TECHNICAL SPECIFICATIONS

FOR

"CONSTRUCTION OF PROJECT ROADS FOR RESSING HEP (12 MW) in LAPORIANG CIRCLE, PAPUMPARE DISTRICT ARUNACHAL PRADESH DURING 2023-24"

M/S GEKAM POWER PRIVATE LIMITED

B-SECTOR, NAHARLAGUN

ARUNACHAL PRADESH

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2.0 ROADS

2.1 General

Road works to be upgraded/constructed under the Contract comprise:

1) construction of permanent areas around structure sites, maintenance and access roads, and roadways linking structure sites to nearby public roads, paved with flexible asphalt cement wearing course or bitumen surface treatment, either granular or asphalt cement base course, and granular sub base course, to the lines, levels, grades and dimensions shown on the Construction Drawings;
2) any local reinstatement of existing asphalt cement paved roadways required including the base and sub base courses, to the lines, levels, grades and dimensions shown on the Construction Drawings;
3) the provision, and subsequent removal upon completion by the Contractor, of all necessary temporary access roads, traffic diversion and protection work's and the like, including the granular or other wearing surface as approved by the Employer's Representative, to satisfy the works programme of the Contractor.

2.1.1 Survey and Setting Out of the Works

The Contractor shall be responsible for survey and setting out the Works during construction to give accurate and continuous control of slopes, design profiles and levels.

2.1.2 Definitions and Terms

For the purposes of this Section of the Specifications the following terms, words or expressions shall have the meanings hereby assigned to them:

Base: A layer of material constructed on top of the subbase, or in the absence thereof, the selected layer.A base may extend to outside the travelled way.

Borrow Area: An area within designated boundaries, approved for the purpose of obtaining borrow material. A borrow pit is the excavated pit in a Borrow area.

Borrow Material: Any rock, gravel, sand or soil obtained from borrow areas, dumps or sources other than cut within the road prism and which is used in the construction of the Works, but not including crushed stone or sand obtained from commercial sources.

Carriageway: The surface normally traversed by vehicles and which consists of one or a number of contiguous traffic lanes, including where appropriate auxiliary lanes and shoulders.

Catchwater Drain or Bank: A longitudinal drain or bank outside the road prism for diverting water that would otherwise flow onto the road prism.

Culvert: A structure other than a bridge, which provides an opening under the carriageway or median fordrainage or other purposes.

Cut: Cut shall mean all excavation from the road prism including side drains, excavations for cross- roads, interchanges, and, where classified as cut, excavation for open drains.

Excess Overburden: Overburden within a borrow area which is not required or is unsuitable for use in construction.

Fill: That portion of the road prism consisting of approved imported material which lies above the roadbed on which the selected layer, subbase, base and shoulders are to be constructed, and which is bounded by the side slopes, shown on typical cross-sections on the Construction Drawings, running downwards and outwards from the outer shoulder breakpoint. Material imported to replace unsuitable material in the roadbed shall also be classified as fill.

Grade Line: The grade line is a reference line in the Construction Drawings of the longitudinal sections of the road indicating at regular intervals the elevations according to which the road is to be constructed. The grade line may refer to the level of the completed road, base or any other layer and may indicate the elevations either along the carriageway centerline or along any designated position on the road cross-section.

Grading Modulus (GM): The cumulative percentages by mass of material in a representative sample of aggregate, gravel or soil retained on the 2.00 mm, 0.425 mm and 0.075 mm sieves, divided by 100.

Inlet and Outlet Drain: Channel leading into or discharging from a culvert, storm water conduit or minor bridge.

Lane: Part of a travelled way intended for a single stream of traffic in one direction, which has normally been demarcated as such by road-traffic markings.

Mitre Drain and Bank: A drain constructed at an angle to the center line of the road to divert water froma side drain. Mitre drains include mitre banks placed across the side drains.

Pavement Layers: The upper layers of the road comprising any selected layers, the subbase,granular, bituminous or asphaltic base and wearing courses, and the shoulder layers.

Pioneer Layer: An initial layer constructed over a weak roadbed where selected material is used to provide a stable platform for the construction of subsequent layers.

Roadbed: The natural in-situ material on which the fill, or in the absence of fill, any pavement layers, are to be constructed.

Road Prism: That portion of the road construction included between the original ground level and the outer boundaries of the slopes of cuttings, fills and side drains. It shall not include the selected layer, subbase, base, surfacing, shoulders or roadbed.

Selected Layer: The lower layer or layers of the pavement which is constructed direct onto the fill, or in some cases the roadbed. It may include roadbed material compacted in-situ.

Side Drain: An open longitudinal drain situated adjacent to and at the bottom of cut or fill slopes.

Shoulder: (i) When referring to this as a surface, the area between the outside edge of the base and the shoulder breakpoint.

(ii) When referring to this as a pavement layer, the upper pavement layer lying between the outside edge of the base and the shoulder breakpoint.

Shoulder Breakpoint: The line along which the extended flat planes of the surface of the shoulder and the outside slope of the fill and pavement intersect. This edge is normally rounded to a predetermined radius

Slope: Unless otherwise stated, slope is given in terms of the ratio of the vertical difference in elevation between any two points and the horizontal distance between them. This ratio may also be expressed as a percentage.

Spoil (material): Material originating from construction operations and which is not utilized for construction purposes.

Subbase: The layer of material on top of the selected layers or fill and below the base and shoulders.

Surface Treatment: The sealing of the carriageway or shoulders by means of one or more successive applications of bituminous binder or tar and crushed stone aggregate.

Verge: The area between the outer edge of the road prism and the boundary of the road reserve. Wearing Course: The natural, bituminous or asphaltic material forming the surface layer on top of the base layer.

2.1.3 Submittals

Deleted

2.1.4 Permanent Access and Maintenance Roads

Permanent roads shall be constructed on the geometric alignments and standards as detailed on the Construction Drawings and/or in accordance with the standards of Government of Arunachal Pradesh. For these road works the Contractor shall undertake earthworks, construct drainage provisions and construct the permanent pavement including, where so specified, an asphaltic concrete wearing and/or base course or a bituminous surface treatment, in accordance with the requirements of the Construction Drawings and the Specification.

2.1.5 Temporary Access Roads

Temporary access roads in addition to permanent roads may also be required by the Contractor and such roads shall be provided, maintained and removed on completion of the whole of the Works in accordance with the provisions of the Specifications and the Contract. Upon removal the land shall be landscaped and treated to return it to its original state unless otherwise approved by the Employer's Representative.

2.1.6 Maintenance of Existing Roads and New Roads

Before the Contractor brings any plant or equipment to Site he shall submit for the Employer's Representative's approval his planned routing of construction traffic on any existing roads or tracks within or in the direct vicinity of the Site, and between the Site and any sources of material outside the boundaries of the Site.

The Contractor shall be responsible for maintaining all public roads and tracks used by him to achieve access for his construction traffic to a standard not less than that prevailing at the commencement of the Contract. All such roads or tracks shall be kept open to traffic of the general public at all times. Such maintenance shall include the regular cleaning of asphaltic or bitumen surfaced roads to remove any mud, earth or rock materials or any other detritus or matter which has been deposited onto the road surface by construction traffic.

Prior to the mobilization of any plant or equipment to any part of the Site, the Contractor and the Employer's Representative shall carry out a joint inspection of all approved construction access routes which may be required for the Works in that part of the Site to agree a detailed record of the conditionof such routes. Should in the opinion of the Employer's Representative any maintenance or repair work be required on a road or track thereafter as a result of its use by construction traffic, the Contractor shall immediately carry out such maintenance or repair work at his own cost as requested by the Employer's Representative.

The Contractor's general obligations shall include for temporary traffic control facilities, maintenance of open drains, culverts, pitching, surfacing, repair of patches and rockfalls and slips of less than 1 cubic meter.

The Contractor shall maintain all new permanent access roads constructed under this Contract to the standard of completion specified herein for the duration of the construction works and immediately before demobilizing his equipment from the Site.

2.2 Materials

2.2.1 Crushed Stone

1) General

Where crushed stone is specified for subbase or base the material shall be obtained from rock quarries where the parent rock is hard, sound, durable and un-weathered and free

of deleterious material. It shall be incumbent on the Contractor to use only material which complies with the prescribed requirements of the following table.

Material Property	Layer				
	Fill layers	**Sub grade layer**	**Subbase (natural)**	**Subbase (crushed stone)**	**Base (crushe dstone)**
Particle size (maximum)	500 mm	1 x layer thickness	2/3 x layer thickness	(see grading	(see grading
Specified compaction [*] (min[m] % of in-situ dry ModAASHTO density)	90% (100% on sand)	93% (100% on sand)	97% or 95%	100%	100%
Bearing capacity (min[m] CBRat specified density)	3% (but 5% on fills higher than 9 m)	10%	40%	-*NA*-	-*NA*-
Grading Modulus (min[m])	-*NA*-	0.75	1.5	(see grading envelope)	(see grading envelope)
Plasticity Index	-*NA*-	15 max[m]	15 max[m]	6 max[m]	6 max[m]
CBR swell (max[m])	-*NA*-	-*NA*-	1% @ 100% Mod AASHTO density	-*NA*-	-*NA*-
Aggregate Crushing Value(10% FACT) (min[m]	-*NA*-	-*NA*-	-*NA*-	110	110
Flakiness Index (max[m]on -26.5 and +13.2 fraction)	-*NA*-	-*NA*-	-*NA*-	35	35
pH (min[m])	-*NA*-	-*NA*-	-*NA*-	6.0	6.0
Total water-soluble salts(max[m])	-*NA*-	-*NA*-	-*NA*-	0.5%	0.5%
Total soluble sulphates(max[m])	-*NA*-	-*NA*-	-*NA*-	0.05%	0.05%

Notes: -NA- 'Not Applicable'
[*] Density acceptance level is given in the table in Sub-section Testing

2) Testing

The minimum frequency of testing that will be required from the Contractor for the purpose of process control is as specified in the following table. The layer shall be deemed to comply with the requirements for compaction if the mean density of a set of tests as defined in this table is equal to or more than the specified lower limits for mean density, and if no single value is less than the lower limit for individual values given in this table.

Test	**Testing Frequency**		**Position or Layer**							
	One test per:	**No. of tests per set**	**Ordinary Fill**		**Selected Subgrade**		**Subbase**		**Base**	**Wearing Course**
			Natural	**sand**	**Natural**	**sand**	**Natural**	**crushed stone**	**crushed stone**	
Field Density:	Fill:1000 m^3	4								
	Other layers: 500 m^3	4								
- Specified density (%)			90.0	100.0	93.0	100	97.0	100.0	100.0	99.0
- Min^m mean density (%)			90.8	100.6	93.7	100.6	97.6	100.6	100.6	99.5
- Min^m density for any single test (%)			85.8	96.4	89.4	96.4	93.0	96.4	96.4	95.0
Indicator Test	Fill:1000 m^3	4	Maximum as specified							
	Other layers : 500 m^3	4								
Aggregatee Crushing Value	5000 m^3	4	Maximum as specified							
Flakiness	5000 m^3	4	Maximum as specified							

The grading of the crushed stone base shall be tested not less frequently than once for every 1000 m^3 of material placed, and shall always be within the following grading envelope:

Sieve Size (mm)	Percentage Passing (by weight)
50.0	100.00
37.5	93 – 100
20.0	66 – 84
14.0	53 – 74
10.0	44 – 64
5.00	30 – 49
2.36	20 – 37
0.600	10 – 24
0.075	5 – 12

2.2.2 Surfacing

1) Bituminous Base and Wearing Courses (Asphalt)

a) General

The materials specified for use in construction of bituminous pavement layers include:

- Coarse and fine mineral aggregates and filler;
- Bitumen products including penetration graded bitumen and cutback bitumen.

The physical and chemical properties of all materials used in the bituminous mixes and/or bituminous layer construction shall conform to the requirements outlined below.

b) Aggregates

Aggregates for use in bituminous paving layers shall be clean, hard, durable and sound and shall consist of crushed stone of uniform quality and free from decomposed rock organic matter or shale. Added mineral filler shall be fine particles of limestone or cement in accordance with ASTM D-242. It shall be dry and free from organic material or clay.

The combined aggregate grading for bituminous mixes including mineral filler shall conform to the following grading curves:

Sieve Size(mm)	Percentage Passing (by weight)	
	Base Course	Wearing Course
25.0	100.0	–
19.0	65 – 100	100.0
9.50	47 – 72	56 – 80
4.75	30 – 56	35 – 56
2.00	19 – 36	22 – 36
0.425	8 – 20	8 – 20
0.075	2 – 8	2 – 8

The Flakiness Index determined in accordance with BS 812 test shall be not more than 30 for the Base Course and 25 for the Wearing Course.

The Elongation Index determined in accordance with BS 812 test shall be not more than 30 for the Base Course and 25 for the Wearing Course.

Aggregates shall be washed if necessary to remove any clay lumps, adherent dust and other deleterious materials, and the aggregate shall not contain more than 1% gypsum or 5% chert.

The Plasticity Index of particles passing the 0.425 mm sieve shall not exceed 4%.

Not less than 90% of the crushed particles retained on the 4.75 mm sieve shall have 2 or more fractured faces.

Further requirements with respect to tests performed according to AASHTO standards are as follows:

Test	Requirement
AASHTO T– 96	The loss in weight of aggregate after 500 revolutions shall not exceed 35%
AASHTO T–104	The soundness of aggregate retained on the 4.75 mm sieve shall not show signs ofdisintegration, and the loss in weight after 5 cycles shall not exceed 10% for the sodium Sulphate tests and 12% for the magnesium Sulphate test
AASHTO T–112	The percentage by weight of friable particles, clay lumps, organic material and shale shall not exceed 1%
AASHTO T–176	The combined mineral aggregates shall have a sand equivalence value not less than 50
AASHTO T–283	When tested for resistance damage, the retained strength shall not be less than 80%

c) Bitumen Mixes for Base and Wearing Courses

The Contractor shall provide adequate transport and storage facilities for bitumen, including measures to protect it from temperatures lower than - 5°C or higher than + 60°C.

Sampling of bitumen shall be carried out in accordance with AASHTO T–40.

The base and wearing courses shall be formed in accordance with an established Job Mix Formula. The Job Mix Formula for each course shall be established by the Contractor subject to the approval of the Employer's Representative. The mix design procedures shall be in accordance with the Marshall method procedure given in the Asphalt Institute Manual (MS-2). The Job Mix Formula shall be re-established if the source of aggregate, filler or bitumen is changed.

Unless otherwise specified, or proposed by the Contractor and approved by the Employer'sRepresentative, the bitumen for the base and wearing courses shall be 60/70 penetration graded bitumen conforming generally to the requirement of AASHTO M–20, and shall be in accordance with the following table:

Requirement		**Base Course**	**Wearing Course**
Number of blows at end of compacted specimen	No.	75	75
Stability (Marshall)	kg	900	1000
Flow (Marshall)	mm	2 – 4	2 – 4
Percent air voids	%	4 – 8	4 – 8
Percent voids in mineral aggregate (VMA)	%	14	15
Percent voids filled with bitumen (VFB)	%	50 – 70	50 – 75
Loss of Marshall Stability (AASHTO T–165)	%	25 (max[m])	25 (max[m])
Filler Bitumen Ratio		0.6 – 1.5	0.6 – 1.4
Bitumen content, by weight of total mix [*]	%	3.5 – 4.5	3.5 – 4.5

[*] The optimum bitumen content shall be determined during the design mix procedure (the given values are tentative).

Any variations of the actual course mix from the approved Job Mix Formula shall not exceed thefollowing tolerances. Any deviation from these limits may be made only with the express approval of theEmployer's Representative.

Sieve Size (Square Openings)		Specified Mix Tolerances
9.50 mm	and above	± 5.0%
4.75 mm	(No. 4)	± 4.0%
2.00 mm	(No. 10)	± 4.0%
0.425 mm	(No. 40)	± 4.0%
0.180 mm	(No. 80)	± 4.0%
0.075 mm	(No. 200)	± 4.0%
Bitumen content		As approved by theEmployer's Representative based on Contractor's trials
Temperature of mix on discharge		± 50°C

Where a road is designated on the Construction Drawings specifically as an "agricultural road", the specified tolerances in the grading percentages at each sieve size as given in the table above may be increased by ± 2%.

d) Bituminous Prime and Tack Coats

A prime coat is MC cutback bitumen which is applied to a previously constructed subgrade, subbase, aggregate base course, or road shoulders. A tack coat is RC cutback bitumen which is applied to a previously constructed bituminous base course, wearing course or surface treatment to provide bondfor a superimposed bituminous course. Unless otherwise specified, or proposed by the Contractor and approved by the Employer's Representative, the following requirements shall be satisfied:

Requirement	Prime Coat	Tack Coat
Bitumen	MC–70 according to AASHTO M–82	RC–70 according to AASHTO M–81
Spraying temperature	45°C – 60°C	40°C – 75°C
Rate of application	0.75 – 2.0 litre/m^2	0.3 – 0.6 kg/m^2

The application surface for prime coat must be sufficiently moist, and the application surface for tack coat must be sufficiently dry. The ambient temperature in both cases is to be above 10°C and there shall be no rain, dust load in the atmosphere, or strong winds.

The prime coat shall be allowed to cure for 3 days as approved by the Employer's Representative. The tack coat shall be allowed to dry to a suitable tacky condition before succeeding asphalt or surface treatment layer is placed.

Traffic shall not be permitted on the application surfaces after they have been cleaned and prepared for prime or tack coat application.

2) Double Seal Bituminous Surface Treatment

The aggregate for the double seal bituminous surface treatment shall consist of approved crushed stone complying with the requirements of BS 594 with the grading, flakiness index and hardness as approved by the Employer's Representative. Material contaminated such that it contains more than the allowable percentage of material passing the 0.425 mm sieve shall not be used for surfacing.

The grading of the material for the crushed stone aggregate including any approved mineral filler for use in double seal bituminous surface treatment shall be within the limits stated as follows.

Sieve Size (mm)	Percentage Passing (by weight)
14.0	100.00
10.0	79 – 100
5.00	52 – 71
2.36	37 – 56
1.18	27 – 42
0.600	19 – 32
0.300	12 – 23
0.150	7 – 17
0.075	4 – 10

The approved grading shall be designated as the target grading and thereafter the composition of the working mix shall be maintained within ± 4% of the target grading.

Sites for the stockpiling of material for the surface treatment wearing course shall be prepared in such a manner that no grass, mud, dirt or other deleterious material will be included when loaded for use or conveyed by vehicle wheels onto the areas to be surfaced or resurfaced, or when being transported to or from the stockpiles.

The priming material and bituminous binders shall comply with the requirements of BS 434 as approved by the Employer's Representative.

3) Granular Wearing Course

Where the material for the wearing course layer to be constructed on either temporary or permanent access roads, maintenance roadways etc. is specified or approved by the Employer's Representative tobe a granular wearing course, this material shall be either natural gravel or crushed stone. The grading ofthe granular wearing course material shall be within the envelope given in the following table:

Sieve Size (mm)	Percentage Passing (by weight)
20.0	100.00
10.0	80 – 100
5.00	60 – 85

2.36	45 – 70
1.18	35 – 60
0.300	20 – 40
0.075	5 – 20

2.2.3 Ancillary Work

1) Kerbs

Precast kerbing and channeling shall comply with the requirements of BS 7263.

2) Guardrail Works

a) Guardrails

The guardrails shall comply with the requirements of AASHTO M–180, Class B, Type 2 galvanized, orequivalent.

The dimensions of guardrails and terminal sections shall be in accordance with the details shown on the Construction Drawings. Guardrails shall be supplied together with all the bolts, nuts, washers and fixing materials required, including the bolts for fixing the guardrails to the posts. All guardrails shall be galvanized with the requirements of ASTM A–123 or ASTM A–153 as appropriate, or equivalent. All bolts, nuts and washers shall have a hot-dip (galvanized) zinc coating which complies with the requirements of ASTM A–123 or ASTM A–153 as appropriate, or equivalent. Galvanized guardrails shall not be nested when stacked for storage.

b) Steel Posts

Steel posts shall comply with the requirements of ASTM A–36 or equivalent. Posts shall have a top diameter of not less than 150 mm.

The posts shall be as shown on the Construction Drawings and shall be provided with the necessary bolts,nuts, washers and spacer blocks for fixing.

c) Road Traffic Markings

Non-reflectorized paint shall comply with the requirements of AASHTO M–248, Type F without glass beads, and the viscosity shall be such that it can be applied without thinning.

The paint shall be delivered to the Site in sealed containers bearing the name of the manufacturer and the type of paint. The color to be used shall be bright white and yellow as directed.

Reflectorized paint shall comply with the requirements of AASHTO M–248, Type F or equivalent.

When required by the Employer's Representative the Contractor shall submit, for each consignment of paint delivered to Site, test certificates from an approved, independent testing authority to show that the respective materials comply in all respects with relevant product specifications.

2.3 Construction Methods and Workmanship

2.3.1 Construction Tolerances

1) Tolerances on Fills, Pavement Layers and Surfacing

a) Surface Levels

The surface over any length of 50 meters shall be deemed to comply with the requirements specified for surface levels if at least 90% of all surface levels are within the H_{90} tolerances as specified in the table in subparagraph (6) below for each layer and before level corrections are made.

Individual spots where the surface level deviates by more than the H_{MAX} tolerance specified in the table in subparagraph (6) shall be repaired to bring them to within the H_{90} tolerance.

b) Widths

The transverse width of fill and pavement layers at any level, measured horizontally from the centerline of the road to the outside edge, shall nowhere differ from the design width, w, at that level by more than the limits listed in the table in subparagraph (6), in which W_{MIN} denotes the maximum shortfall in width and W_{MAX} the maximum distance by which the width may exceed the theoretical width.

c) Thickness

The layer thickness shall be deemed to comply with the requirements specified for layer thickness if:

i) at least 90% of all thickness measurements taken are equal to or thicker than the specified thickness minus the D_{90} tolerance as specified in the table in subparagraph (6) for each layer before any thickness corrections are made, and

ii) The average layer thickness over any length of 50 meters is not less than the layer thickness specified minus the D_{AVE} tolerance specified in the table in subparagraph (6).

iii) Individual spots where the actual thickness is less than the thickness specified minus the D_{MAX} tolerance in each case shall be locally repaired to bring them within the D90 tolerance.

iv) The thickness of each bituminous course shall be determined by taking core samples, as requested by the Employer's Representative.

d) Cross-Section

When tested with a 3-metre straight edge laid at right angles to the road centerline the surface shall not deviate from the bottom of the straight edge by more than 10 mm for crushed stone base and surfacing.

At any transverse section the difference in level between any two points shall not vary by more than 20 mm (for subbase, base and surfacing) from their difference in level computed from the cross-section shown on the Construction Drawings.

e) Surface Regularity

When tested with a rolling straight edge the number of surface irregularities shall not exceed those given below (applied to base and surfacing):

- The number of irregularities equal to or exceeding the specified value when taken over 100-meter sections:

  - Crushed stone base or wearing surface (6 mm irregularities) ..... ≤ 6
  - Bituminous surfacing (6 mm irregularities) ..... ≤ 3

- The maximum value of any individual irregularity measured with the rolling straight edge or a 3-meter straight edge laid parallel to the road centerline shall not exceed 10 mm (for base and surfacing).

f) Tolerance Testing Frequency

The minimum testing frequency that will be required from the Contractor for his process control is shown in the following table:

Test		Testing Frequency	Position or Layer						
			Top of Fill	Selected Subgrade	Subbase	Granular or Asphaltic	Granular WearingCourse	Asphalt ic Wearing	Surface Treatme
Surface Levels (mm)	H_{90}	1 per 20 m (3 points per test cross-section)	± 25	± 25	± 20	± 15	± 10	± 8	± 8
	H_{MAX}		± 40	± 40	± 30	± 20	± 15	± 12	± 12
Width	W_{MIN}	1 per 200 m	- 100	- 75	- 40	- 20	- 10	- 10	- 10
(mm)	W_{MAX}		+ 300	+ 150	+ 100	+ 75	+ 50	+ 50	+ 50
Thickness (mm)	D_{90}	1 per 20 m (3 points per test cross-section)	–	- 25	- 10	- 10	- 10	- 5	- 5
	D_{MAX}		–	- 40	- 20	- 15	- 15	- 8	- 8
	D_{AVE}		–	- 10	- 5	- 5	- 5	- 2	- 2

The edges of the wearing course and bituminous surfacing shall be true to line with a maximumpermissible deviation of 25 mm from the specified edge line.

2.3.2 Tolerances on Road Ancillary Work

1) Concrete Kerbing

a) Horizontal Alignment

The maximum horizontal deviation of edges, centerline or vertical surfaces from the specified position shall not exceed 25 mm.

b) Vertical Alignment and Levels

The maximum vertical deviation of edges, center line or vertical surfaces from the specified alignment shall not exceed 1:500 when taken over any section more than 10 meters in length.

The top of kerbing shall nowhere deviate more than 10 mm from the required level.

c) Trueness of Exposed Surfaces

When tested with a 3-metre straight edge no surface irregularities shall exceed 6 mm.

d) Cross-Sectional Dimensions

All cross-sectional dimensions shall be within 6 mm of the specified dimensions.

2) Road Traffic Markings

The width of lines and other markings shall not deviate from the specified width by more than 5%. The length of segments of broken longitudinal lines shall not deviate from the specified length by more than 150 mm.

The position of lines, letters, figures, arrows, retro-reflective road studs and other markings shall not deviate from the true position specified by more than 20 mm. The alignment of any edge of a longitudinal line shall not deviate from the true alignment by more than 10 mm in 15 meters.

2.3.3 Natural Road Materials – General

1) Placing and Spreading of Materials

All materials which are deposited in place prior to compaction shall be evenly spread over the whole of the designated area for the layer concerned and, in such quantity, that the thickness of any one layer, when measured after compaction, shall comply with the requirements specified.

Any new layer other than the mixed wearing course of less than 75 mm in compacted thickness shall be bonded to the previous layer by scarifying the previous layer to a depth of not less than 25 mm or to such greater depth so that the total compacted thickness of the new layer plus the scarified portion of the previous layer will not be less than 100 mm.

2) Breaking Down and Preparation of Material

All material used in the construction of any layer shall be reduced to the maximum permissible sizes as specified in Sub-section 2.2.1 Crushed Stone during excavation by cross ripping, secondary blasting or other suitable means if necessary, before any breaking down as described hereinafter is attempted.

In order that layer thicknesses are not dictated by the presence of isolated larger rocks, the Employer's Representative may request that material which cannot be broken down to the size generally obtainablefor the rest of the material in the layer be bladed off and removed.

The material placed on the road shall be thoroughly broken down throughout the layer by means of equipment suited for this purpose. Any oversize material which cannot be broken down to the required size shall be bladed off the road and disposed of or utilized as approved by the Employer's Representative.

The Contractor shall be at liberty to use what he considers to be the most suitable equipment, but in the event of disagreement between the Employer's Representative and the Contractor as to the adequacy ofthe equipment used or the process employed, the

material shall be given normal grid rolling as described in Sub-section 2.3.3 (4) Compaction. The Employer's Representative may at any time require that all material be given normal grid rolling or any equal alternative treatment approved by him.

During such processing the layer shall be frequently bladed to bring oversize material to the surface to facilitate breaking down.

When normal grid rolling cannot effectively break down the material to the required size, the Employer's Representative may request the use of specialized equipment, such as crushing, heavy vibrating grid rollers and self-propelled tamping rollers in order to break down the material.

Where the coarse and fine fractions of the material are not uniformly distributed or have been allowed to become segregated, the material shall be thoroughly mixed on the surface by blading in successive cuts over the full depth of the layer with a motor grader, after the required amount of water has been added as described below. Such mixing shall continue until a uniform mixture of the various size fractions of the material has been obtained.

Where the material intended for use in the pavement layers cannot be suitably broken down by the methods described above, or requires modification by screening out certain fractions, the Employer's Representative may request that the material be crushed. No material shall be side spoiled.

3) Watering and Mixing

Any water required before material is compacted shall be added to the material in successive applications by means of water sprinklers fitted with sprinkler bars or by means of pressure distributors all capable of applying the water evenly and uniformly over the area concerned.

The water shall be thoroughly mixed with the material to be compacted by means of motor graders or other suitable equipment. Mixing shall continue until the required amount of water has been added and until a uniform mixture is obtained. Thereafter compaction may proceed.

The amount of water to be added shall be sufficient to bring the material to the optimum moisture content for the compaction equipment used and the density required, provided always that on any layer other than the mixed wearing course compaction shall not be attempted and will not be approved with materials which are more than 2% above the optimum moisture content. Should the material be too wet,due to rain or any other cause, it shall be harrowed and allowed to dry out to a moisture content conforming to the above requirements before compaction proceeds.

4) Compaction

a) General

Compaction shall be carried out in a series of continuous operations covering the full width of the layer concerned and the length of any section of a layer being compacted shall, wherever possible, be not less than 100 meters nor more than can be properly compacted with the available equipment. The Employer's Representative reserves the right to request the Contractor to reduce the length of any layer compacted in any single operation if the proper compaction of such a layer is not being achieved.

The types of compaction equipment to be used and the amount of rolling to be done shall be such as to ensure that the specified densities are obtained without damaging lower layers or structures.

During compaction the layer shall be maintained to the required shape and cross-section, and all holes, ruts and laminations shall be removed.

The compacted layers shall be adequately drained and shaped to prevent water from standing on or scouring the finished work. Windrows shall be removed to facilitate drainage of water from the surface.

No material for a succeeding layer shall be placed if the underlying layer is softened by excessive moisture.

b) Normal Grid Rolling

For the purpose of this Specification normal grid rolling shall be taken to mean the following:

The grid roller, which shall have a minimum mass of 13.5 tonnes, shall make two complete passes of the material, each pass consisting of rolling with the grid roller in a longitudinal direction over the whole width of the layer so that each roll laps over half the previous roll. The material shall then be bladed to windrow on one side of the fill, respreads and subjected to two more grid roller passes.

The above procedure shall be applicable to a compacted layer thickness of up to 150 mm. Where the actual layer thickness is in excess of 150 mm, the number of passes of the grid roller shall be increased proportionately.

2.3.4 Construction of Cuts and Fills

This section covers all work for the construction of cuts and fills up to the underside of the selected subgrade layer.

1) Classification of Cut and Borrow Excavations

The following classification of excavation in different materials shall be applicable to roadworks in accordance with this Section of the Technical Specification:

a) Excavation in Rock

Excavation in naturally occurring rock material, which can only be removed by drilling and blasting.

b) Common Excavation

Excavation in all material not classified as excavation in rock shall be classified as common excavation. This may include, but not be limited to, excavation of all sediments, soils, highly or completely weathered or decomposed rock, sands, gravels, cobbles, boulders and core stones less than 1.0 m^3 in volume, which can be effectively excavated (whether or not requiring assistance by ripping) but without the requirement for blasting.

Notwithstanding the above classification, all material excavated from previously constructed fills, subgrades and subbases shall be classified as soft material.

The Contractor shall be at liberty to use any method he wishes to use for excavating any class of material, but the method of excavating the material shall not dictate the classification of the excavation.

2) Classification of Compaction

a) General

The method of processing and the compaction of fill material shall be classified as described below.

b) Compaction to a Minimum Percentage of Modified AASHTO Density

Wherever a density requirement of a soil or granular layer is specified in terms of a percentage of modified AASHTO density in this Specification or on the Construction Drawings or when approved by the Employer's Representative, the Contractor shall be at liberty to employ any type of compaction equipment he may choose in order to achieve such density over the full specified depth of the layer, provided always that he complies in all respects with the general requirements of this Specification and that the equipment employed is adequate and suitable for the purpose and is in no way detrimental to any part of the Works.

3) Rockfill Processing and Compaction

Rockfill processing and compaction shall apply to material consisting predominantly of stones and boulders with some fine material and which, due to the mechanical interlocking of the rock, cannot be compacted effectively by the construction methods normally used for soils and granular.

When the layer thickness after compaction is 200 mm or less, the processing and compaction of such material shall not necessarily be classed as rockfill processing and compaction, and the Employer's Representative may approve that the material be given compaction as for twelve-pass roller compaction.

The maximum size rock used in a rock fill shall be 750 mm and the layer thickness before

compaction shall not be more than one and a half times the maximum actual size of the rock. The Employer's Representative may request that after the material has been dumped on the fill, up to 5% oversize material be bladed off the fill and disposed of as described in Sub-section 2.3.4 (2) Classification of Compaction so that the layer thickness need not be dictated by the presence of isolated large rocks.

The compacted layer shall contain no rock with a maximum dimension greater than the compacted layerthickness.

The material to be compacted shall be off-loaded by progressive end tipping, spreading, pushing and levelling by means of bulldozers or other suitable equipment in such a manner that the fine material is well mixed with the rock. Hauling, spreading and compacting equipment shall be routed uniformly over the full width of the layer to be compacted.

When the stability of a fill may be materially improved by the controlled placing of earth and rockfill in successive layers, a concurrent supply of both types of material shall be arranged. A material transition zone shall then be incorporated to prevent the finer material from being sieved through to the rockfill voids, as approved by the Employer's Representative.

During the spreading and compaction process the material shall be compacted and broken down by means of grid or other suitable rollers and shall finally be compacted by means of vibratory rollers in accordance with the formula given below. In order to achieve a good mechanical interlock of the rock and a maximum compaction of the finer material in the interstices between the rock, the type of vibratory roller used, the operating speed, number of passes and the layer thickness shall be governed

$$\frac{Pe \times n}{h \times v} \geq 1200$$

by the following formula:

where: P_e = total static and dynamic force per meter width of compacting drum extendedby the vibratory roller at the operating frequency, as given by the manufacturer (in kN/meter)

- ***n*** = number of passes required
- ***h*** = compacted layer thickness (in meters)
- ***v*** = roller speed (in meters per second).

Operating frequencies shall be limited to between 1100 vpm and 1800 vpm and P_e shall not be less than 120 kN/meter width multiplied by the loose layer thickness (in meters).

a) Twelve-pass Roller Compaction

When, due to the nature of the material used, the degree of compaction cannot be satisfactorily controlled by the testing of the in-situ densities, the Employer's Representative may request that the material be placed and compacted using twelve passes or coverage (per 150 mm of compacted layer thickness) of a combination of various items of compacting equipment. The Employer's Representative may also request that the number of passes required be increased or reduced.

4) Stripping of Surface Soil Layer, Clearing and Grubbing

Prior to starting any cut excavations, roadbed preparation or embankment construction, the Contractor shall obtain his approval from the Employer's Representative regarding any stripping of the surface soil layer or clearing and grubbing that may be required. The Contractor shall, if so approved by the Employer's Representative, remove the surface soil layer together with any grass and other unsuitable vegetation to temporary stockpiles.

Clearing shall consist of the removal from the portions of the road falling within the road prism of all trees, bushes, and other vegetation, rubble and all other objectionable material resulting from the clearing and grubbing. In the roadway, all stumps and roots shall be removed over their full depth and the cavities be backfilled and compacted to the density of the surrounding ground.

Any loose boulders or materials situated on higher ground and outside the road prism which may pose a danger to construction or post construction traffic and persons shall also be removed.

5) Cut and Borrow

a) General

When excavating cut the Contractor shall exercise proper care not to loosen, where this can be avoided, any material outside the specified cut line, whether by ripping, blasting or other means, thereby endangering the structural stability of the slopes or subsequently causing undue erosion or disintegration of the batters. This would normally entail modifying the methods of excavating when working in the vicinity of the final cut surface.

Care shall also be exercised not to undercut any slopes and proper control shall be exercised at all times by regular survey checking and the use of batter poles at close intervals. Where the batters are nevertheless undercut, the Employer's Representative may request that such remedial measures as he considers necessary be carried out the Contractor's expense, which may in serious cases include cutting back the whole or major portions of the batter to uniform slope.

b) Dimensions of Cuts

The dimensions of cuts shall be generally in accordance with the details of the typical cross-sections and details as shown on the Construction Drawings and further defined or amended during the course of construction. The Contractor shall obtain requests beforehand from the Employer's Representative regarding the slope of the sides of cuttings and the depth to which cuttings are to be taken, including thedimensions of any in-situ treatment of cuts that may be required below the level of subgrade.

In cuts excavated in rock the rock material shall be removed to the level that will permit the construction of the subbase layer, unless otherwise shown on the Construction Drawings or approved by the Employer's Representative.

All cuts carried below the specified levels shall be backfilled with suitably sized rock material and be compacted at the Contractor's own expense.

c) Use of Cut Material

Unless a road is being constructed alongside other earthworks which are also to be utilized for balancing cut and fill, all suitable and approved materials excavated from the road prism shall, in so far as it is practicable, be used in the construction of fill, side fill, shoulders, subbase, mitre banks and for such other purposes as shown on the Construction Drawings or as approved by the Employer's Representative.

Coarse rock encountered in cuttings shall be utilized for the construction of the lower layers of fills high enough to accommodate thick layers or, where so required, shall be conserved and used as directed for constructing the sides of embankments or to serve as protection against embankment or channelerosion.

The Employer's Representative shall have full control over the use of all material arising from cut excavations, but the Contractor shall plan his operations, and in particular his cut to fill operations, in such a manner that all cut material may be used in the manner most economical to the Employer. The Contractor shall neither borrow nor spoil any material without the Employer's Representative's approval and without satisfying the Employer's Representative that it is necessary and the most economical method of constructing the Works. Surplus material shall not be disposed of by side spoiling along the length of roads.

d) Borrow

Where sufficient quantities of suitable cut material are not available, additional material shall be excavated from approved borrow areas or may be provided by any other Permanent Works excavations adjacent to the road or as approved by the Employer's Representative. In lieu of borrow, cuts may be widened or slopes of cuts may be flattened, provided that the Employer's Representative determines the need for such action before the Contractor starts work on any particular cut.

e) Selection

The Employer's Representative may request that particular materials in borrow pits or in cuts be selected for a specific purpose. Where selection is requested, the method of excavation and the programme of work shall be arranged in such a way so as to avoid double handling where possible, andto meet the requirements of the Employer's Representative. If selected materials designated by the Employer's Representative are contaminated, used incorrectly or become unavailable through injudicious planning of borrow pit or excavating operations, the Contractor shall replace the shortfall with material of at least equal quality, excavated and transported from borrow pits at his own expense. In general, the excavated materials shall be placed directly in their final position in fill.

f) Temporary Stockpiling of Materials

Where the earthwork pattern is such that selected materials cannot be placed directly in their required position, the Employer's Representative may approve their removal into temporary stockpiles. Stockpile sites shall be approved by the Employer's Representative and shall be prepared by clearing and light grading.

g) Disposal of Surplus Material

Any surplus material arising from excavations, including any waste or oversize material bladed off the road, shall be disposed of as approved by the Employer's Representative who may require that the material be utilized in the uniform widening of fills or the flattening of slopes, or be deposited in such places and for such purposes as he may request. Spoil material need not be compacted but must, if required, be spread, shaped and given a smooth surface such as is formally obtainable with careful bulldozer operations.

Any surplus material arising from excavations shall be disposed of, to designated spoil tips or as approved by the Employer's Representative. Spoiling alongside roads or tracks will not be permitted.

6) Cut to Spoil

No material shall be spoiled without the written approval of the Employer's Representative. Material arising from cuttings which is either unsuitable for use in any part of the Works or surplus to requirements shall be spoiled at points approved by the Employer's Representative and in a manner satisfactory to him. Spoil heaps shall be neatly trimmed and finished to even surfaces.

When material is either oversize or otherwise unsuitable for use because it has not been properly excavated or broken down to maximum dimensions, has not been properly selected, or has beencontaminated, such material shall be removed from the road and carted to spoil and, except as provided for below, no payment shall be made in respect of the removal to spoil of such material.

7) Treatment of the Roadbed

a) Removal of Unsuitable Material

Any roadbed material occurring below the top of selected fill level, which is considered by the Employer's Representative to be of a quality or moisture content that would be detrimental to the construction or final performance of the road, shall be removed to such widths and depths as approved by the Employer's Representative and be disposed of as requested. The excavated spaces shall then be backfilled with approved imported material compacted to the required density.

b) Three-pass Roller Compaction

Any portion of the roadbed which by reason of its inadequate natural density is specified or requested by the Employer's Representative to be given three-pass roller compaction, shall be prepared by shapingwhere necessary and compacting with a suitable roller.

Except where otherwise approved by the Employer's Representative, compaction shall comprise not lessthan three complete coverages by the wheels of the roller specified or ordered over every portion of the area being compacted. The Contractor shall make every endeavor to take full advantage of favorable soil moisture conditions during the rainy season and, as far as possible, to carry out such compaction when the roadbed is neither excessively dry nor excessively wet.

c) Preparation and Compaction of Roadbed

Where a suitable in-situ foundation fails to meet the requirements for density it shall be scarified, watered and compacted to a percentage of modified AASHTO density. The density and the depth of compaction shall be as approved by the Employer's Representative.

Where any additional material has to be imported to obtain the required levels and layer thicknesses, and where the thickness of the imported material, measured after compaction, would be less than the specified layer thickness, the roadbed material shall be scarified, the necessary imported material placed,and this combined material mixed and compacted to the full specified depth of the layer.

d) In-situ Treatment of Roadbed

Wherever shown on the Construction Drawings or approved by the Employer's Representative, the roadbed shall be treated in-situ by breaking up undesirable formations of hard or rocky materials in order to achieve a uniform standard of compaction or to improve drainage.

Where the Employer's Representative request the Contractor to rip the in-situ material, the whole of the material shall be sized by rolling or knapping until the maximum dimension of any clod or spall is not more than two-thirds of the thickness of the layer after compaction. The material shall then be compacted in accordance with Sub-section 2.3.4 (2) Compaction.

Where the Employer's Representative request the Contractor to blast the in-situ material, the whole of the material shall be processed and compacted as described in Sub-section 2.3.4 (2) Classification of Compaction.

8) Fill

a) General

The dimensions of fills shall be in accordance with the cross-sections and details shown on the Construction Drawings or as may be amended by the Employer's Representative during the course of construction. Before construction the Contractor shall obtain approvals regarding the actual slope of each fill, any roadbed preparation or subsoil drainage required, selection of materials, method and classification of compaction and any other matter that may affect the construction of the fill or sequenceof operations.

The thickness of individual layers shall depend on the type of material encountered and the maximum size of the particles in such material. Where the material can generally be broken down to a maximum size of 200 mm or less, the layer thickness shall not exceed 200 mm after compaction, subject to the specified densities being attained over the full depth of compaction. In the case of material that cannot be reduced to a maximum size of 200 mm or less after removal of the oversize material as described in Sub-section 2.3.3 (2) Breaking Down and Preparation of Material, thicker layers shall be constructed but the thickness of the loose layer shall not be more than is necessary to ensure that the maximum particle size is generally not more than the completed layer thickness.

Fill shall be placed in successive layers parallel to the final fill surface, wherever this is practicable, and the construction of tapered layers shall be restricted to the bottom layers of fill where it may be unavoidable due to cross fall or tapering out of fills.

b) Placing of Rock

Rock material containing rock particles greater than 300 mm in size shall not be used at a depth of less than 150 mm below the top of fill level, unless otherwise approved by the Employer's Representative.

c) Placing on Unstable Ground

Where fill is to be constructed across water-logged or soft clayey ground that displays excessive movement under normal compaction equipment and haulage trucks, thereby precluding the effective compaction of the bottom fill layers, the Employer's Representative may request that a pioneer layer be constructed on the unstable ground. This layer is to be constructed by dumping and spreading successive loads of suitable coarse material in a uniform layer of a thickness just sufficient to provide a stable working platform for the construction of further fill layers which are to be compacted to a controlled density. Light hauling equipment and, where necessary, end tipping shall be used to place the material, and the layer shall be compacted by the use of light compaction equipment that will give the most effective compaction without overstressing the roadbed. Pioneer layers need not be compacted to a controlled density.

d) Benching

Where the cross fall of the foundation is more than 1 in 4, the foundation shall be cut away to form benches on which the fill is constructed, each bench being cut as the fill is compacted and built up. The dimensions of benches as well as the extent by which existing fills have to be cut back to form the benches shall be subject to the Employer's Representative's approval. The slope shall be given an initial bench at the toe of the fill as set out from the specified levels and cross-sections.

On areas of solid rock, the dimension of benches may be smaller than that required for the operation of equipment and may consist of stepping or serrating the slope, with the steps sloping inwards to ensure asatisfactory bond between slope and fill. The fill in such cases shall preferably consist of rock.

e) Construction of Fills near Structures

At all fills adjoining uncompleted structures, such as bridges and culverts, where the construction of the fill and the backfilling behind the structure cannot be done simultaneously, the fill shall be constructed insuch a manner that the longitudinal slope of the surface of the fill at any stage forms a continuous plane sloping towards the structure with a gradient not exceeding 10%. When the structure is completed, the remaining portion of the fill shall be completed in a similar manner simultaneously with the backfilling ofthe structure, whilst maintaining the backfill behind the structure at the same elevation as the adjoining fill.

f) Rock Toe Construction

Where rock toes are required to be constructed in the toe of the fill, the Employer's Representative may request that fill material consisting of assorted boulders and/or blasted rock fragments between 150 mm and 750 mm in size be selected from excavations or from borrow pits. This material shall be placed in such a way that the larger material is lodged in the outside face of the fill to form a stable interlocking rip-rap surface and the smaller material is spread to form a dense but porous toe to the fill.

9) Finishing of Slopes

Fill slopes shall be finished to neat lines with all loose rocks and uncompacted material removed. No boulders in excess of 750 mm in size shall be permitted and isolated large boulders in otherwise smaller size material shall not be allowed to project out of the surface.

In the case of rockfill the Employer's Representative may request that soft material be dumped over the side of fills and be worked into the interstices between the rock on the surface of the slope.

2.3.5 Construction of Crushed Stone Subbase, Base and Wearing Courses

1) General

Before any crushed stone layer is constructed, the underlying layer shall comply with the

requirements for the layer concerned and shall have been approved by the Employer's Representative.

Before any material for a subbase or base course is dumped on the road, the Contractor shall check the underlying layer to establish whether there is any damage, wet spots or other defects, which shall be rectified in accordance with the approvals of the Employer's Representative before the next layer is constructed.

The crushed stone base shall, where possible, be supported along the outer edge during construction by placing, compacting and trimming the adjacent shoulder before the base is constructed. Excess material resulting from the trimming of the shoulders shall be removed from the area where the base is placed, to beyond the shoulders.

No crushed stone layer shall be rolled if the underlying layer, either on account of rain or by any other cause, is so wet as to constitute a danger of the underlying layers being damaged.

Work shall be so carried out that the road will be adequately drained at all times during construction, which may require the use of temporary drainage pipes passing through the shoulders. The Contractor shall not start constructing the final bituminous surfacing of any part of the road before he has completed the shoulders of such section and the Employer's Representative has approved it.

2) Spreading and Mixing

The dumps of material for the new layer shall be broken down and spread out to a layer with a thickness which will be suitable for mixing, and oversize material shall be removed. The required quantity of water shall then be added and the material mixed until a homogeneous mixture is obtained.

Unless otherwise specified the mixing of materials from various sources requires the material from the first source to be dumped on to the road, prepared, broken down and spread in a layer of uniform thickness, after which it is lightly rolled with a steel-wheeled roller. The material from the second source shall then be thoroughly mixed as described in Sub-section 2.3.5 (4) Watering and Slushing.

The shoulders shall first be constructed and then neatly cut to the required line to provide lateral support for the crushed stone layer. Where the shoulders are to be constructed from a different material as the layer, care shall be taken not to contaminate the layer material with the shoulder material.

The maximum compacted thickness of any layer of crushed stone material compacted in one process shall be 150 mm, unless otherwise approved by the Employer's Representative.

Excess crushed stone material shall not be spread over the shoulders or side fills, but shall be removed from the road. It shall not be reused unless it has been rescreened, retested

and again approved for use. It shall not be mixed with approved material unless screened, tested and again approved for use on its own.

3) Compaction

After mixing, the crushed stone material shall be placed to the correct thickness and level and thoroughly compacted by suitable equipment so that the specified density is obtained throughout the entire layer after slushing.

The finally compacted layer shall be free from surface laminations, portions exhibiting segregation of the fine and coarse aggregate, corrugations, or other defects that may adversely affect the performance of the layer.

Care shall be taken during rolling to ensure that concrete edging, kerbs and gutters already laid are not displaced or damaged. Any concrete edging, kerbs and gutters damaged during construction shall immediately be replaced or repaired by the Contractor at his own expense.

At junctions with existing bituminous surfaces, the new base shall not be feathered-off to obtain continuity of grade, but the existing work in the vicinity of the joint shall be cut back so as to ensure an overall compacted thickness of new base and surfacing of not less than 100 mm.

4) Watering and Slushing

After compaction short sections of the surface shall be thoroughly watered, rolled and slushed by meansof steel-wheeled rollers with a mass of not less than 12 tonnes each, and/or with pneumatic-tyred rollers. The process shall continue until all excess fines are brought to the surface. The grout thus formedshall be uniformly broomed over the surface with stiff brooms to correct any areas still deficient in fines, whereupon the excess fines shall be broomed from the surface of the layer. This process shall continue until all excess fines in the mixture have been brought to the surface of the layer and its specified density has been reached. Excess fines and loose aggregate shall then be swept from the surface while the surface is still damp, and the layer shall then be allowed to dry out.

During slushing operations, care shall be taken not to roll the surface out of shape. The slushing process shall be carried out on each section in one continuous process, and each section shall be completed before the next is proceeded with.

The completed layer shall be firm and stable with a closely-knit surface of aggregate exposed in mosaic and free from nests of segregated material, laminations or corrugations.

5) Protection of Crushed Stone Layers

The Contractor shall protect and maintain the completed crushed stone layers at his own expense until the next layer or the seal or surfacing is applied or, in the case of the granular wearing course, until the end of the construction period. Maintenance shall include the

immediate repair of any damage to or defects in the layer and shall be repeated as often as is necessary. Repairs shall be so made as to ensure an even and uniform surface to be restored after completion of the repair work.

Traffic shall not be allowed direct on any unprimed crushed stone base layer unless so approved by the Employer's Representative.

2.3.6 General Requirements for Bituminous Surfacing

1) Weather Limitations

The minimum road surface temperatures at which the spraying of the different types and grades of binder may be carried out are as follows:

- 40/45 EVT tar ..... 10°C
- 45/50 EVT tar ..... 16°C
- 50/55 EVT tar ..... 21°C
- penetration grade bitumen ..... 25°C
- cutback bitumen ..... 10°C
- Bitumen emulsion ..... 10°C

No bituminous work shall be done during foggy or rainy weather conditions or when the atmosphere contains a significant amount of blown sand, and no spraying of binder shall be done when strong winds are blowing such that this could interfere with the proper execution of the work.

2) Preparation of Areas to be surfaced

The areas to be surfaced shall be cleaned of all dust, dirt, dung, oil or any other foreign materials that may be deleterious to the surfacing.

Before any priming material is sprayed the surface and other requirements of the layer to be primed shall be checked for compliance with the specified tolerances and corrected if out of tolerance.

3) Heating of Bituminous Binders

The Contractor shall submit in advance to the Employer's Representative for approval all relevanttechnical data from the supplier with respect to the bituminous binders, including all certified test results. This submission shall also include sufficient information concerning the correct methods and conditions of handling, heating, transporting, pumping and spraying for each of the types of binder material to be used, and the Contractor shall ensure that he complies with the approved requirements or recommendations of the supplier or any other requirements including control at all times of the following:

- solubility
- general handling temperatures
- minimum storage and pumping temperatures

- maximum and minimum mixing temperatures
- maximum and minimum spraying temperatures
- density

Binders stored in a heated condition shall be kept in a container having a properly functioning circulationsystem and a securely fitting lid.

Binders that have been heated above the maximum temperatures required by the approved technical data on the respective type of binder material shall not be used and shall be removed from Site. Every effort shall be made to maintain the binder temperature for spraying to within ± 5°C of the recommended temperature.

Where newly constructed base or shoulder areas are to be surfaced, these areas shall be checked for compliance with the specified tolerances and all other requirements, and portions not satisfying these requirements shall be corrected or removed and reconstructed before they are surfaced.

4) Maintenance

The Contractor shall maintain the bituminous surface until the work is finally accepted by the Employer'sRepresentative. Any damage occurring to the surface or any defects that may develop before the Taking-Over Certificate is issued, fair wear and tear excepted, shall be corrected by the Contractor at his own expense and in accordance with the requirements of the Employer's Representative.

Should any bleeding occur during the course of the Contract or during the Defects Notification Period and which, in the opinion of the Employer's Representative, can be attributed to the Contractor not observing any of the requirements of this Specification, not using the correct rate of application, or to any other omission or fault on the part of the Contractor, any corrective work requested by theEmployer's Representative shall be at the Contractor's own cost, including the supply, precoating, stockpiling at selected sites and later removal if not used of any aggregate reserved for corrective work. The Contractor shall not allow any construction equipment to pass over the completed surface treatment where this is likely to cause damage.

2.3.7 Priming of Subgrade or Base Course

1) Weather or Other Limitations

No prime shall be applied under the following adverse conditions as determined by the Employer's Representative:

- during foggy or wet conditions or when rain is imminent;
- when the atmosphere contains a significant amount of blown sand;
- when wind is blowing sufficiently hard to cause uneven spraying;
- when free water is visible at the surface of the layer, or when the moisture content of the layeris higher than just below optimum moisture content;
- after sundown.

2.3.8 Preparation of the Layer to be Primed

No longer than 24 hours before spraying, the layer to be primed shall be broomed and cleaned of all loose or deleterious material, taking care not to cause any damage to the layer. A light spray of water, sufficient to dampen the surface, shall be uniformly applied to the layer immediately before the application of the prime. If the water is over-applied the layer shall be allowed to dry until a uniform damp surface is obtained.

Before any priming material is sprayed the surface and other requirements of the layer to be primed shall be checked for compliance with the specified tolerances and corrected if out of tolerance.

2.3.9 Application of the Prime Coat

A mat or other suitable approved material shall be used at all joints at the beginning and end of all sprays in order to obtain a neat start and cut-off.

The rate of application shall be between 0.9 litre/m^2 and 2.3 litre/m^2 or as approved by the Employer's Representative after trial applications to short sections if necessary. The actual application rate will depend on the openness of the base material, and no more prime coat is to be applied than can be absorbed by the granular base within 24 hours. Any excess prime shall be removed with blotter sand.

Wherever feasible, the prime shall be applied in one or more lanes evenly over the full width of the road and allowed to penetrate and cure until traffic can pass over the surface without the wheels picking up the prime. All traffic shall be kept off the surface until this condition is obtained.

The distributor used should be in good condition and the spray nozzles cleaned and set at the correct height to ensure a double overlap of the prime material, allow uniform coverage and to prevent streaking.

Where the primed surface is to be used by traffic, the prime shall be applied and allowed to penetrate for not less than two hours, or as approved by the Employer's Representative, before a blinding layer of crushed dust is applied at a rate of approximately 0.0035 m^3/m^2. Any "caking" of aggregate which may take place and cause problems during the surfacing process and all loose aggregate shall be removed before the final surfacing is commenced.

If the prime is applied in more than one lane, allowance shall be made for overlapping of lanes by 100 mm.
Unless otherwise specified in the approved technical information from the supplier, or otherwise proposed by the Contractor and approved by the Employer's Representative, the temperature for storage and spraying shall be in accordance with the following table:

Type of Prime	Maximum Storage Temperature (°C)		Spraying Temperature Range (°C)
	≤ 24 hours	> 24 hours	
Cut-back bitumens:			
- MC–30	65	30	45 – 60
- MC–70	80	50	60 – 80
Tar Prime:			
- RTH/TRL 3/12P *or* 1/4P	60	40	54 – 68
- Inver bitumen emulsion			10 – air temperature

Care shall be taken to protect all kerbing and guttering, guard rails and channeling from the prime by covering them with a suitable protective material when spraying. The Contractor shall at his own cost replace all soiled items which cannot be properly cleaned.

2.3.10 Construction of Bituminous Base and Wearing Courses (Asphalt)

1) Surface Preparation and Tack Coat

When the bituminous mix is to be placed upon a granular subgrade, subbase or base course, the surface shall have been primed and approved by the Employer's Representative.

When the bituminous mix is to be placed upon an existing bituminous surface, including on the asphalt base course prior to the application of the wearing course, the surface shall be cleaned of all foreign material and broomed free of dust, to the approval of the Employer's Representative and a tack coat shall be applied prior to placing the new layer.

The tack coat shall be applied at a rate between 0.23 litre/m2 and 0.35 litre/m2 at a spray temperature between 25°C and 60°C. The distributor used should be in good condition and the spray nozzles cleaned and set at the correct height to ensure a double overlap of the tack coat material, allow uniform coverage and to prevent streaking.

2) Delivery, Spreading and Finishing

The maximum temperature of the bituminous mix at the mixing plant shall be 170°C when 60/70 penetration bitumen is used, and the application temperature shall be between 145°C and 165 °C. The minimum temperature for rolling shall be 120°C.

The mix shall be laid by means of a paver, and rolled and compacted to not less than 97% of the average daily Marshall bulk density.

Rolling shall be carried out by means of approved self-propelled steel drum rollers followed by pneumatic-tyred rollers until the layer has become thoroughly compacted throughout and is true to grade and cross section. Unless otherwise approved by the

Employer's Representative, the following stages shall be used:

- initial breakdown using dual drum steel vibratory roller;
- intermediate rolling using tandem pneumatic smooth tyred roller;
- final rolling using 2-axle tandem steel wheeled roller.

Placement once commenced, must be continued without interruption. No greater amount of the mixture shall be delivered to any length of road during any one day than can be properly distributed and rolled on that length of road during that day.

Rolling shall be commenced along the lower edge of the area to be rolled and be continued until the edge is thoroughly compacted, after which the roller shall be gradually advanced to the crown point, both sides being rolled in a like manner. Rolling of both the base course and surface course shall be continued until all roller marks are eliminated. Longitudinal and transverse joints shall be made in a careful manner to ensure well-bonded and sealed joints.

In the case of wearing course, the edge of the previous surface course shall be cut back for its full depth so as to expose a fresh surface and, if necessary to obtain a well-bonded joint, shall be painted with a tack coat after which the hot surface mixture shall be placed in contact with it and raked to a proper depth and grade.

3) Testing

Unless otherwise approved, the schedule of testing shall be as given in the following table:

Work Item	**(A) Tests at Source of Material**		**(B) Tests at Roadworks Site**	
	Test	**Frequency**	**Test**	**Frequency**
Materials used inasphalt mix (at batching plant)	1 Specific gravity &water absorption 2 Abrasion 3 Chert content 4 Clay lumps & friablematerials 5 Flaky & elongated particles 6 Soundness	- One test for eachsource - Test when materialsquality changes - Test when requestedby Employer's Representative		

Materials used inasphalt mix (from hot bins)	1 Gradation 2 Specific gravity &water absorption 3 Plasticity Index 4 Sand equivalent 5 Stripping with asphalt	- One test for eachsource - Test when materialsquality changes - Test when requestedby Employer's Representative		
Asphalt mixdesign for each layer (at batching plant)	1 Complete mix designin accordance with Specification 2 Loss of stability	- One test for each jobmix - Test when materialsquality changes - Test when results not consistent with mixdesign results - Test when requestedby Employer's Representative		
Asphalt for eachlayer	**At Batching Plant:** 1 Stability 2 Flow 3 Extraction (binder content &gradation) 4 Air voids 5 Voids in mineral aggregates 6 Daily Marshall density7 Loss of stability	- Test every 3 workingdays - Test for eachbatching plant - Test when requestedby Employer's Representative	**Behind Spreader:** 1 Stability 2 Flow 3 Extraction (binder content & gradation) 4 Air voids 5 Voids in mineral aggregates 6 Daily Marshall density 7 Road density & thickness (after final compaction)	- Test each working day - Test for eachbatch - Test when requested by Employer's Representative

2.3.11 Construction of Double Seal Bituminous Surface Treatment (DSBT)

1) Application of Tack Coat and Aggregate

A bituminous tack coat consisting of the type and grade of binder specified shall be sprayed on the properly cleaned and prepared base course or existing surface over the full specified width of the surfacing. Immediately after the binder has been sprayed, it shall be covered with aggregate of the size specified in Sub-section 2.3.11 (2) Double Seal

Bituminous Surface Treatment.

The actual rates of application of binder and aggregate to be used in construction will be confirmed by the Employer's Representative, after testing of the aggregates which the Contractor proposes to use for the surface treatment and prior to any surfacing work being carried out.

The aggregate shall be applied by means of self-propelled chip spreaders. Chip spreaders shall commence spreading the aggregate as closely as possible behind the distributor, and shall be operated in such a manner that the tack coat is covered with aggregate before the wheels of the chip spreader or truck pass over the uncovered tack coat. All chips shall be spread within 15 minutes after the binder has been sprayed.

The quantity of bitumen sprayed in any single spray operation shall be governed by the quantity of aggregate and the number of trucks available, which shall be sufficient to ensure the continuous application of stone behind the distributor.

2) Second Application of Bituminous Binder and Aggregate

The bituminous binder as approved by the Employer's Representative shall be applied and be followed by the second application of aggregate of the size specified or as approved by the Employer's Representative.

The second application of binder shall take place preferably within 48 hours after the application of the tack coat when bitumen is used for the tack coat, and not less than ten days after the application of the tack coat when tar is used in the tack coat.

3) Rolling and Brooming

As soon as the aggregate has been applied, rolling shall commence with a self-propelled 15 tonne pneumatic-tyred roller working parallel to the centre line of the road from the shoulders towards the crown of the road until the whole surface has been covered with at least three passes.

After the bituminous binder has set sufficiently to prevent any aggregate from being dislodged, the surface shall be slowly dragged with a dragbroom in order to ensure even distribution of the aggregate. If there are areas which are deficient in stone chips, additional material shall be added by hand so as to leave the carpet with one layer of stone shoulder to shoulder.

If there are areas with an excess of stone chips, such excess shall be removed by hand so as to leave the carpet with one layer of stone shoulder to shoulder. The importance of applying only a single layer of stone is stressed. Every care shall be taken to avoid over-application of stone.

When the spreading of aggregate is completed, the surface shall be rolled with a 15 tonne pneumatic- tyred roller for two to four coverages. Final rolling shall then be done with a

steel flatwheel or roller of 6 tonne to 8 tonne mass, working parallel to the centre line of the road from the shoulders towards the crown of the road, until every portion of the area concerned has been covered by at least two to four passes of the roller, provided only a limited amount of crushing of the aggregate takes place, but if in theopinion of the Employer's Representative general crushing occurs under the rollers, such rolling shall be stopped regardless of the number of passes completed by the roller.

4) Fog or Mist Spray

A fog or mist spray of 30% or 60% spray grade emulsion shall be applied to the surface of the second layer of stone by means of a pressure distributor at a rate of application as approved by the Employer's Representative.

2.3.12 Kerbs

1) Excavation and Preparation of Bedding

Trenches for kerbs shall be excavated to the required depth and all unsuitable material shall be removedand replaced with a layer of approved bedding material at least 75 mm thick. The bedding shall be compacted and accurately shaped to the required grade. No concrete or precast concrete units shall be placed on uncompacted or disturbed material.

Where prefabricated kerbs are to be placed on an excavated rock surface, the surface shall be cleaned and all loose material removed. The rock surface shall be washed down and then all standing water removed and allowed to dry. Large irregularities and depressions in the surface shall be filled with Class 15/20 concrete in accordance with the Concrete Works specified under this technical specification, such that any remaining minor irregularities can be brought to the required levels using the bedding mortar.

2) Prefabricated Concrete Kerbing

Prefabricated concrete kerbing shall be laid on the approved bedding with close joints filled with 3:1 sand: cement mortar not exceeding 10 mm in thickness and neatly pointed with a pointing trowel. The exposed faces of kerbs and edging shall be constructed true to line and elevation.

Kerbing around curves shall first be laid along the full curve length before the joints are filled, unless otherwise approved by the Employer's Representative, however at spacing's of not greater than 6000 mm a joint not exceeding 4 mm shall be left unfilled.

Kerbs shall be temporarily propped during construction. Where required, the kerbing shall be propped with in-situ concrete in accordance with the details on the Construction Drawings or as requested by the Employer's Representative.

3) Backfilling

After completing the concrete work, the spaces at the backs of kerbs shall be backfilled with approved material to pavement or road shoulder level.

Such backfill shall be placed in layers not exceeding 150 mm and each layer shall be

thoroughly compacted at optimum moisture content before the succeeding layer is placed thereon.
Where kerbs are laid after construction of the base for a road with asphalt surfacing, the spaces between the concrete and adjoining base shall be backfilled with premixed bituminous material.

a) Construction Sequence

i) Where kerbs are constructed before the base, precautionary measures shall be taken to prevent the concrete work from being damaged or shifted.

ii) Where kerbs are constructed after the asphalt base and/or asphalt surfacing, or the double sealbituminous surface treatment, the asphalt base and/or asphalt surfacing or bituminous surface treatment shall be constructed wider than the specified width and shall than be cut back accurately with a mechanical saw to a marked line to give a neat joint line between the kerbs and the asphalt layer. The base shall then be removed to the required depth.

Any concrete spilled onto the asphalt surface shall be removed. Where so required by the Employer's Representative, the Contractor shall, without any additional compensation, paint emulsion over the stained surface.

b) Protection

During transporting and laying care shall be taken to protect all precast units against chipping or breakage.

Concrete kerbing as well as any other structures adjacent to the road shall be protected against staining by bitumen being sprayed or premix being placed. Where bitumen is to be sprayed, all such work shall be completely covered with polyethylene sheeting or other approved material, properly secured to prevent the sheeting from lifting during windy conditions. Any work stained by bitumen shall be broken down and replaced, unless all such bitumen is completely removed so as not to show any stains.

Transition sections on kerbing and kerbing-channeling combinations shall be constructed to the same standards and by the same methods as described for the uniform sections, but with the required modifications. Sections may be either precast or cast in-situ units.

2.3.13 Guardrails

The holes for the steel posts shall be of sufficient size to permit proper setting of the posts and to allow sufficient room for backfilling and tamping. A length of at least 1.0 metre of the posts shall be embeddedin concrete in the ground as shown on the Construction Drawings or as approved by the Employer's Representative.

The steel posts shall be spaced to suit the standard length of guardrail supplied. Where shown on the Construction Drawings or requested by the Employer's Representative, posts shall be set at half spacings.The posts, spacer blocks (if applicable) and guardrails shall be

completely erected, set true to line and level, so that the rail is at the required height above the level of the completed road shoulder and the lap is in the direction of the traffic movement. The guardrail shall be suitably braced to prevent any movement and all bolts shall be tightened prior to casting in the posts.

After the Employer's Representative has signified his approval of the guardrails so erected, the posts shall be concreted in. Not less than 7 days after concreting the post holes shall be backfilled to final ground level with an approved sandy soil close to optimum moisture content in layers not exceeding 100mm thick and thoroughly rammed in.

When the backfilling is complete and the bracing removed, the posts shall be rigid and vertical and the guardrail true to line and level and firmly fastened to the posts. Excess excavated material shall be disposed of as approved by the Employer's Representative.

All guardrails shall be erected in such a way that there are no projecting ends that might interfere with or endanger traffic. The edges and the centre of the rail element shall make contact with the spacer block or with the post where no spacer blocks are used.

Guardrail elements shall lap in the direction of the traffic and, if specified, guardrails shall be provided with terminal sections which shall be lapped on the traffic face. All splices of rail elements shall be at a post, and plate ends shall make contact through the entire area of the splice.

2.3.14 Finishing the Road

After completing the permanent bituminous seal, the road and road vicinity shall be cleared of all excess earth, stones, boulders, foreign objects, debris and other waste material resulting from the construction of the Works, but material shall not be dragged, pushed or scraped across the surfacing. All finishing and clearing not previously done or completed shall be completed such that the road can be brought into use by the public without any delay.

Culvert inlets and outlets, culvert barrels, and open drains shall be cleared of all debris, soil, silt and other material. All junctions, intersections, islands, kerbing and other elements making up the completed works shall be neatly finished off.

The cost of these requirements is deemed to be included in the other rates for road construction, and the Contractor shall not be entitled to any additional payment for this work.

2.3.15 Road Traffic Markings

1) Weather Limitations

Road-marking paint shall not be applied to a damp surface or when the relative humidity exceeds 80%, or at temperatures lower than 10°C, or when in the opinion of the Employer's Representative wind strength is such that it may adversely affect the painting operation.

2) Surface Preparation

Traffic markings shall be applied to bituminous surfaces only after sufficient time has elapsed to ensure that damage will not be caused to the painted surface by volatile substances evaporating from the bituminous surfacing. In no case shall traffic markings be applied until at least 48 hours after the completion of the bituminous surfacing or any longer period required by the Employer's Representative has expired.

Before the paint is applied the surface shall be clean and dry and completely free from any soil, grease, oil, acid or any other material which will be detrimental to the bond between the paint and the surface. The portions of the surface where the paint is to be applied shall be properly cleaned by means of watering, brooming or compressed air if required.

3) Setting Out of Road Traffic Markings

The dimensions and positions of traffic markings shall be as shown on the Construction Drawings or as approved by the Employer's Representative. The positions of the proposed road marking lines are to be indicated on the road. These premarkings must be approved by the Employer's Representative prior to the commencement of any painting operations.

The positions and outlines of special markings are to be produced in chalk on the finished road and must be approved by the Employer's Representative before they are painted. The use of approved templates will be permissible on condition that the positioning of the marking is approved by the Employer's Representative before painting is commenced. Lines on curves, whether broken or unbroken, shall not consist of chords but shall follow the correct radius.

4) Application of Paint

The paint shall be applied as figures, signs, letters, symbols, broken or unbroken lines or other marks as shown on the Construction Drawings or as approved by the Employer's Representative.

Paint shall be applied without the addition of thinners.

Where painting is done by hand it shall be applied in two layers, and the second layer shall not be applied before the first layer has dried out sufficiently. As most road-marking paint reacts with the bitumen surface of the road, the paint is to be applied with only one stroke of the brush or roller at any one point on the road.

Ordinary road-marking paint shall be applied at a nominal rate of 0.42 litre/m^2, or as approved by the Employer's Representative. Each layer of paint shall be continuous over the whole area being painted.
If any substandard work is carried out such work shall be removed, replaced or repaired as required by the Employer's Representative, at the Contractor's own cost. Rejected traffic markings and paint that has been splashed or has dripped onto the surfacing, kerbs, structures or other such surfaces shall be permanently removed by the Contractor at his own cost.

After the application of paint, the traffic markings shall be protected against damage by traffic or other causes. The Contractor is responsible for the erection, placing and removal of all warning boards, flags, cones, barricades and other protective measures which may be necessary.

2.3.16 Road Safety Works

1) Raised Pavement Markers (Cat's Eyes)

The cat's eyes or road studs are used to form a semi –permanent marking and provide improved visibility during night time and wet –weather conditions. These shall be either reflex lens type or solid white beads. These shall be provided at hazardous locations and while approaching important intersections/sharp bends/high embankments etc. to supplement the paint or thermoplastic line markings and road sketches passing through villages' settlements and habitations.

2) Retro-reflective Sheeting

The retro-reflecting sheeting shall be used on the signs. The sheeting shall be weather-resistant and show colour fastness. It shall be new and unused and shall show no evidence of cracking, scaling, pitting, blistering, edge lifting or curling and shall have negligible shrinkage or expansion. A certificate of having tested the sheeting for these properties in an unprotected outdoor exposure facing the sun for two years and its having passed these tests shall be obtained from a reputed laboratory by the manufacturer of the sheeting and shall be provided for review and comments, if any, of the Employer's Representative.The reflective sheeting shall be of High Intensity Grade with encapsulated lens or with micro prismatic retro-reflective element material as specified by the Government of Laos. The retro-reflective surface after cleaning with soap and water and in dry condition shall have the minimum co-efficient of retro- reflection (determined in accordance with ASTM standard D 4956-0.