10.6 ROADWAY SURFACING - GENERAL

a. The Contractor shall carry out, as shown on the Drawings, the surfacing of the road construction works as described in Sub-Clause 10.1.2. Generally, the surfacing work shall consist of subgrade preparation, crushed stone sub-base, penetration macadam base course and hot asphalt mix surface course as described in Clauses 10.7 to 10.10. Surfacing work for the reservoir permanent access road below EL. 157.000 m shall consist of subgrade preparation, crushed stone sub-base and a concrete pavement specified in Clause 10.11.

b. At least 30 days prior to the commencement of construction of facilities for the crusher plant for crushed stone for sub-base and base the Contractor shall submit details of the proposed facilities, including asphalt mixing plant and paving equipment, for approval. The proposed facilities and equipment shall be in accordance with the proposals included by the Contractor in his Tender and approved in the Letter of Acceptance. Where external commercial materials are proposed to be used the Contractor shall submit full details for the Engineers approval in accordance with Clause 1.4.

10.7 SUBGRADE

10.7.1 Preparation

a. The subgrade shall be prepared to the lines, grades, dimensions shown on the Drawings and specified in the Specifications. The cut subgrade shall be trimmed by the means of grader or other approved equipment and any damage to the subgrade shall be repaired before placing sub-base materials. The subgrade to be prepared shall extend 500 mm outside the designed edges of sub-base as shown on the Drawings. The scarifying depth in subgrade preparation shall not be more than 50 mm.

b. When the subgrade is prepared by cutting or where a change of material properties of the subgrade occurs, the prepared subgrade shall be checked by Laboratory CBR Test and at the places where the subgrade material properties change. CBR Tests shall be made on samples obtained from two test holes at each location and the average test value shall be considered for the design CBR value.

c. When the CBR test value is less than 3, such subgrade material shall be removed and replaced with other approved material for the distance and to the depth directed by the Engineer and the field CBR Test on the prepared subgrade shall be carried out. Payment for excavating and replacing unsuitable subgrade material shall be as specified in this Clause.

d. Where the subgrade is formed in embankment of common materials from road excavation, required excavation or from borrow area, the Laboratory CBR Test of common material shall be performed by the Contractor in advance of its use and the test data and design of pavement structure shall be submitted to the Engineer for approval. Whenever the quality of material in a borrow area or from required changes, the Laboratory CBR Test shall be carried out on the material.

e. The subgrade of the road construction in embankment conditions shall be compacted to not less than 95 percent of the maximum dry density at the optimum moisture content by steel rollers weighing more than 10 tonne, or other types of roller of equivalent capacity. The travelling direction of the roller shall be parallel to the road center line and rolling

shall begin from the sides in such a manner that every roller track will overlap with the immediately preceding and adjacent track by half of the roller width. The roller pass shall be preceded by sprinkling of water, if required, as determined by the Engineer.

f. After compaction, the subgrade shall be inspected and tested for density at intervals of 50 m along the road center line. Any deviation in elevation from the levels shown on the Drawings shall be adjusted by removing or adding approved material. In areas where the density of the subgrade material does not meet the requirements of paragraph e. of this Sub-Clause excavation shall be carried out to a depth of 300 mm, or as directed, so as to remove all objectionable material and the excavation shall be filled with proper material and compacted until the required density has been obtained. No payment will be made for removing and replacing previously compacted subgrade material directed in accordance with this paragraph.

g. Sufficient metal templates shall be furnished by the Contractor and used by the Contractor in the presence of the Engineer or by the Engineer to check the finished surfaces of the pavement structure at intervals of 20 m along the road axis. The templates shall be submitted to the Engineer for his approval. The templates used to control the work shall be maintained at all times in a proper condition so as to produce the correct cross-sectional profile. The templates shall be checked at intervals and if necessary, repaired or adjusted as directed by the Engineer.

h. The Contractor shall furnish sufficient straightedges 3 m long, to check the straightness of the surface of the pavement. The checking shall be made on a line parallel to the center line of road 800 mm inside from the roadway edge at intervals of 1.5 m.

i. Covered drains serving as culvert, drain pipes and any other minor structures below the subgrade level, including the fully compacted backfill over them, shall be completed before the work is begun on the subgrade. Drains, outlets for drainage and headwalls for culverts shall be in an operating condition so as to ensure prompt and effective drainage and avoid damage to the subgrade by surface water. No work shall be started on the preparation of the subgrade until the prior works herein described have been approved by the Engineer.

10.7.2 Payment

a. Except as otherwise provided separate payment will not be made for subgrade preparation in accordance with this Clause and all costs shall be deemed to be included in the rates for common embankment or excavation. (Items J.1 and J.2)

b. Payment for excavation of unsuitable material from subgrades in cut-section will be made in accordance with Sub-Clauses 3.4.3 and 3.4.11 as applicable.

c. Payment for the replacement of unsuitable material excavated from subgrades in cut-sections with approved material and recompaction will be made in accordance with Sub-Clause 10.5.7.a.

10.8 CRUSHED STONE SUB-BASE

10.8.1 Material

a. The material for the crushed stone sub-base shall be constructed of crushed rock to the lines, grades and dimensions shown on the Drawings or directed and shall have the following properties:

(i) The material for the crushed stone sub-base shall be well graded crushed rock sufficiently hard and resistance to weathering.

(ii) When subjected to the Los Angeles abrasion test, the material shall show a rate of abrasion lower than 50 percent.

(iii) The material shall be free from dust or other foreign matter and contain no excessively flat or elongated grains, where an excessively flat grain is defined as one with thickness smaller than half the average thickness of grains of similar size and an excessively elongated grain is defined as one with its length larger than two times its breadth.

(iv) Grading of the material shall be as follows:

Sieve No.	Percentage Passing by Weight
50 mm (2")	100
25 mm (1")	55 – 85
20 mm (3/4")	50 – 80
5 mm (No.4)	30 – 60
0.4 mm (No.40)	10 – 30
0.074 mm (No.200)	5 – 15

(v) The plasticity index of the minus No. 40 fraction shall not be higher than 6 and the minus No.200 fraction shall not exceed half of the minus No.40 fraction by weight.

(vi) 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 fractured face.

(vii) The sub-base shall have a Modified CBR Test Value greater than or equal to 30.

b. The crushing plant shall be such that raw material of different sizes can be fed to the crusher at an even rate to produce material with acceptable grading. The material produced shall be loaded directly from the crushing plant outlet for transportation to the prepared subgrade. If more material is produced than can be hauled to the subgrade, the stockpiling shall not last for a period longer than one day.

10.8.2 Construction

a. The crushed stone sub-base shall be constructed in layers of approximately equal thickness of 100 mm to 150 mm. The crushed and mixed material shall be loaded directly from the crushing plant outlet and transported to the prepared subgrade or foundation and spread in a

generally uniform thickness and then, blended and mixed insitu by grader. Water shall be sprinkled evenly before blending commences. After one grader pass, water shall be sprinkled again until the optimum moisture content is obtained, and then the material shall be blended by one additional pass of the grader. If, in the opinion of the Engineer, the mixing of the material is still uneven, additional grader passes shall be made until even mixing is obtained to the approval of the Engineer.

b. When the material has been blended and evenly mixed, it shall be worked and finished so that the layer, after compaction, will have the specified thickness. After grading, if there is still coarse material along the grader blade or if any portion is still found to be unevenly mixed, adjustment shall be made by hand or, if required, by replacing the material.

c. The trimmed layer shall be compacted with a macadam roller weighing more than 10 metric tonne or other appropriate equipment as approved by the Engineer. The roller shall travel parallel to the road center line, beginning from the edges of the fill, in such a way that every two successive tracks will overlap by half of the roller width. Where roller compaction is impracticable, approved mechanical tampers or other compacting equipment shall be used.

d. Each layer of the sub-base shall be compacted for its full width until the dry density is greater than or equal to 95 percent of the maximum density as determined in accordance with the Modified Proctor Test (Moisture-Density Relation Test) by JIS A 1210 or AASHTO T 180 Method D, and the grains are in sufficient contact.

e. If surface irregularities are found after compaction, the irregular portion shall be scarified, replaced wholly or in part with better graded material, and recompacted. The surface shall then be graded again by grader or by hand and further compacted, repeating the operation till the specified density and dimensions are obtained. In the process of such alternate grading and compacting, water may be sprinkled if required. When placing the second layer upon the first layer, the surface of the first layer shall have the appropriate moisture content. The checking of the elevation and width shall be made at every 20 m and 50 m respectively along the road center line.

10.8.3 Testing

a. The finished crushed stone sub-base shall be checked for thickness by the Contractor in the presence of the Engineer by drilling check holes. The drill holes will be spaced at distances not exceeding 50 m. The average thickness as revealed by the holes shall not be less than 95 percent of the designed thickness and in no cases shall the thickness be less than 90 percent of the designed thickness. Any portion failing to meet the above standard shall be scarified and reconstructed by and at the expense of the Contractor.

b. After compaction the dry density of each layer of sub-base shall be tested in accordance with Sub-Clause 10.8.2.d of this Clause by the Contractor in the presence of the Engineer at intervals of 50 m along the road center line at locations directed by the Engineer.

10.8.4 Measurement and Payment

a. Measurement, for payment, of crushed stone sub-base will be made of the volume in cubic metres of the crushed stone sub-base constructed as shown on the Drawings or as directed.

b. Payment for crushed stone sub-base will be made at the rate per cubic metre tendered in the in the Bill of Quantities (Item J.3) which rate shall include the cost of furnishing, hauling, spreading and compacting the material, testing and of all other labour and equipment incidental to the work.

10.9 PENETRATION MACADAM BASE COURSE

10.9.1 General

The Contractor shall construct the penetration macadam base course of 100 mm thick after compaction between the top of the sub-base and the underside of the bituminous surface course or the concrete wearing course as the case may be.

10.9.2 Materials

a. The Contractor shall test all paving materials before their use in the construction. The Contractor shall furnish samples as well as the manufacturer's specifications for such tests. No material shall be delivered to the jobsite or used in the construction before its adequacy has been ascertained and approved by the Engineer. During construction the Contractor shall furnish, as required by the Engineer, sample materials for further tests, and materials found to be unsatisfactory shall be hauled away from the jobsite by and at the expense of the Contractor.

b. For the prime coat, the medium-curing asphalt MC-70 conforming to the requirement of AASHTO M 82, ASTM D 2027 or JRA shall be used. MC-70 shall be heated in open boiler at a general temperature of 50 to 70°C and shall be placed at the rate of 0.8 to 1.6 litres per square meter.

c. The asphalt cement shall be of 85 to 100 or 80 to 100 penetration grade and shall conform to the requirements of AASHTO M 20 and ASTM D 946 or JIS K 2207, respectively. Heating temperature shall be between 135°C and 195°C or as determined by the Engineer.

d. The aggregate shall be crushed gravel or rock classified into coarse aggregate, filler and chip, each having the following grading:

Coarse Aggregate (either A or B)

Classi-fication	Sieve Size and Percentage Passing by Weight						
	60mm (2-½")	50mm (2")	40mm (1-½")	25mm (1")	20mm (¾")	13mm (½")	5mm (No.4)
A	100	70-90	50-70	25-45	15-35	0-15	0-5
B		100	65-85	35-55	15-35	0-15	0-5

Intermediate Aggregate for Filler

Classi-fication	Sieve Size and Percentage Passing by Weight					
	20mm (¾")	13mm (2")	9.5mm (⅜")	5mm (No.4")	2.5mm (No.8)	1.2mm (No.16)
C	100	90-100	45-75	5-25	0-10	0-5

Fine Aggregate for Chip

Classi-fication	Sieve Size and Percentage Passing by Weight				
	20mm (3/8")	5mm (No.4)	2.5mm (No.8)	1.2mm (No.16")	0.3mm (No.50)
D	100	85-100	10-40	0-10	0-10

The aggregate shall be hard, dry, clean and free from organic impurities or other objectional matter.

The proportion of excessively flat or elongated grain shall not be more than 10 percent, where an excessively flat grains is defined as one with thickness smaller than half the average thickness of grains of similar size and an excessively elongated grain is defined as one with its length larger than two times its breadth.

When subjected to the Los Angeles abrasion test, the rate of abrasion shall not be larger than 40 percent.

The stripping resistance of the aggregate, when mixed with asphalt cement, shall not be smaller than 95 percent.

e. Unless otherwise approved, the quantity of materials required for penetration macadam of 50 mm thick after compaction shall be as follows:

Coarse Aggregate	:	0.050 m^3/m^2
Asphalt Cement	:	2.30 l/m^2
Filler	:	0.015 m^3/m^2
Asphalt Cement	:	1.30 l/m^2
Chip	:	0.010 m^3/m^2
Asphalt Cement	:	1.00 l/m^2
Chip	:	0.005 m^3/m^2
Total Aggregates	:	0.08 m^2l/m^2
Total Asphalt Cement	:	4.60 l/m^2

10.9.3 Construction

a. Construction work shall be performed by dividing the depth of base course into two layers each 50 mm thick and proceeding in the following order:

(i) Clean and repair crushed stone sub-base or rock surface as applicable;

(ii) Place prime coat of MC-70;

(iii) Spread and compact coarse aggregate;

(iv) Perform first spraying of asphalt cement;

(v) Spread and compact filler;

(vi) Perform second spraying of asphalt cement;

(vii) Spread and compact first layer of chip;

(viii) Perform third spraying of asphalt cement;

(ix) Spread and compact second layer of chip;

(x) Repeat process (iii) to (ix) for second layer of base course;

(xi) Perform additional compaction.

b. Construction of penetration macadam base course shall be performed in fine weather when the ambient temperature is 15°C or higher and wind velocity is below 16 kilometres per hour. Work shall not be performed on a wet surface or with wet aggregate nor on a day with the probability of rain.

c. Before applying the prime coat, the sub-base surface shall be graded and compacted to remove all irregularities and the compacted density shall not be less than 95 percent of the maximum dry density all in accordance with Clause 10.8.3. The surface shall be thoroughly cleaned with brooms or other equipment.

d. The bitumen for each layer shall be applied in the quantities specified in Sub-Clause 10.9.2. Bitumen shall be heated to the required temperature and applied evenly by means of a distributor. The road clearance of the nozzle and the distributor shall be adjusted to factory specifications, usually about 30 cm. The machine shall be checked for speed and accuracy of control devices prior to its use. At each end of the section upon which bitumen is to be applied, a sheet of heavy paper shall be placed to avoid uneven application of bitumen at the ends. After spraying is completed for the section, the paper shall be removed and burned without delay. Care shall be exercised so that from 20 to 30 litres of bitumen will remain in the tank shall be waster in places designated by the Engineer and covered with earth. If the spraying machine becomes clogged during the spraying operation, the application of bitumen shall be continued by means of hand tools. If the bitumen applied for any layer is insufficient in quantity, it may be supplemented in the application for the next layer. However, the application shall not be reduced for any layer on account of over-application for the preceding layer. During the spraying operation, the Contractor shall use approved methods to prevent staining the structures or vegetation nearby. Any staining that does occur shall be immediately removed by and at the expense of the Contractor.

e. The aggregate for each layer shall be place evenly in the specified quantities by spreader and graded to the lines and grades shown on the Drawings. The transportation and windrowing of material shall be such that the time lapse between bitumen application and aggregate placement shall be as specified in paragraph g. of this Subclause. The spread aggregate shall be graded by grader or broom and projecting rock fragments or excessively flat or elongated material shall be removed by hand. The removal by hand of unsuitable particles shall continue during compaction till all the aggregate has even grading on the compacted surface.

f. Compaction after aggregate spreading shall be performed first by one pass of a tyre roller and then, after brooming, by macadam roller weighing 10 metric tons, repeating the process until the layer is sufficiently hard and compact as determined by the Engineer. Compaction shall begin from the edges of the layer. The roller shall travel in directions parallel to the road center line in such a way that each roller track shall overlap with the immediately preceding and adjacent track by half the width of the track. Where roller compaction is impracticable, compaction shall be performed by mechanical tamper.

The height of the compacted surface shall not deviate from the designed lines and grades by more than 1.0 cm. Any portion failing to meet this requirement shall be scarified and recompacted by and at the expense of the Contractor. The travelling speed of the roller shall not exceed 5 km per hour and sharp turns or sudden application of the brake shall not be made by the roller while performing compaction.

g. The brooming of the prime coat before spreading the coarse aggregate shall be performed 24 to 48 hours after the application of the prime coat and only after the prime cost has sufficiently dried. A limited amount of sand as determined by the Engineer may be sprinkled on the prime coat to make further work possible if it necessary to perform further work without waiting for the prime coat to dry sufficiently. Excess sand shall be removed by brooming prior to spreading of the coarse aggregate.

h. The filler shall be placed within 15 minutes after completion of the first spraying of asphalt cement. Similarly, placing of the first-layer chip and the second-layer chip shall follow within 15 minutes after the second and the third applications of asphalt cement, respectively.

i. Within 10 days after placing and compacting the second-layer of the base course, additional compaction shall be performed with a 10 tonne roller.

j. After completion of placing and compacting the second-layer of the base course the road shall be closed to traffic for at least 48 hours. If, for progress of the work, it is impracticable to close and the road to traffic, a speed limit of 20 kilometres per hour shall be imposed on all vehicular traffic for at least 48 hours.

10.9.4 Measurement and Payment

a. Measurement, for payment, of penetration macadam base course shall be made of the volume in cubic metres of penetration macadam base course placed as shown on the Drawings or directed.

b. Payment for penetration macadam base course will be made at the rate per cubic metre tendered therefor in the priced of Bill of Quantities (Item J.4) which rate shall include the cost of application of prime coat, testing, furnishing and transporting material, placing, brooming, grading, compacting and traffic control, and all other materials, labour and equipment incidental to the work.

10.10 HOT ASPHALT MIX SURFACE COURSE

10.10.1 General

The Contractor shall construct the surface course of dense graded asphalt concrete to the lines, grades and dimensions as shown on the Drawings or directed by the Engineer.

10.10.2 Bituminous Tack Coat

A bituminous tack coat shall be placed between the existing bituminous penetration macadam base course surface or concrete surface and bituminous surface course. Rapid-curing cutback asphalt RC-250, conforming to the requirement of AASHTO M 81, ASTM D 2028, or JRA, shall be used for the tack coat. RC-250 shall be placed by a distributor as specified in Clause 10.9 at a rate of 0.4 to 0.8 litre per square metre and the application temperature of the RC-250 shall be 60 to 100°C.

10.10.3 Materials

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

Stability	900 kg
Flow	2.5 – 4.0 mm
Voids in Total Mix	3 – 5%
Voids Filled with Asphalt	75 – 85%

b. The grading of the aggregate shall be as follows:

Sieve Designation	Percentage Passing by Weight
25 mm (1")	100
20mm (3/4")	95 – 100
13mm (1/2")	75 – 90
5mm (No.4)	45 – 65
2.5mm (No.8)	35 – 50
1.2mm (No.16)	18 – 29
0.6mm (No.30)	10 – 21
0.3mm (No.50)	6 – 16
0.074 (No.200)	4 – 8

c. Design of Hot Asphalt Mixes

(i) The design of hot asphalt mixes shall be undertaken by the Contractor. The design of the mixes shall be carried out in the Contractor's Laboratory or another laboratory approved by the Engineer. The design of the hot asphalt mixes shall be undertaken on the basis of trial mixes prepared and tested according to standard Marshall methods in the presence of the Engineer.

When tested according to the Marshall method and calculated by the prescribed method the test properties of the specimens shall have the values in paragraph a. of this Sub-Clause.

(ii) Based on these tests results and before stockpiling aggregate, the Contractor shall submit a proposed job-mix formula for the approval of the Engineer. The formula submitted shall propose definite single values for:

- the percentage of aggregate passing each specified sieve;
- the percentage of bituminous material to be added, on the total aggregate basis;
- the temperature of the mixture leaving the mixer;

- the temperature of the mixture delivered on the road; and
- the grading of bituminous material.

d. Values shall be proposed within the limits specified for the particular type of bituminous concrete called for. The Engineer will determine a job-mix formula with single values 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:

Aggregate passing the No. 4 and larger sieve	± 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 mixer	± 6°C
Temperature delivered on the road	± 6°C

e. Whenever tests 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 undertake further testing in accordance with paragraph c. of this Sub-Clause and prepare another new job-mix formula for the approval of the Engineer and the Engineer shall 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 prior to final incorporation into the work.

f. The coarse aggregate, as retained on 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. The percentage of wear, when tested according to the Los Angeles abrasion test by ASTM C 535, JIS A 1121 or AASHTO T 96, shall not more than 40 percent. The sodium sulphate soundness loss shall not exceed 9 percent nor shall the magnesium sulphate loss exceed 12 percent. 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 fractured face.

g. The fine aggregate, defined as the fraction passing No.8 sieve, shall have general characteristics and soundness in accordance with AASHTO M 29, ASTM D 1073, or JRA.

h. Mineral filler, when required, shall consist of limestone dust, Portland cement or other non-plastic mineral material from sources approved by the Engineer. 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:

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

(i) Asphalt cement shall be of penetration grade 60 –70 and shall conform with the requirements of AASHTO M 20, ASTM D 946 or JIS K 2208.

10.10.4 Construction

a. Preparation of Bituminous Mixture

(i) Mixture aggregates shall be dried and heated at the paving plant before entering the mixer. When introduced into the mixer, the combined aggregates for asphalt mixture shall contain not more than 0.5 percent moisture.

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

(iii) 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 of the calibrated amount for a 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.

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

(v) Mixing shall continue for the time necessary to coat all particles uniformly as approved by the Engineer. This time is dependent upon the mix design and type of mixing equipment used. To compute the mixing time in a continuous mixer, the weight of its contents at operating level is divided by the weight of mixture delivered per second by the mixer as follows:

$$\text{Mixing Time in seconds} = \frac{\text{Pugmill Dead Capacity in kilogram}}{\text{Output in kilogram per second}}$$

(vi) The Engineer will direct control testing to be undertaken by the Contractor on days when hot asphalt mix in being placed. The Engineer shall direct the frequency of control testing on the basis of the daily production volume. All control testing shall be in accordance with current ASTM procedures and be within the limits specified in Sub-Clause 3. Of this Clause.

b. Transportation and Delivery of the Mixture

(i) Trucks used for hauling bituminous mixtures shall have tight, clean and smooth metal beds. To prevent mixtures from adhering to them, bed 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.

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

(iii) Loads shall not be dispatched from the mixer when the work of spreading and compacting bituminous mixture is expected to be done during the hours before sunset unless artificial lighting as approved by the Engineer is provided.

(iv) Mixtures shall be delivered to the work site at a temperature within the tolerances required by the approved job-mix formula.

c. Spreading and Laying

(i) Immediately before placing bituminous mixture, the existing underlying base course or concrete surface shall be cleaned of loose or deleterious material using a power sweeper equipped with a blower, supplemented with hand brooms if necessary, or removed by other means as directed by the Engineer.

(ii) The mixture shall be laid only upon an approved underlying course which is thoroughly dry and in suitable condition and only when weather conditions are fair unless otherwise directed by the Engineer. The bituminous tack coat shall be placed immediately ahead of the bituminous paver as approved by the Engineer.

(iii) Placing shall commence at points farthest from the mixing plant and progress continuously toward the plant unless otherwise ordered by the Engineer. Hauling over material already place shall not be permitted until the material has been thoroughly compacted as specified and allowed to cool to atmospheric temperature.

(iv) Upon arrival at the point of placement, 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 grade and surface contour required.

(v) 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 which will meet the specified thickness, smoothness and grade, and shall also be equipped with an automatic line and grade controlling device. 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 a distribution system to place the mixture uniformly in front of the screed. The screed or strike-off assembly shall effectively produce a finished surface of required evenness and texture without tearing, shoving, or gouging. The paver shall be capable of operating at forward speeds consistent with the satisfactory laying of the mixture and the paver spread shall be regulated to eliminated pulling and tearing of the bituminous material.

(vi) Mixture shall be placed in strips not less than 3 meters or at least half the width of the road pavement surface. To ensure proper

drainage, spreading shall begin along the pavement center line on a crowned section or on the high side of a pavement with a one-way slope.

(vii) After the first strip 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 metre straightedge shall be placed across the longitudinal joint to determine if the surface conforms to the grade and contour requirements.

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

d. Compaction of Mixture

(i) After spreading, the mixture shall be thoroughly and uniformly compacted with power rollers as directed by the Engineer. Rolling shall begin after spreading 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 spread and continue toward either edge. On subsequent strips laid, rolling shall start from the edge adjacent to the previously laid material and continue toward the opposite edge.

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

(iii) Sufficient rollers shall be furnished and operated to handle plant output. Each paver used shall work in conjunction with at least two road rollers, a steel drummed roller for breakdown rolling and a multi-tyred roller for finish rolling. Rolling shall continue until all roller marks are eliminated, the surface is of uniform texture and true to grade and cross section, and a field density is achieved of not less than 98 percent 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 T 166. The method of sampling the mixture and the compaction of specimens shall be in accordance with AASHTO T 168 and AASHTO T 245 respectively. Field density tests shall be made at least twice daily.

(iv) In areas not accessible to rollers, the mixture shall be thoroughly compacted with hot mechanical tampers to provide an equivalent finished surface quality of texture, line and grade.

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

e. Joint, Trimming, Edges, and Cleanup

(i) Placing of the bituminous paving shall be as continuous as possible. Rollers shall not pass over the unprotected and freshly laid mixture unless authorised by the Engineer. Transverse joints

shall be formed by cutting back on the previous run to expose the full depth of the course. When 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.

(ii) 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 by the Contractor as directed by the Engineer.

10.10.5 Completion Test

a. Surface Test

(i) 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.

(ii) 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 with new material as directed by the Engineer and shall be at the expense of the Contractor.

(iii) Finished surfaces shall not vary the design elevations by more than 2.5 mm when tested with a crown template and a 3 m, straight-edge furnished by the Contractor. Tests shall be performed at 25 m intervals along the road center line or as directed.

(iv) The width shall not be less than 25 mm of the design section measured at 50 m intervals.

b. Thickness Tests

(i) The total thickness of each completed course of asphalt concrete shall be determined by core tests conducted by the Contractor for each completed layer taken at places designated by the Engineer. One core test is required for every 1000 m² of area paved with a minimum of one core test for each day's production. The thickness shall not be 5 mm less than the designed depth for any one test and not less than 2.5 mm for an average of 10 tests.

(ii) When deficiencies in either elevation or thickness exceeds the specified tolerance, the Contractor shall remove and replace the asphaltic mix surfacing with new material, as directed by the Engineer, and all costs shall be at the expense of the Contractor.

10.10.6 Measurement and Payment

a. Measurement, for payment, of hot asphalt mix surface course shall be made of the area of surfaces covered by hot asphalt mix as shown on the Drawings or as directed by the Engineer.

b. Payment for hot asphalt mix surface course will be made the applicable rate per square meter tendered therefor in the priced Bill of Quantities (Item J.5) which rate shall include the cost of all labour, materials,

equipment and incidentals for application of tack coat, for planning, testing, furnishing, transportation, placing, compacting and finishing of asphalt concrete t the specified thicknesses, for traffic control, and all other necessary works connected therewith.

10.11 CONCRETE PAVEMENT

10.11.1 General

The Contractor shall construct the reinforced concrete pavement of 150 mm thickness on the top of the sub-base to the lines, grades and dimension as shown on the Drawing or as directed by the Engineer.

10.11.2 Materials

a. Concrete for the reinforced concrete pavement shall be Type-D concrete as specified in Section 9 of this Specification.

b. Reinforcement bar or other deformed steel bar shall be the reinforcement bar specified in Section 9 of this Specification.

c. Welded wire mesh shall be the steel mesh reinforcement having the wire size and pitch as shown on the Drawings complying with AASHTO M 55 (ASTM A 185) weld steel wire Fabric for Concrete.

d. Other metals including round bar (slip bar, cross bar, chair, etc.), tie bar with screw painting, cap and others necessary to complete joint shall be as specified for miscellaneous metalwork in Section 11 of this Specification.

e. Joint filler and joint sealant shall be as specified in Clause 9.21 of this Specification.

f. For the prime coat, medium-curing cut-back asphalt MC-70 conforming to the requirements of AASHTO M 82, ASTM D 2027 or JRA shall be used.

10.11.3 Construction

a. Construction work shall be performed in the following sequence

(i) Clean and repair crushed stone sub-base;

(ii) Apply prime coat of MC-70 on the sub-base;

(iii) Install reinforcement, chairs, joint, forms, etc.;

(iv) Place Type-D concrete; and

(v) Compact and cure concrete pavement.

b. Before applying the prime cost, the sub-base surface shall be graded and compacted to remove all irregularities and the compacted density shall not be less than 95 percent of the maximum dry density all in accordance with Clause 10.8. The surface shall be thoroughly cleaned with brooms or other equipment.

c. Prime coat shall be heated in an open boiler to a temperature of 50°C to 70°C then applied to the prepared surface at a rate of 0.8 to 1.6 litre per square metre as directed.

d. The brooming of the prime coat before placing the concrete shall be performed 24 to 48 hours after application of the prime coat and only after the prime cost has sufficiently dried. A limited amount of sand as

determined 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 prior to placing the reinforcement bar.

e. The concrete shall be placed evenly to the lines and grades shown on the Drawings. The concrete shall be adequately compacted to the satisfaction of the Engineer. The surface shall be broomed to create a non-skid surface. All concrete work shall be in accordance with the requirements of Section 9 of the Specification.

10.11.4 Measurement Payment

a. Measurement, for payment, shall be made of the area in square metres of the completed reinforced concrete road.

   Measurement will not be made of the volume of prime coat, metalwork, steel reinforcement dowel bars nor any other item incorporated in the concrete pavement.

b. Payment for the production and construction of concrete pavement, 150 mm thick shall be made at the rate per square metre tendered therefor in the Bill of Quantities (Item J.6) which rate shall include the cost of all materials, labour and equipment for completing the work, for planning, preparation, application of prime coat, testing, furnishing, placing, compacting, testing reinforcement, dowel bars, metalwork, joint filler and all other necessary work corrected therewith.

10.12 GUARD RAIL

10.12.1 General

The Contractor shall furnish and install Guard Rail on the crest of the Dam Embankment and along permanent access roads and parking areas as shown on the Drawings or directed by the Engineer.

10.12.2 Requirements

a. Guard Rail shall be as shown on the Drawings or approved by the Engineer, supported on precast concrete posts as shown on the Drawings. The end of each run of Guard Rail shall be provided with terminal end sections.

b. Bolts and nuts required for the erection of the Guard Rail shall be furnished by the Contractor.

c. The concrete posts shall be set to the depths shown on the Drawings and shall be firmly in place by compacted earth or concrete. Each installed Guard Rail shall be true to line, level and grade.

d. The Guard Rail and all metalwork used in its erection shall be furnished galvanised.

10.12.3 Measurement and Payment

a. Measurement, for payment, of furnishing and installing Guard Rail shall be made of the length along the centerline of the Guard Rail.

   Payment for furnishing and installing Guard Rail will be made at the rate per linear metre tendered therefor in the Bill of Quantities (Item J.7). This rate shall include the cost of furnishing the Guard Rail and concrete

posts and all labour and materials required for installing the posts and Guard Rail in accordance with the requirements of this Clause including excavation of post holes and the placing of compacted fill and concrete around posts.

CONSTRUCTION OF THE JATIBARANG MULTIPURPOSE DAM

PACKAGE 1: JATIBARANG MULTIPURPOSE DAM INCLUDING APPURTENANT STRUCTURES

SPECIFICATION

SECTION 11. FURNISHING AND INSTALLING METALWORK

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SECTION 11. FURNISHING AND INSTALLING METALWORK

11.1 FURNISHING AND INSTALLING METALWORK - GENERAL

11.1.1 The Requirement

The Contractor shall design, furnish and install metalwork as shown on the Drawings or directed and the detailed requirements of this Section.

11.1.2 Standards

a. Except as otherwise specified, all material and methods of fabrication shall conform to the standards listed in Table 11.1.2.

TABLE 11.1.2 – STANDARDS FOR METALWORK

Item	Standard
Structural Steel	ASTM A 36 or JIS G 3101 SS 41
Steel Pipe (Black)	ASTM 120 Schedule 40 or JIS G 3444
Bolt and Nut	ASTM A 307 Grade A or JIS B 1180
Arc Welding Electrode	AWS, JIS Z 3211
Gas Welding Electrode	AWS, JIS 3201
Steel Plate	JIS G 3106 SM 41
Stainless Steel Plate	JIS G 3404-3407 SUS 304

b. Where items of metalwork are not covered by the standards in Table 11.1.2, the applicable standards in Section 13 of the Specification shall be used or as directed or approved by the Engineer.

11.1.3 Drawings for Metalwork

a. Standard details of metalwork are shown on the relevant Drawings for the various major structures.

b. No further detailed drawings for metalworks other than those included in the Tender Documents will be provided by the Engineer. The Contractor shall perform all necessary design and provide the complete shop drawings required for the fabrication and installation of all metalwork. Any fabrication or procurement of items prior to approval of the design and shop drawings and supporting data shall be at the Contractor's risk.

c. All shop drawings and designs prepared by the Contractor shall be submitted in accordance with Clause 1.4.

11.1.4 Fabrication

a. Metalwork shall be shop-fitted and shop-assembled where possible and shall conform to the details on the approved shop drawings.

b. 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.

c. 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 or plastic plugs will not be permitted.

d. All welding shall be performed by operators who have been tested and meet the requirements of the American Welding Society (AWS), JIS Z 3801, JIS Z 3821, JIZ Z 3841, or approved equivalent. 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 AWS or approved equivalent.

e. 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.

11.1.5 Embedment of Metalwork

a. Metalwork to be embedded in concrete shall be secured in position and embedded when the concrete is being placed or, if shown on the Drawings or directed, recesses or blockouts shall be made in the concrete and the metalwork shall be grouted in place using a non-shrink cement grout or mortar or embedded in second-stage concrete.

b. The surfaces of all metalwork to be in contact with concrete shall be thoroughly cleaned immediately before the grout, mortar or concrete is placed and shall be prepared in accordance with Sub-Clause 11.1.6.

c. Metalworks shall be accurately positioned and aligned to the tolerances specified in Clause 9.24 or as shown on the Drawings or approved shop drawings, and shall be held securely in the correct position during placing and setting of the concrete.

d. Where it is impracticable to place anchors or anchor bolts required for the installation of comparatively light metalwork when the concrete is placed, holes shall be drilled into the concrete after it has set for 28 days and expansion bolts, adhesive anchor bolts, or other approved anchors shall be installed. For galvanized metalwork, galvanized expansion bolts or adhesive anchor bolts shall be used. For painted metalwork, corrosion-resistant steel expansion bolts or adhesive anchor bolts shall be used.

11.1.6 Non-shrink Grout or Mortar and Dry-pack for Metalwork

a. Non-shrink grout or mortar, or dry-pack for metalwork shall be mixed in the proportions and to the consistency directed. The Contractor shall furnish cement and fine aggregate complying with Clause 9.3, 9.4 and 9.5 for all grout, mortar or dry-pack. The cost of materials for and the mixing and placing of non-shrink grout, mortar or dry-pack shall be included in the rates tendered in the Bill of Quantities for furnishing and installing the various items of metalwork for which the grout, mortar or dry-pack is required.

b. Before placing grout, mortar or dry-pack, the surfaces of existing concrete on which the grout, mortar or dry-pack will be placed shall be roughened and shall be cleaned of all laitance, loose or defective concrete coatings and other foreign material by approved means

followed by thorough washing. Such surfaces shall be kept moist for at least 24 hours immediately before placing grout, mortar or dry-pack.

11.1.7 Protective Coatings

a. Except where otherwise specified, all metalwork shall, on completion of fabrication and inspection by the Engineer, be hot dipped galvanized at a rate of 0.6 kilograms per square meter and galvanizing shall be performed in accordance with ASTM A 123 or JIS H 8641.

b. In metalwork which is to be hot dipped galvanized:

(i) after fabrication all joints which are not already welded shall be seal-welded; and

(ii) tapped holes shall be tapped slightly oversize and tapped again to the correct size after galvanising.

c. Any metalwork to be painted shall be cleaned of loose mill scale, loose rust and other foreign matter by approved mechanical means. Oil and grease deposit shall be removed by solvents. Surface preparation shall be in accordance with Table 11.1.7.

Any part of metalwork to be embedded in concrete shall not be painted, except as specified in Clause 12.17, but shall be cleaned in the same manner and protected in accordance with Sub-Clause 11.1.4.

Immediately after fabrication and inspection by the Engineer, all ungalvanized ferrous metal, unless otherwise provided in the Specification, shall be cleaned and shop coated in accordance with Table 11.1.7. After painting at the shop, touch up coat and the final two coats of approved paint system shall be applied to the exposed surfaces of metal in place in accordance with Table 11.1.7. The dry film thickness of each coat of paint shall be in accordance with the Table 11.1.7.

d. For galvanized pipe for handrails and drain pipes, painting will not be required except for approved field weld joints and two coats of approved zinc rich epoxy primer paint shall be applied subject to the requirements of paragraph e. of this Sub-Clause.

TABLE 11.1.7 PAINT SYSTEM

Location	Site	Process	General Name	No. of Coats	Coating Interval (at 20°C)	Dry Film Thickness (micron/coat)	
						Ave	Min
Exposed Portion	Shop	Surface Preparation	Commercial Cleaning (SSPC-SP6)				
		Primer Coat	Wash Primer of Long Exposure Type	1	4 hours to 3 months (Note: Excluding casting and forging steel)	20	15
		1st coat	Red Lead Anti-Corrosive Paint	1	24 hours to 3 months	35	25
		2nd Coat	Red Lead Anti-Corrosive Paint	1	24 hours to 3 months	35	25
	Field	Surface Preparation	Power Tool Cleaning (SSPC-SP3)		Note: Damaged areas and Welded Area		
		Touch-up	Wash Primer of Long Exposure Type	1	4 hours to 3 months (Note:-ditto-)	20	15
		Touch-up	Red Lead Anti-Corrosive Paint	2	24 hours to 3 months (Note:-ditto-)	35	25
		3rd coat	Alkyd Resin Paint	1	15 hours to 1 month	25	20
		4th coat	Alkyd Resin Paint	1		25	20

e. All galvanized metal surfaces shall be acid-etched prior to the application of the finishing surface coats:

f. The Contractor shall submit details of his proposed paint systems in accordance with Table 11.1.7.

g. The Contractor shall test all protective coatings in accordance with the requirements of Section 12 of the Specification except that the frequency of testing shall be increased as directed by the Engineer to provide adequate testing for the smaller areas being coated.

11.1.8 Checkout Sheet

At least 7 days before placing concrete in any structure or installing any metalwork, the Contractor shall submit, for approval, 3 copies of an approved check 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.

11.1.9 Measurement and Payment

a. Except where otherwise specified measurement, for payment, for furnishing and installing the various items of metalwork described in this Clause shall be made of the nominal calculated mass of the items to be installed or taken from receipted invoices, copies of which shall be supplied to the Engineer.

b. Except where direct payment is specified, the cost of furnishing and installing metalwork which is a minor part of an item of metalwork shown in the priced Bill of Quantities shall be included in the rate tendered for the item to which it is appurtenant.

c. During the course of the Contract, the Contractor may be required to furnish miscellaneous items of metalwork which are not mentioned in the Specification. Payment for these items of metalwork will be made at the appropriate rates tendered in the Bill of Quantities for similar items of work.

d. The cost of preparing designs, shop drawings and data for metalwork and submitting designs, shop drawings and data to the Engineer shall be included in the rate tendered in the Bill of Quantities for the item to which it is appurtenant.

11.2 MISCELLANEOUS METALWORK

11.2.1 General

The Contractor shall furnish miscellaneous metalwork as described in this clause in accordance with the Drawings or as directed.

11.2.2 Materials

a. All materials for metalwork shall be fabricated, installed and treated for corrosion protection in accordance with Clause 11.1.

b. Stainless steel pipe shall comply with the relevant JIS standard and shall be subject the Engineer's approval.

11.2.3 Items to be Furnished and Installed

a. Miscellaneous Metalwork, Galvanised

- Grating including that in the gallery, air shaft etc.

- Steps and steel ladders including those in airshaft, tailrace gate tower etc.
- Cable duct steel covers
- Cable tray in the gallery
- Handrail in the gallery

b. Miscellaneous Metalwork Painted in Accordance with Sub-Clause 11.1.7

- Handrails for the intake and tailrace gate
- Drainage pipe100 mm and 125 mm dia in hydropower station
- Drainage pipe 40 mm dia. in the gallery
- Spiral staircase in the hydropower station
- Fence posts

c. Miscellaneous Metalwork (Stainless Steel)

- 150 mm dia drainage pipe in the hydropower station

11.2.4 Measurement and Payment

Measurement of the mass in kg of miscellaneous metalwork (galvanized) and miscellaneous metalwork (anti-corrosion painting) and miscellaneous metalworks (stainless steel) shall be determined in accordance with Sub-Clause 11.1.9.

Payment for miscellaneous metalwork, (galvanised), (anti-corrosion painting) and (stainless steel), (Items K1, K2, K3) shall be made in accordance with Sub-Clause 11.1.9.

11.3 MISCELLANEOUS METALWORK FOR DIVERSION TUNNEL PLUG

11.3.1 General

The Contractor shall furnish and install metalwork for the diversion tunnels plug as shown on the Drawings or directed.

11.3.2 Materials

All materials for metalwork shall be fabricated, installed and treated for corrosion protection in accordance with Clause 11.1.

11.3.3 Items to be Furnished and Installed

The items to be furnished and installed by the Contractor shall include:

a. Header and return pipes and air outlet pipes 40 mm diameter and 25 mm riser pipes and joint grout outlets for the tunnel plug grouting works in accordance with Clause 5.10.

b. Cooling pipes 25 mm diameter thin walled steel pipes for cooling tunnel plug concrete in accordance with Clause 9.11.11.

c. Drain pipe 150 mm diameter with valve.

d. Other miscellaneous metalwork shown on the Drawings or directed.

11.3.4 Payment

Payment for furnishing and installing miscellaneous metalwork for the diversion tunnel plug will be made at the Lump Sum price tendered therefor in the Bill of Quantities (Item K4.1). The price shall include the cost of all labour, equipment and materials, regardless of the types of steel for the respective items required for furnishing, fabricating, installing and painting and galvanizing the metalwork, drilling holes in concrete tunnel lining for special grout outlets and all incidentals thereto.

11.4 MISCELLANEOUS METALWORK FOR ADIT FILLING

11.4.1 General

The Contractor shall furnish and install metalwork for the grouting of the concrete filling of adits as described in Clause 5.11 as shown on the Drawings or directed.

11.4.2 Materials

All materials for metalwork shall fabricated, installed and treated for corrosion protection in accordance with Clause 11.1.

11.4.3 Items to be Furnished and Installed

The items to be furnished and installed by the Contractor shall include:

Header and return pipes and air outlet pipes 40 mm diameter and 25 mm riser pipes and joint grout outlets for the grouting works for the concrete filling of adits in accordance with Clause 5.11.

11.4.4 Payment

Payment for furnishing and installing miscellaneous metalwork for the adit concrete filling will be made at the Lump Sum price tendered therefor in the Bill of Quantities (Item K4.2). The price shall include the cost of all labour, equipment and materials, regardless of the types of steel for the respective items required for furnishing, fabricating, installing and painting and galvanizing the metalwork and all incidentals thereto.