20.5 BITUMINOUS PRIME COAT

20.5.1 General

This work shall consist of furnishing and applying bituminous material to a previously prepared surface of base course, sub-base or bridge deck to the area 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 approved surface of the base course only when the surface to be treated is dry or slightly moist. No application shall be made when the weather is foggy or rainy.

20.5.4 Equipment for Prime Coating

(a) The liquid bituminous material shall be sprayed by means of a pressure distributor of not less than 1000 liters capacity, mounted on pneumatic tires of such width and number that the load produced on the road surface will not exceed 1 kN (100 kgf) per cm width of tire.

(b) The tank shall have a heating device which will be able to heat a complete charge of bituminous liquid to 180° C. The heating device shall be such that overheating will not occur. The liquid shall be insulated in such a way that the drop in temperature when the tank is filled with bituminous liquid at 180°C and not heated will be less than 2°C per hour.

(c) The distributor shall be able to vary the spray width of the bituminous liquid in maximum steps of 100 mm to a total width of 4 m. The spraying bar shall have nozzles from which the liquid is sprayed in a fan-shaped pattern on the road surface and equally distributed over the total spraying width. The distributor shall be designed so that deviation from the prescribed rate of application does not exceed ten percent (10%) and shall be equipped with a device for hand spraying of the bituminous liquid.

20.5.5 Application of Prime Coat

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

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

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

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

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

20.6 ASPHALT TREATMENT BASE

20.6.1 General

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

20.6.2 Materials

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

Properties of Bituminous Materials

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

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

Grading of Aggregate for ATB

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

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

(i) the percentage of aggregate passing each specified sieve;
(ii) the percentage of bituminous material to be added;
(iii) the temperature of the mixture leaving the mixer;
(iv) the temperature of the mixture delivered on the road; and
(v) the grading of bituminous material.

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

Tolerances for Job-Mix Formula for ATB

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

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

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

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

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

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

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

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

Grading of Mineral Filler for ATB

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

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

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

20.6.3 Preparation of Sub-base

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

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

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

20.6.4 Preparation of the Bituminous Mixture

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

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

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

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

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

20.6.5 Transportation and Delivery of the Mixture

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

(b) The mixture shall generally be placed at a temperature of between 120°C to 150°C when asphalt cement is used. When the mixture is placed during

warm weather and the Engineer has determined that satisfactory results can be obtained at a lower temperature, he may direct that the mixture be mixed and delivered at the lower temperature.

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

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

20.6.6 Spreading

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

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

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

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

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

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

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

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

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

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

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

20.6.7 Compaction of the Mixture

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

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

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

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

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

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

20.6.8 Trimming and Clean-up

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

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

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

20.6.9 Completion Test

(a) Surface Test : Tests for conformity with the specified crown, grade and width shall be made by the Contractor immediately after initial compaction.

Any deviation shall be corrected by removal or addition of materials and continuous rolling.

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

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

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

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

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

20.7 BITUMINOUS SURFACE COURSE

20.7.1 Aggregates for Bituminous 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, coordinated and operated to produce a mixture which complies with the requirements of this Clause.

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

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

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

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

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

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

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

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

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

(iv) shall be totally wasted.

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

20.7.4 Job Mix Formula

The Engineer will, together with the Contractor, determine a Job Mix Formula for the asphalt concrete mixture, established among other things on the basis of ASTM D1559, Marshall Tests, made with specified aggregates and asphalt to be used. Modifications of the Job Mix Formula shall only be made with the approval of the Engineer.

20.7.5 Preparation and Composition of the Mixture

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

Composition of Mixture for Bituminous Surface Course

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

20.7.6 Spreading and Compacting

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

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

(c) Screed action shall include any cutting, crowning or other practical action which is effective on the mixture without tearing, shoving or gouging, and which produces a surface texture of uniform appearance. The screed shall be adjustable to the required section and thickness. The paver shall be provided with either a full width roller or tamper or other suitable compacting device. Pavers that leave ridges, indentations or other marks in the surface that cannot be eliminated by rolling or prevented by adjustment in operation shall not be used.

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

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

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

20.7.7 Requirements for the Mixture

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

Required Properties of Bituminous Mixture

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

20.7.8 Spreading and Compacting

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

20.7.9 Required Density

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

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

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

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

20.7.10 Tolerances

Tolerances for Asphalt Pavement

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

20.8 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 the payment item for sub-base course

Sub-Base Course

Measurement shall be made of the volume of sub-base 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 sub-base course shall also include complying with the specified requirements for subgrade preparation.

Base Course

Measurement shall be made of the volume of base course 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 shall be made of the volume of bituminous prime coat sprayed on the designated surface up to the limits shown on the Drawings. The basis of determination of the volume shall be the measured area sprayed multiplied by the rate of application instructed 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.

Asphalt Treatment Base

Measurement will be made of the mass in ton (1 ton = 1000 kg mass) of asphalt treatment 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 necessary to complete the Works in accordance with the Specifications and instructions by the Engineer.

Bituminous Surface Course

Measurement will be made of the mass in ton (1 ton = 1000 kg mass) of bituminous 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 necessary to complete the Works in accordance with the Specifications and instructions by the Engineer.

The following pay items shall be measured and paid for under this clause:

Pay Item No.	Description	Unit of Measurement
H1.1	Bituminous Prime Coat	litre
H.2.4	Bituminous Prime Coat	litre
K.1.13	Bituminous Prime Coat	litre
H1.2	Bituminous Surface Course, 50 mm thick	ton
H.2.5	Bituminous Surface Course, 50 mm thick	ton
H.2.3	Asphalt Treatment Base (A.T.B)	ton
K.1.12	Asphalt Treatment Base (A.T.B) on the Bridge	ton
H.2.1	Sub-Base Course (Class C)	m^3
K.1.15	Sub-Base Course (Class C)	m^3
H2.2	Base Course (Class A)	m^3
K.1.14	Base Course (Class A)	m^3

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SECTION TS 21. LANDSCAPING

SECTION TS 21. LANDSCAPING

21.1 GENERAL

This section covers landscaping works to be carried out on the Site

21.2 SCOPE OF WORK

The work to be competed includes the following:

- Planting of trees
- Maintenance of trees

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)	Diameter of Trunk measured 1000 mm above ground level (mm)	Ideal Spacing Interval (m)
Angsana	2200	200	60	5
Glodogan	1700	150	15	4
Flamboyant	2200	200	80	5

Branches and leaves shall be in good healthy condition

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

21.3.2 Method of Planting

21.3.2.1 Ground Preparation

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

- An area 800 mm by 800 mm by 600 mm deep shall be dug and the soil loosened and removed.
- All rocks and debris shall be removed
- The loosened red soil shall be mixed with natural fertiliser in the ratio of 1:1
- The excavation shall be half filled with the soil-fertiliser mix
- Mix enough red soil with peat moss in the ratio of 2 parts soil to 1 part peat moss to form a 100 mm thick layer.
- The soil-peat moss mix shall be placed in the hole to form the 100 mm thick layers.
- Backfill the hole with the remaining red soil and tamp down.
- The prepared ground shall be left for a minimum of 10 days before tree planing.

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.
- Stake the tree with 3 60 mm dia. bamboo stakes and fasten the tree to stakes with plastic rope a t a height of tow thirds of the trunk height.

21.3.2.3 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 coat.

21.4 MEASUREMENT AND PAYMENT

Measurement shall be made of the number of trees planted and accepted 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 and equipment for completing the tree planting and maintaining the trees until the end of the defects liability period.

The following pay item shall be measured and paid for under this clause:

Pay Item No.	Description	Unit of Measurement
I.1.7	Tree Planting (Angsana, Glodogan, Flamboyan)	No.

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SECTION TS 22. PRESERVATION OF EXISTING SIMONGAN WEIR

SECTION TS 22. PRESERVATION OF EXISTING SIMONGAN WEIR

22.1 GENERAL

This section of the Technical Specification covers the general and specific requirements for the preservation of a portion of the existing Simongan Weir. The work shall performed as shown in the Drawings and as specified hereunder.

22.2 SCOPE OF WORK

The work generally comprises the complete dismantling and reconstruction of a designated portion of the existing Simongan Weir and re-assembly in a new location as a historical relic (i.e. not functional)

The work to be performed includes, but is not limited to the following:

- Removal of steel gates, hoists, guide frames, columns, roof of operation shed and other non-masonry components.
- Cutting the stone masonry portion into regular shaped blocks of size not less then 5 tons
- Transporting all components to a new site
- Preparation of the new site
- Construction of foundations
- Repair or replacement of any damaged or badly deteriorated parts of gates, handrails or building elements
- Re-assembly of components on new site
- Interconnecting masonry block units by Drilling holes and grouting in deformed steel reinforcement using non-shrink grout
- Painting of all metalwork items in accordance with system 3 as described in Section 24 of the Technical Specification, Protective Treatment of Metalwork, modified to permit mechanical wire brushing surface preparation

22.3 METHOD OF CONSTRUCTION

The Contractor shall submit a detailed method statement for the approval of the Engineer detailing all aspects of the work and, in particular, his proposed method of cutting the stone masonry units and their removal and of the precautions to be taken to preserve the integrity of all items to be reconstructed.

22.4 MATERIALS AND WORKMANSHIP

Items for preservation shall be those in the original structure.

Earth fill, backfill, rubble stone, gravel shall be in accordance with Section 2 of the Technical Specification.

Concrete work shall be in accordance with Section 3 of the Technical Specification.

Falsework and scaffolding shall be in accordance with Section 10 of the Technical Specification.

Wet stone masonry shall be in accordance with Section 17 of the Technical Specification.

Painting shall be in accordance with Section 24 of the Technical Specification

Steel Fence shall be in accordance with Section TS 25 of the Technical Specification.

Other items shall be as directed by the Engineer.

22.5 MEASUREMENT AND PAYMENT

22.5.1 Removal and Transportation of Gates etc

Payment for removal of steel gates, hoists, guide frames, columns and roof of operation shed etc. and transporting them to the preservation site shall be made in accordance with the lump sum entered in the priced Bill of Quantities following the completion of transportation of all such components to the new site and their satisfactory stacking to the approval of the Engineer.

Items to be paid under this clause are as follows:

Pay Item No.	Description	Unit of Measurement
L.1.1	Removal of Steel Gates, Hoists, Guide Frames, Columns and Roof of Operation Shed, etc. and Transporting them to the Preservation Site.	L.S.

22.5.2 Cutting and Transportation of Masonry

Measurement shall be made of the volume of stone masonry cut into blocks and transported to the preservation site.

Payment will be made at the rate entered in the priced Bill of Quantities and includes the entire cost of completing the work including materials, labour, equipment, transportation and all associated costs and, in particular, includes the cost of using specialised methods of sawing the masonry into blocks and taking precautions to prevent the existing structure breaking during cutting lifting and transportation.

Items to be paid under this clause are as follows:

Pay Item No.	Description	Unit of Measurement
L.1.2	Cutting, Dismantling Part of the Existing Wet Masonry Made Weir into Blocks and Transporting them to the Preservation Site	No.

22.5.3 Re-assembly of Masonry Blocks

Measurement shall be made of the volume of masonry blocks reassembled on the new site to the approval of the Engineer.

Payment will be made at the rate entered in the priced Bill of Quantities and includes the entire cost of completing the work including materials, labour, equipment, transportation and all associated costs and, in particular, includes the cost of taking precautions to prevent blocks of the existing structure breaking during re-assembly and repair of any block so damaged.

Items to be paid under this clause are as follows:

Pay Item No.	Description	Unit of Measurement
L.2.15	Assembling Blocks into Original Configuration including Scaffolding	L.S.

22.5.4 Interconnection of Masonry Blocks

Measurement shall be made of the volume of non-shrink mortar used in the joints between the masonry blocks

Payment for non-shrink mortar shall be made at the rate entered in the priced Bill of Quantities which shall include the entire cost of completing the work including materials, labour, equipment and all associated costs.

Measurement shall be made of the length of 45 mm dia. drilled holes in which 16 mm dia. deformed steel reinforcing bars have been grouted and approved by the Engineer.

Payment will be made at the rate entered in the priced Bill of Quantities which shall include the entire cost of completing the work including materials, labour, equipment and all associated costs including drilling, steel reinforcing bar and grouting.

Items to be paid under this clause are as follows:

Pay Item No.	Description	Unit of Measurement
L.2.16	Jointing Blocks with Non-Shrink Mortar	m^3
L.2.17	Drilling Holes in Blocks , Anchoring with Steel Deformed Bar and Filling the Hole with Non-shrink Mortar	m

22.5.5 Re-assembly of Other Components

Payment for re-assembly of steel gates, hoists, guide frames, columns and roof of operation shed etc. shall be made in accordance with the lump sum entered in the priced Bill of Quantities following the completion of their setting of the components in their final location to the approval of the Engineer. The lump sum shall be deemed to include the entire cost of completing the work including materials, labour, equipment and all associated costs including the cost of repairing or replacing damaged or deteriorated components and painting of all metalwork.

Items to be paid under this clause are as follows:

Pay Item No.	Description	Unit of Measurement
L.2.18	Setting Steel Gates, Hoist, Guide Frames, Columns and Roof of Operation Hut etc.	L.S.

22.5.6 Other Items

Other items for payment including earthworks, concrete works, wet stone masonry, metalwork shall be paid in accordance with the payment clauses in the respective sections of the Technical Specification.

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SECTION TS 23. MISCELLANEOUS WORKS

SECTION TS 23. MISCELLANEOUS WORKS

23.1 GENERAL

This section of the Technical Specifications covers the requirements for various works not specified elsewhere including the following :

- Water Level Gauge
- Water Level Staff
- Information Board
- Name Plates
- Storage Facility for Temporary Gate
- PVC Pipe
- Rubber Sheet

23.2 WATER LEVEL GAUGE

23.2.1 Scope

The work to be performed includes the furnishing, installation and commissioning of pressure-type water level gauge equipment consisting of a sensor enclosed in a protective pole, a transducer, an analogue recorder, a power supply unit and a step-down transformer all in accordance with the technical requirements listed below or as directed by the Engineer.

23.2.2 Technical Requirements

The water level gauge equipment shall comply with the following requirements:

Sensor and Transducer

Detection Method:	Semiconductor pressure gauge type
Measuring Range:	0 to 9m
Linearity:	Within ± 0.1% of full scale
Output signal:	DC 0 to 1 V and DC 0 to 5 V
Cable length between sensor and transducer:	Approx. 50 m
Digital (BCD) signal:	Shall be output from transducer
Power Supply:	DC 11 to 16 V approx. 25 mA
Dimensions and Weight	To be advised by Contractor

Analogue Recorder

Type	Desk-top type
Input signal	DC 0 to 1V
Recording range	0 to 9 mm
Accuracy	Within 0.1 % of full scale
Recording method	2 pen-endless
Recording pen	Cartridge pen
Recording paper	Roll type, 200 mm width
Rolling speed	6 mm/hr., 18 mm/hr. by crystal clock
Continuous recording period	3 months/1 month
Power supply	DC 12 V, AC 100 V ± 10% 50/60 Hz
Dimensions	470 x 327 x 250 mm
Weight	Approx. 26 kg

Power Supply Unit

Output voltage	DC 12 V
Output Current	100 m A (max.)
Power supply	AC 100 V, ± 10%, 50 / 60 Hz
Dimensions	245 x 176 x 414 mm
Weight	Approx. 7 kg

Step-Down Transformer

Output voltage	AC 100 V
Power supply	AC 220 V

23.2.3 Submittals

The Contractor shall submit shop drawing, technical data sheets of all proposed equipment and schedules for installation, inspection, testing and commissioning to the Engineer for approval in accordance with clauses 1.4 and 1.5 of the General Specification.

23.2.4 Construction

The equipment shall be installed in accordance with the approved shop Drawings and tested and commissioned in accordance with the schedule referred to above.

23.3 WATER LEVEL GAUGING STAFF

23.3.1 Scope of Work

The work includes the furnishing and installation of sets of vertical water level gauging staffs to be installed for the purpose of visual observation of water depth.

23.3.2 Technical Requirements

Each set shall consist of five segments.

The material shall be anodised aluminium plate.

Figures, letters and calibration of the staff gauge shall be clear and crisp and capable of being read in poor light conditions.

23.3.3 Submittal

The Contractor shall submit shop drawing and technical details of proposed materials for the Engineer's approval

23.3.4 Construction Requirements

Staff gauges shall be installed firmly and plumb in the locations shown on the Drawings or as directed by the Engineer.

23.4 INFORMATION BOARD

23.4.1 Scope of Work

The work includes the furnishing, erection and subsequent removal of a project information board in accordance with the Drawings and instructions of the Engineer.

23.4.2 Material Requirements

The supporting frame shall be tubular steel, painted with anti-corrosion paint or timber (Kayu Kamper) with the information board made of zinc-coated steel sheet of thickness not less than BWG 30.

23.4.3 Submittal

The Contractor shall submit shop drawing and technical details of proposed materials for the Engineer's approval

23.4.4 Construction Requirements

The information board shall be erected true and level in a location as directed by the Engineer. The supports shall be founded firmly in the ground and be sufficiently braced to resist wind loads.

23.5 NAME PLATES

23.5.1 Scope of Work

The work comprises the furnishing and installation of name plates on the weir and on the bridge in accordance with the Drawings.

23.5.2 Material Requirements

Name plates shall be made of cast bronze conforming to the requirements of JIS H 5113.

23.5.3 Submittal

The Contractor shall submit shop drawing and technical details of proposed materials and method of attachment for the Engineer's approval.

23.5.4 Construction Requirements

Name plates shall be set in the locations as directed by the Engineer.

23.6 STORAGE FACILITY FOR TEMPORARY GATE

23.6.1 Scope of Work

The work comprises the construction of a reinforced concrete slab with steel runners to support the temporary gate components and the provision of a tarpaulin cover with holding-down anchors.

23.6.2 Technical Requirements

The work shall be constructed as shown on the Drawings and as directed by the Engineer.

Earthworks shall be in accordance with section TS 2.

Concrete works shall be in accordance with section TS 3.

Steelwork shall be as shown on the Drawings.

Painting of Steelwork shall be in accordance with TS 24, system 11.

23.7 PVC PIPE

23.7.1 Technical Requirements

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

23.7.2 Construction Requirements

PV C pipes shall be cut to the required lengths and installed in the locations shown on the Drawings. When PVC pipes are embedded in concrete they shall be held rigidly in place prior to and during placement of concrete. Any concrete or other material accumulated inside PVC pipes shall be removed and the bore of the pipes shall permit free draining of water.

23.8 RUBBER SHEET

23.8.1 Technical Requirements

Rubber sheet shall be made from natural rubber and other elastomeric materials having the same properties as specified for elastomeric bridge bearings in Section TS 11.

23.8.2 Construction Requirements

The Contractor shall submit technical data and samples of proposed materials for the Engineer's approval prior to procurement.

Rubber sheet shall be cut to the specified size and installed in place using a bonding agent approved by the Engineer.

23.9 RAIN GAUGE EQUIPMENT

23.9.1 Scope of Work

The work includes the furnishing, installing, testing and commissioning of the following equipment:

- Rain gauge of the tipping bucket-type consisting of a rainfall collector, tipping bucket and A/D collector
- Automatic rainfall recorder of the pen and paper type capable of continuous recording for 90 days

Service manuals shall be provided with all equipment

23.9.2 Rain Gauge

Equipment Operation:

The rain gauge shall measure rainfall which flows into a tipping bucket through an orifice in the top of the equipment. When the bucket tips it shall operate a mercury lead switch which shall transmit the signal to a recorder. The equipment shall also be capable of transmitting to a telemetering system. Rainwater collected in the tipping bucket shall be discharged to the outside through a pipe.

Equipment Specification:

Output signal:	1 pulse / tilt, non-voltage make contact signal
Measuring Unit:	1 mm per tilt
Accuracy:	+ or – 3 % at 100 mm/hr rainfall
Diameter of Orifice:	200 mm

The rain gauge shall be mounted on a 100 mm high concrete base.

23.9.3 Automatic Rainfall Recorder

Equipment Function:

When the bucket is tilted and a signal received from the rain gauge, the cumulative rainfall shall be recorded by the pen of the chart.

Equipment Specification:

The recording equipment shall be equal or better than the following specification.

Recording System	50 tips reciprocation
Chart Paper:	Roll-type (two tips per scale unit)
Chart Drive:	Battery-driven crystal clock
Chart Speed:	6 mm per hour
Recording Period:	3 months
Recording Paper Width:	50 mm
Recording Paper Length:	15 m

23.10 MEASUREMENT AND PAYMENT

Water Level Gauge

Payment for the water level gauge shall be made following completion of commissioning, testing, inspection and approval by the Engineer of the entire water level gauge 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 any other incidental costs necessary for its completion in accordance with the Drawings and the Specification to the Engineer's approval.

Water Level Gauging Staff

Payment for the water level gauging staffs shall be made following completion of their installation and approval by the Engineer in accordance with the rate per set entered in the priced Bill of Quantities which shall be full compensation for the cost of all materials, labour, equipment and any other incidental costs necessary for their completion.

Information Board, Name Plates, Storage Facility for Temporary Gate

Payment for the Information Board, Name Plates and Storage Facility for Temporary Gate shall be made following completion of their respective installation and approval by the Engineer in accordance with the lump sums entered in the priced Bill of Quantities which shall be full compensation for the cost of all materials, labour, equipment and any other incidental costs necessary for their completion .

PVC Drain Pipe

Measurement shall be made of the length of PVC drain pipe, complete, in place and approved by the Engineer.

Payment for shall be made at the rate entered in the priced Bill of Quantities which shall include the entire cost of completing the work including materials, labour, equipment and all associated costs.

Rubber Sheet

Measurement shall be made of the number of rubber sheets, complete, in place and approved by the Engineer.

Payment for Rubber Sheet shall be made at the rate entered in the priced Bill of Quantities which shall include the entire cost of completing the work including materials, labour, equipment and all associated costs.

The following pay items shall be measured and paid for under this clause:

Pay Item No.	Description	Unit of Measurement
I.1.1	Furnishing and Installing Water Level Gauge (Pressure Gauge Type) consisting of Pole Type Protective Pipe, sensor, cable and Converter)	set
I.1.2	Furnishing and Installing Water Level Gauging Staff	set
I.1.4	Information Board	L.S.
1.1.5	Name Plate for Weir and Bridge	L.S.
I.1.6	Storage Facility for Temporary Gate	L.S.
E.3.7	Rubber Sheet (200 mm x 200 mm x 30 mm)	No.
E.3.8	Drain Pipe, PVC Pipe, Dia 150 mm	m
E.4.10	Drain Pipe, PVC Pipe, Dia 100 mm	m

DIVISION C

MECHANICAL AND ELECTRICAL WORKS

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SECTION TS 24. PROTECTIVE TREATMENT OF METALWORK

SECTION TS 24. PROTECTIVE TREATMENT OF METALWORK

24.1 GENERAL

24.1.1 Scope

This section covers the general and specific 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 the following:

- all metal components of gates for the Simongan Weir
- all metal components of off-take gates
- other metal components associated with the gates of the Simongan Weir
- all handrails, ladders, safety rails
- all metal machinery components including those supplied by specialised suppliers
- All metal components in the Simongan Weir Management Complex

24.1.2 Submission by Contractor

The Contractor shall prepare detailed painting procedures for the protective treatment of all metal items to be furnished by the Contractor under the Contract base on the minimum requirements described in this section of the Specification for the approval of the Engineer in accordance with clause 1.5.8 of the General Specification.

24.2 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 called for in clause 24.5 and specified in clause 24.8.

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.

All galvanised steel surfaces required to be painted shall be etched with a solution containing 4.5 percent of copper acetate applied twenty-four hours in advance of painting.

24.3 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 :

(i) 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.

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

(iii) 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 that 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.

24.4 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.

In cases where more than one coat of the same colour is not be applied, alternate coats shall be tinted to give contrast between coats.

24.5 PAINTING SCHEDULE FOR SYSTEMS APPLICATION

The following systems shall be applied to the items listed below. Where particular items are not listed they shall be treated in accordance with the system specified in the technical specification for that particular item or, where not specified, in accordance with the system appropriate to its location as shown in the tables in clause 23.8. or in accordance with the Engineer's directives.

Painting System 1

Gate guide frame
Gate leaves
Other ferrous metal subject to immersion in water

Painting System 10

Gate hoists

System 7

Handrails, steps, ladders, steel fencing

24.6 SURFACES NOT TO BE PAINTED

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

24.7 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 and supervisor from the paint manufacturer in the presence of the Engineer.

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 m^2 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.

24.8 PAINT SYSTEM

The appropriate paint system as specified in clause 23.5 and for which details of surface preparation and coating are specified hereunder shall be used. Where technical specifications for steel elements are not specified the coating system to be used shall be that for the location appropriate to its location.

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.

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 (ISO 8501-1 Sa 2 ½)				
			Primer Coat	Epoxy Zinc Rich Paint	1	3 days 6 months	20	15
			1st Coat	Coat Tar Epoxy Resin Paint	1	24 hours 7 days	280	200
			2nd Coat	Coat Tar Epoxy Resin Paint	1	-	280	200
		Field	Surface Preparation	Power Tool Cleaning (ISO 8501-1 Pt 3)		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

Paint System No.	Location	Site	Process	General Name	No. of Coats	Coating Interval (at 20°C)	Dry Film Thickness (micron/coat)	
							Ave	Min
2	Ferrous Metal Intermittent Immersion and Splash	Shop	Surface Preparation	Commercial Blast Cleaning (ISO 8501-1 Sa 2 ½)				
			Primer Coat	Epoxy Zinc Rich Paint	1	3 days 6 months	20	15
			1st Coat	Epoxy Resin Paint	1	24 hours 7 days	110	80
			2nd Coat	Epoxy Micaceous Iron Oxide Paint	1	24 hours 18 months	50	35
		Field	Surface Preparation	Power Tool Cleaning (ISO 8501-1 Pt 3)		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
			3rd Coat	- ditto -	1	- ditto -	40	20
			4th Coat	- ditto -	1	-	40	20

Paint System No.	Location	Site	Process	General Name	No. of Coats	Coating Interval (at 20°C)	Dry Film Thickness (micron/coat)	
							Ave	Min
3	Ferrous Metal Atmospheric Exposure	Shop	Surface Preparation	Commercial Blast Cleaning (ISO 8501-1 Sa 2 ½)				
			1st Coat	Lead Suboxide Anti-Corrosive Paint	1	24 hours 6 months	35	25
			2nd Coat	- ditto -	1	- ditto -	35	25
			3rd Coat	Phenol Micaceous Iron Oxide Paint	1	24 hours 18 months	50	35
		Field	Surface Preparation	Commercial Blast Cleaning (ISO 8501-1 Sa 2 ½)		Note : Damage areas and welded areas only		
			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
			4th Coat	Long Oil Alkyd Resin	1	24 hours 1 month	25	20
			5th Coat	- ditto -	1	-	25	20

Paint System No.	Location	Site	Process	General Name	No. of Coats	Coating Interval (at 20°C)	Dry Film Thickness (micron/coat)	
4	Equipment for Temporary use	Shop	Surface Preparation	Commercial Blast Cleaning (ISO 8501-1 Sa 2 ½)			Ave	Min
			1st Coat	Zinc Chromate Primer	1	8 hours 6 months	35	25
			2nd Coat	- ditto -	1	-	35	25
		Field	Surface Preparation	Power Tool Cleaning (ISO 8501-1 Pt 3)		Note : Damaged areas and welded areas only		
			Touch-up	Zinc Chromate Primer	2	8 hours 6 months	35	25

Paint System No.	Location	Site	Process	General Name	No. of Coats	Coating Interval (at 20°C)	Dry Film Thickness (micron/coat)	
5	Small Sized Steel Pipe (except Hydraulic Piping)	Shop	Surface Preparation	Solvent Wash (SSPC-SP1)			Ave	Min
			Coating	Hard-Drying Anti Corrosive Oil	1	Over 4 hours	50	-

Paint System No.	Location	Site	Process	General Name	No. of Coats	Coating Interval (at 20°C)	Dry Film Thickness (micron/coat)	
6	Ferrous Metal Embedded in Soil	Shop	Surface Preparation	Blast Cleaning (SSPC-SP10)			Ave	Min
			1st Coat	Zinc Chromate Primer	1	8 hours 6 months	35	25
			2nd Coat	Zinc Chromate Primer	1	8 hours 6 months	35	25
			3rd Coat	Alkyd Resin Paint	1	5 hours 6 months	20	15
			4th Coat	Alkyd Resin Paint	1	-		

System No.	Location	Site	Process	General Name	No. of Coats	Coating Interval (at 20°C)	Dry Film Thickness (micron/coat)	
7	Small Sized Steel Pipe (except Hydraulic Piping), Handrailing, stairs, fence posts, etc	Shop	Surface Preparation Hot Dip Galvanising (Ref. Cl. 21.9)	Hand Tool Cleaning (SSPC-SP2)			Ave	Min
		Field	1st Coat	Zinc Chromate Primer	1	8 hours 6 months	35	25
			2nd Coat	Polyurethane	1	8 hours 6 months	35	25

Paint System No.	Location	Site	Process	General Name	No. of Coats	Coating Interval (at 20°C)	Dry Film Thickness (micron/coat)	
8	Ferrous Metal Embedded in Concrete			Clean	Nil			

Paint System No.	Location	Site	Process	General Name	No. of Coats	Coating Interval (at 20°C)	Dry Film Thickness (micron/coat)	
9	Ferrous Metal Embedded in Soil	Shop	Surface Preparation	Commercial Blast Cleaning (ISO 8501-1 Sa 2 ½)			Ave	Min
			1st Coat	Coal Tar Primer	1	24 hours 5 days		
			2nd Coat	Coal Tar Enamel		Note: 2nd+3rd Coat Simultaneous Application		3000
			3rd Coat	Glass Cloth				

Paint System No.	Location	Site	Process	General Name	No. of Coats	Coating Interval (at 20°C)	Dry Film Thickness (micron/coat)	
10	Ferrous Metal in Sheltered Locations	Shop	Surface Preparation	Commercial Blast Cleaning (ISO 8501-1 Sa 2 ½)			Ave	Min
			Primer Coat	Epoxy Zinc Rich Paint	1	3 days 6 months	20	15
			2nd Coat	Chlorinated Rubber		As recommended by supplier	60	50
			3rd Coat	Chlorinated Rubber		As recommended by supplier	60	50

Paint System No.	Location	Site	Process	General Name	No. of Coats	Coating Interval (at 20°C)	Dry Film Thickness (micron/coat)	
							Ave	Min
11	Handrails, stairs, steps, etc	Shop	Surface Preparation	Commercial Blast Cleaning (ISO 8501-1 Sa 2 ½)				
			Primer Coat	Red Lead Primer	2	3 days 6 months	35	25
			2nd Coat	Oil Based Paint (Paint spec. and colour to Engineer's approval	1	As recommended by supplier	100	90
		Field	3rd Coat	Oil Based Paint (Paint spec. & colour to Engineer's approval	1	As recommended by supplier	100	90

24.9 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.

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.

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 or ISO 8501-1 Sa 2 1/2

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 an 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.

24.10 OTHER PROTECTIVE COATING SYSTEMS

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

24.11 MEASUREMENT AND PAYMENT

Measurement and payment for the protective treatment of metalwork will not be made exclusively and all costs incurred by the Contractor in complying with the requirement of this section shall be deemed to be included in the rates and unit prices entered in the Bill of Quantities for works which incorporate the requirements of this section. These shall include the entire cost of completing the work including materials, labour, equipment, transportation and any other associated costs.