing.