

## **SECTION 4: BITUMINOUS CONSTRUCTION**

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<b>SECTION 4: BITUMINOUS CONSTRUCTION</b>	<b>I</b>
<b>SECTION 4.01 MATERIALS FOR BITUMINOUS CONSTRUCTION</b>	<b>1</b>
4.01.1 SCOPE	1
4.01.2 AGGREGATE MATERIALS GENERAL	1
4.01.3 AGGREGATES FOR BITUMINOUS PAVING MIXES	3
4.01.4 AGGREGATES FOR SEAL COATS	4
4.01.5 BITUMEN	6
4.01.6 BITUMEN PRODUCTS	7
4.01.7 MEASUREMENT	14
<b>SECTION 4.02 BITUMINOUS PRIME AND TACK COATS</b>	<b>15</b>
4.02.1 SCOPE	15
4.02.2 MATERIALS	15
4.02.3 EQUIPMENT	15
4.02.4 CONSTRUCTION OF TRIAL SECTIONS	15
4.02.5 APPLICATION PROCEDURES	16
4.02.6 MEASUREMENT	18
<b>SECTION 4.03 BITUMINOUS COURSES</b>	<b>19</b>
4.03.1 SCOPE	19
4.03.2 MATERIALS	19
4.03.3 JOB MIXES AND PROJECT MIXES	19
4.03.4 EQUIPMENT	21
4.03.5 CONSTRUCTION OF TRIAL SECTIONS	23
4.03.6 MIXING PROCEDURES	23
4.03.7 SURFACE PREPARATION	24
4.03.8 DELIVERY, SPREADING AND FINISHING	25
4.03.9 SAMPLING AND TESTING	30
4.03.10 SURFACE TOLERANCES	32
4.03.11 DETERMINATION OF LAYER COURSE THICKNESSES.	32
4.03.12 MEASUREMENT	33
<b>SECTION 4.04 BITUMINOUS BASE COURSE</b>	<b>35</b>
4.04.1 SCOPE	35
4.04.2 MATERIALS	35
4.04.3 JOB MIX AND PROJECT MIX	35
4.04.4 EQUIPMENT	36
4.04.5 CONSTRUCTION OF TRIAL SECTIONS	36
4.04.6 MIXING PROCEDURES	36
4.04.7 SURFACE PREPARATION	36
4.04.8 DELIVERY, SPREADING AND FINISHING	36
4.04.9 SAMPLING AND TESTING	37
4.04.10 SURFACE TOLERANCES	37
4.04.11 DETERMINATION OF THICKNESS	37
4.04.12 MEASUREMENT	38
<b>SECTION 4.05 BITUMINOUS WEARING COURSE</b>	<b>39</b>
4.05.01 SCOPE	39
4.05.02 MATERIALS	39
4.05.03 Job Mix AND PROJECT MIX	41
4.05.04 EQUIPMENT	44
4.05.05 CONSTRUCTION OF TRIAL SECTIONS	44

4.05.6	MIXING PROCEDURES	44
4.05.7	SURFACE PREPARATION	45
4.05.8	DELIVERY, SPREADING AND FINISHING	45
4.05.9	SAMPLING AND TESTING	45
4.05.10	SURFACE TOLERANCES	45
4.05.11	DETERMINATION OF THICKNESS	46
4.05.12	MEASUREMENT	46
<b>SECTION 4.06: BITUMINOUS SEAL COATS AND SURFACE DRESSINGS</b>		<b>47</b>
4.06.01	SCOPE	47
4.06.02	MATERIALS	47
4.06.03	EQUIPMENT	48
4.06.04	CONSTRUCTION OF TRIAL SECTIONS	48
4.06.05	RATES OF APPLICATION	48
4.06.06	CONSTRUCTION	49
4.06.07	TOLERANCES AND RECORDS	52
4.06.08	MEASUREMENT	53
<b>SECTION 4.07 BITUMINOUS LEVELLING COURSE</b>		<b>54</b>
4.07.1	SCOPE	54
4.07.2	MATERIALS	54
4.07.3	JOB MIX AND PROJECT MIX	54
4.07.4	EQUIPMENT	54
4.07.5	CONSTRUCTION OF TRIAL SECTIONS	54
4.07.6	SURFACE PREPARATION	55
4.07.7	DELIVERY, SPREADING AND FINISHING	55
4.07.8	SAMPLING AND TESTING	55
4.07.9	SURFACE TOLERANCES	55
4.07.10	DETERMINATION OF THICKNESS	56
4.07.11	MEASUREMENT	56
<b>SECTION 4.08: PAVEMENT REPAIRS, TRENCH EXCAVATION AND RESTATEMENT WORKS</b>		<b>57</b>
4.08.1	SCOPE	57
4.08.2	MATERIALS	57
4.08.3	EQUIPMENT	57
4.08.4	GENERAL REQUIREMENTS	58
4.08.5	PREPARATION OF PAVEMENT	58
4.08.6	PLACING AND FINISHING REPAIR MATERIALS	59
4.08.7	ADDITIONAL REQUIREMENTS FOR REPAIRS TO EXISTING PAVEMENT	60
4.08.8	ADDITIONAL REQUIREMENTS FOR ROAD OPENINGS	60
4.08.9	SAMPLING AND TESTING	61
4.08.10	SURFACE TOLERANCES	61
4.08.11	MEASUREMENT	61
<b>SECTION 4.09 ROAD PLANING AND GRINDING</b>		<b>63</b>
4.09.01	SCOPE	63
4.09.02	EQUIPMENT	63
4.09.03	ROAD PLANING AND GRINDING OPERATIONS	63
4.09.04	PREPARATION OF PLANED SURFACE FOR RESURFACING	64
4.09.05	MEASUREMENT	65

## **SECTION 4.01 MATERIALS FOR BITUMINOUS CONSTRUCTION**

### **4.01.1 SCOPE**

**A.** Materials specified for use in the construction of the various bituminous pavement courses include the following:

- Coarse and fine mineral aggregates and filler.
- Bitumen products including penetration graded bitumens, cutback bitumens, emulsified bitumens and modified bitumens for use in bituminous courses and surface treatments.

**B.** All material sources and the quality of materials proposed for use in the Works shall be approved prior to procuring or processing material from such sources. Inspection, sampling, testing and retesting as necessary, shall be at the Contractor's expense as specified hereunder for specific materials.

**C.** Storage and handling of all materials shall conform to the relevant requirements of Part 1 of Specification Section 4.3: Materials. Materials shall be stored on hard, clean surfaces.

### **4.01.2 AGGREGATE MATERIALS GENERAL**

#### **A. Sources and Production**

**A.1** The Contractor shall have satisfied himself as to the location, suitability and quantity of materials available; extent of work necessary to obtain the material available; the work required to open the quarry and to crush, screen and wash (if necessary) the materials; and the length of haul to the Site prior to the start of Works.

**A.2** Prior to starting quarry operations, the Contractor shall obtain written permission for extraction from the Authorities and/or owners concerned.

**A.3** Crushing and screening plant shall not be put into operation prior to the Engineer's written approval. If after being put into operation any plant fails to perform as intended the Contractor shall either rectify the defects in the existing plant to the satisfaction of the Engineer or shall provide alternative approved plant.

**A.4** Approval of the crushing and screening plant and other equipment shall not relieve the Contractor of his responsibilities in respect of producing aggregates which conform to the Specifications and in the quantities required for the timely completion of the Works.

## **B. Stockpiling**

**B.1** Stockpile areas shall be surveyed prior to stockpiling to establish control points and to obtain a record of existing cross sections for future use in determining stockpile quantities. The stockpile areas shall be adequately drained at all times.

**B.2** Stockpiling procedures shall not result in degradation or segregation of the stockpiled material or the introduction of foreign materials into the stockpile. Heights of aggregate stockpiles shall not exceed 5 metres.

**B.3** Topsoil shall be stripped from the stockpile areas prior to use and stored on site in heaps no higher than 1.5 metres and reinstated on completion of the works.

## **C. Sampling and Testing**

**C.1** Sampling and testing procedures shall conform to the relevant requirements of Part 1 – Section 4.6: Samples and Approvals and to the following requirements.

**C.2** The Contractor shall submit to the Engineer for approval at least 30 days prior to the scheduled beginning of crushing and screening operations, a statement of origin and composition of all aggregates proposed for use in the Works.

**C.3** In order to ascertain the properties of aggregate materials, the Contractor shall submit for testing and approval, representative samples of all materials intended for incorporation into the Works, prior to starting quarry operations. The representative samples shall be taken by the Contractor in the presence of the Engineer.

**C.4** Tests performed by the Contractor shall be utilized in assessing the location, extent of deposits and quantities of materials conforming to the Specification when properly processed. Any special tests that may be required by the Engineer shall be carried out by the Contractor either in his own laboratory or in an outside laboratory approved by the Engineer. All testing as carried out by the Contractor shall not obviate the need for further testing by the Engineer. Approval of specific sources of materials shall not be construed as final approval and acceptance of materials from such sources.

**C.5** Processed materials shall be tested and approved before being stockpiled on Site or incorporated in the Works and shall be inspected and tested at any time by the Engineer during preparation, storage and use. Questionable materials awaiting testing and approval shall not be unloaded and mixed with materials previously approved. If the grading and quality of any materials delivered to the Site do not conform to the grading and quality of the established control samples, the Engineer shall reject such materials.

**C.6** Samples shall satisfy all specified test requirements. The Contractor shall allow the Engineer to inspect any and all materials used or to be used at any time during or after preparation or while being used during construction of the Works. Unsatisfactory materials, whether in place or not, shall be removed promptly from the Site. The Contractor shall furnish all necessary materials, labour, tools, equipment and transport required by the Engineer for such inspections.

#### **4.01.3 AGGREGATES FOR BITUMINOUS PAVING MIXES**

**A.** Aggregates for use in bituminous base course, levelling course, macadam and cold mix courses shall consist of crushed rock or crushed gravel. Aggregates for use in wearing courses shall consist of crushed rock.

**B.** Coarse aggregate shall be the fraction of crushed aggregate material retained on a 4.75 mm (No. 4) sieve. Fine aggregate shall be the fraction of crushed aggregate material passing a 4.75 mm (No. 4) sieve. Mineral filler shall be added when the combined grading of coarse and fine aggregates is deficient in material passing a 0.075 mm (No. 200) sieve.

**C.** The material from hot bins passing the number 40 sieve (0.425mm) when tested in accordance with AASHTO T90 shall be non-plastic. In addition the material from cold bins shall not have a PI larger than 4.

**D.** Aggregates shall not contain more than 1% gypsum and the coarse fraction of the aggregate shall not contain more than 5% chert.

**E.** Aggregates shall be of uniform quality, free from decomposed stone, organic matter, and shale.

**F.** The percentage by weight of friable particles, clay lumps, and other deleterious matter shall not exceed 1% as determined by AASHTO T112.

**G.** Aggregate particles shall be clean, hard, durable and sound. Crushing shall result in a product such that, for particles retained on a 4.75 mm (No. 4) sieve, at least 90% by weight shall have 2 or more fractured faces.

**H.** The flakiness index and the elongation index tests shall be conducted in accordance with BS EN 933-3:1997 with the following maximum limits:

	<b>Wearing Course</b>	<b>Binder &amp; Bituminous Base Courses</b>
Flakiness Index (FI).	20	35
Shape Index (SI).	25	30

**I.** Aggregates shall be washed to remove any clay lumps, organic matter, adherent dust, clay film or other extraneous or deleterious matter that may prevent or detract from proper adhesion of bitumen to the aggregate particles.

**J.** Mineral filler shall consist of finely divided mineral matter such as limestone dust, hydrated lime, other non-plastic mineral filler free from clay and organic impurities and Portland cement, conforming to AASHTO M 17.

**K.** Combined coarse and fine aggregates for bituminous mixes, including mineral filler, when tested in accordance with AASHTO T 27 and T11, shall conform to the gradings shown in Table 4.1.1.

**TABLE 4.1.1: GRADING OF AGGREGATES FOR BITUMINOUS MIXES**

<b><u>SIEVE SIZE</u></b>	<b><u>PER CENT PASSING</u></b>	
	<b>Base Course</b>	<b>Wearing Course</b>
1" (25.0 mm)	100	.....
3/4" (19.0 mm)	65-100	100
3/8" (9.5 mm)	47-72	56-80
No. 4 (4.75 mm)	30-56	35-56
No. 10 (2.00 mm)	19-36	22-36
No. 40 (0.425 mm)	8-20	8-20
No.200 (0.075 mm)	2-8	2-8

**L.** The loss in weight of aggregate after 500 revolutions, when tested in accordance with AASHTO T 96, shall not exceed 35%.

**M.** When tested for soundness in accordance with AASHTO T104 the coarse aggregate (retained on No.4 sieve) shall not show signs of disintegration and the loss by weight after 5 cycles shall not exceed 10% in the case of the sodium sulphate test and 12% in the case of the magnesium sulphate test.

**N.** When testing for resistance to stripping in accordance with AASHTO T-182 at least 95% coated particles shall remain.

#### **4.01.4 AGGREGATES FOR SEAL COATS**

**A.** Cover aggregates for bituminous seal coats shall consist of screenings of crushed stone. Aggregate for slurry seals shall consist of crushed stone fines or natural sand blended with not less than 50% crushed stone fines. For heavy duty applications slurry aggregate shall consist of 100% crushed fines. The suitability of sources of crushed stone fines for use in slurry seal shall be demonstrated to the Engineer for approval prior to use.

**B.** Aggregates shall not contain more than 1% crystalline or amorphous gypsum (expressed as SO<sub>3</sub>) and shall not contain more than 5% chert.

**C.** Aggregate particles shall be clean hard durable and sound. For particles retained on 4.75 mm (No. 4) sieve at least 90% by weight shall have 2 or more fractured faces and 100% by weight shall have one or more fractured faces.

**D.** Flakiness and Elongation Indices shall be tested in accordance with BS EN 933-3:1997 and shall not exceed 25 %. The percentage by weight of clay lumps & friable particles as determined by AASHTO T 112 shall not exceed 3%. Lightweight aggregate of specific gravity of 2 or less shall not exceed 3 % as determined by AASHTO T 113.

**E.** Aggregates shall be washed or processed by any alternative approval method to remove any clay lumps, organic matter, adherent dust or clay films or other extraneous or deleterious matter that may prevent or detract from proper adhesion of bitumen to the aggregate particles.

**F.** Cover aggregates and aggregate for slurry seals shall be tested in accordance with AASHTO T 27 and T11 and shall conform to the gradations given in Table 4.1.2.

**Table 4.1.2: Gradation of Aggregates for Seal Coats**

<b>Sieve Designation (Square openings)</b>	<b>1st Application Grading B</b>	<b>2<sup>nd</sup> Application Grading C</b>	<b>Slurry Aggregate</b>
25.0 mm (1 in)	100		
19.0 mm (3/4 in)	90 - 100		
12.5 mm (1/2 in)	20 - 55	100	
9.50 mm (3/8 in)	0 -15	58 - 100	100
4.75 mm (No. 4)	0 - 5	10 -30	90 - 100
2.36 mm (No. 8)	-	0 -10	65 -90
1.18 mm (No. 16)	-	0 -5	45 -70
0.60 mm (No. 30)	-	-	30 - 50
0.30 mm (No. 50)	-	-	18 -30
0.15 mm (No. 100)	-	-	10 -20
0.07 mm (No. 200)	0 - 0.5	0 - 0.5	5 -15

**G.** The loss in weight of aggregate after 500 revolutions, when tested in accordance with AASHTO T 96 (Los Angeles Test), shall not exceed 30 %.

**H.** When tested for soundness in accordance with AASHTO T 104, the aggregates shall not show signs of disintegration and the loss by weight shall not exceed 10% in the case of the sodium sulphate test or 12% in the case of the magnesium sulphate test.

**I.** When tested for resistance to stripping in accordance with AASHTO T 182, at least 95% of the aggregate surface area shall remain coated with a bitumen film.



#### **4.01.5 BITUMEN**

##### **A. Type Certification and Grade**

**A.1** The Contractor shall furnish the vendor's certified test reports for each load of bitumen delivered to the site. Each report shall be delivered to and approved by the Engineer before the material in the load may be used. The furnishing of the vendor's certified test report for the bituminous material shall be the basis for final acceptance.

**A.2** The grade of bitumen may be changed by the Engineer by one grade either side of the specified grade at no extra cost to the Employer. When more than one type or grade is specified under any item, the Engineer shall select the type and grade to be used in the Works.

##### **B. Transporting Bitumen**

**B.1** All transporting of bitumen shall be by conveyances that are free from contamination. Tank cars or tank trucks used for transporting bitumen shall be carefully inspected, drained and cleaned before loading to prevent contamination of the bitumen from residues of previous loads. Bitumen may also be delivered and transported in metal drums.

**B.2** Tank trucks or trailers used to transport bitumen shall be equipped with a suitable sampling device which shall be built into the tank, recirculating or discharge line so that a sample can be drawn during circulation or discharge.

##### **C. Storage of Bitumen**

**C.1** The Contractor shall provide an adequate storage facility for bitumen at the site of the mixing plant. This facility shall be clean, stable and provided with cover and shelter from excessive temperatures.

**C.2** No open fires or smoking shall be permitted in or around the storage facility.

**C.3** The storage capacity shall be sufficient to maintain a uniform operation while allowing for delayed shipments and time for testing. Different batches of bitumen shall be separated to allow for easy identification.

**C.4** If the bitumen is delivered to the site in metal drums they shall be inspected on arrival at Site for perforations, rusting, melting and other defects that would directly cause pollution or chemical changes to the bitumen. Any drums showing any of these defects shall be rejected by the Engineer.

**C.5** The stored bitumen products should be protected from temperatures that exceed the range of -5°C to +60°C.

**D. Heating of Bitumen**

**D.1** Heating equipment shall be of a type approved by the Engineer. Any method of agitation or heating that introduces free steam or moisture into the bitumen shall not be approved. During the process of manufacture, conveyance, storage and construction, all bitumen shall not be heated to temperatures more than 10°C above the maximum application temperature specified nor above 170 °C, whichever is the lower. Materials heated in excess of these temperatures shall be rejected by the Engineer and not be used in the Works.

**D.2** Tanks for heating and storage of bitumen shall be capable of heating the material, under effective and positive control at all times to the specified temperature. The system shall provide uniform heating for the entire contents of the tank. The circulation system shall be of adequate size to ensure proper and continuous circulation of the bitumen during the entire operating period. Steam, oil jacketing or other insulation shall be provided for maintaining the required temperature of bitumen, weigh buckets, spray bars and other containers.

**D.3** Thermometers of approved types and adequate range (calibrated in 1°C increments) for accurately measuring the temperature of the bitumen while heating shall be located so as to be readily visible and shall be kept clean and in proper working order at all times.

**D.4** Where storage tanks are required, their capacity shall be sufficient for at least one day's production.

**D.5** Bitumen materials wasted through careless handling or rendered unsuitable for use by overheating shall not be used in the Works.

**E. Sampling and Testing**

**E.1** Procedures for sampling of bituminous materials shall conform to AASHTO T 40.

**E.2** General requirements and procedures for sampling and testing of the various types of bitumen shall conform to Part 1–Section 4.6: Samples and Approvals.

**4.01.6 BITUMEN PRODUCTS**

**A. Penetration Graded Bitumen**

**A.1** Penetration graded bitumen shall conform generally to the requirements of AASHTO M 20 as given in Table 4.1.3.

**TABLE 4.1.3: PROPERTIES OF PENETRATION GRADE BITUMEN**

	Penetration Grade					
	<u>40 - 50</u>		<u>60 - 70</u>		<u>85 - 100</u>	
	Min	Max	Min	Max	Min	Max
Ductility at 25°C (cm)	100	-	100	-	100	-
Penetration at 25°C (0.1 mm)	40	50	60	70	85	100
Softening Point (° C)	50	58	48	56	45.8	48
Specific Gravity at 25°C	1.01	1.06	1.01	1.06	1.0	-
Loss on heating 163°C	-	0.8	-	0.8	-	1.0
Penetration of residue % of original	58	-	54	-	50	-
Solubility in Trichloroethylene (% wt)	99	-	99	-	99	-
Ash content % wt	-	1.0	-	1.0	-	1.0
Flashpoint (Cleveland Open Cup.) (°C)	250	-	250	-	225	-

**A.2** Sampling and testing shall be in accordance with the AASHTO standard method listed in AASHTO M 20.

**A.3** The penetration bitumen application temperature range shall be determined to ensure that the appropriate viscosity range for each application is achieved. If the viscosity curves are not available the values given in table 4.1.4 shall be used.

**TABLE 4.1.4: BITUMEN APPLICATION TEMPERATURE RANGE**

Bitumen Grade	40/50	60/70	80/100
Application Temperature °C	150-170	145-165	140-160

## **B. Bitumen Modifier**

**B.1** Whenever specified, an approved modifier shall be incorporated in all penetration graded bitumens immediately prior to the time of use unless otherwise shown on the Drawings. The modifier shall serve to polymerize the bitumen by converting the benzylic carbon groups into ketones.

**B.2** The modified bitumen shall demonstrate significantly reduced temperature susceptibility and/or improved adhesive qualities. The workability of the modified bitumen shall be unchanged from that of unmodified bitumen.

**B.3** The mixing and preparation of modified bitumen shall be carried out in accordance with the manufacturers' instructions, and with the approval of the Engineer.

**C. Rapid-Curing (RC) Cutback Bitumen**

**C.1** RC cutback bitumen shall conform to the requirements of AASHTO M 81, grades RC-70, RC-250, RC-800, and RC-3000 with properties as listed in Table 4.1.5.

**C.2** Sampling and testing shall be in accordance with the AASHTO standard methods listed in AASHTO M 81.

**C.3** RC cutback bitumen spraying temperature ranges shall be as follows:

<b>RC Cutback Bitumen Grade</b>	<b>Spraying Temp °C</b>
RC - 70	40 - 75
RC - 250	65 - 105
RC - 800	90 - 115
RC - 3000	105 - 135

**D. Medium-Cured (MC) Cutback Bitumen**

**D.1** MC cutback bitumen shall conform to the requirements of AASHTO M 82, grades MC-30, MC-70, MC-250, MC-800 and MC-3000 with properties as listed in Table 4.1.6.

**D.2** Sampling and testing shall be in accordance with the AASHTO standard methods listed in AASHTO M 82.

**D.3** MC cutback bitumen spraying temperature ranges shall be as follows:

<b>MC Cutback Bitumen Grade</b>	<b>Spraying Temp °C</b>
MC - 30	21 - 63
MC - 70	45 - 80
MC - 250	70 - 110
MC - 800	95 - 125
MC - 3000	110 - 145

**E. Slow-Curing (SC) Cutback Bitumen**

**E.1** SC cutback bitumen shall conform to the requirements of ASTM D 2026 grades SC-70, SC-250, SC-800, and SC-3000 with properties as listed in Table 4.1.7.

**E.2** Sampling and testing shall be in accordance with the appropriate ASTM standard methods.

**E.3** SC cutback bitumen spraying temperature ranges shall be as follows:

<b>SC Cutback Bitumen Grade</b>	<b>Spraying Temp °C</b>
SC – 70	45 - 80
SC -250	70 - 110
SC - 800	95 - 125
SC - 3000	110 - 145

**F. Emulsified Bitumens**

**F.1** Selection and use of emulsified bitumens shall generally be in accordance with the recommendations in AASHTO R 5, subject to the following requirements.

**F.2** Emulsified bitumens which have been subjected to freezing temperature while in storage shall be retested and acceptance or rejection of the material shall be based on the results of the retest.

**F.3** The manufacturer shall furnish samples of the base bitumen used in the emulsion.

**F.4** When samples of undiluted emulsion are not readily available for test purposes, tests shall be made on the diluted emulsion and the respective specifications modified to reflect the changes in properties resulting from dilution of the bitumen.

**F.5** All emulsified bitumens shall adhere firmly to the surface of the mineral aggregate or the highway surface as appropriate. Failure of the emulsified bitumen to perform satisfactorily on the job shall be deemed cause for its rejection regardless of satisfactory laboratory test results.

**G. Anionic Emulsified Bitumen**

**G.1** Anionic emulsified bitumens shall, prior to dilution, conform to the requirements of AASHTO M 140, for Types SS-1 and SS-1h and as listed in Table 4.1.8.

**G.2** Sampling and testing shall be in accordance with AASHTO T 59.

**G.3** Emulsified bitumen spraying temperature ranges shall be determined to ensure that appropriate viscosities for each application are achieved. If the viscosity curves are not available values shall be 25-65°C, except for Grade RS-2 where the range shall be 50-75°C. The temperature range for pugmill mixing for medium and slow setting types shall be 15-65°C.

**H. Cationic Emulsified Bitumen**

**H.1** Cationic emulsified bitumens shall, prior to dilution, conform to the requirements of AASHTO M 208, for Types CSS-1 and as listed in Table 4.1.9.

**H.2** Sampling and testing shall be in accordance with AASHTO T 59.

**H.3** The emulsified bitumen spraying temperature range shall be so that appropriate viscosity for each application is achieved. If viscosity curves are not available these values, generally considered as guidance shall be in the range of 25-65 °C (except for Grade CRS-2 where the range shall be 50-75 °C). The temperature range for pugmill mixing for medium and slow setting types shall be 15-65 °C.

**TABLE 4.1.5: PROPERTIES OF R.C. CUTBACK BITUMEN**

	<b>RC-70</b>		<b>RC-250</b>		<b>RC-800</b>		<b>RC-3000</b>	
	<b>Min.</b>	<b>Max.</b>	<b>Min.</b>	<b>Max.</b>	<b>Min.</b>	<b>Max.</b>	<b>Min.</b>	<b>Max.</b>
Kinematic Viscosity at 60°C centistokes	70	140	250	500	800	1600	3000	6000
Flash Point (Tag, open-cup) °C	-	-	27	-	27	-	27	-
Water, %	-	0.2	-	0.2	-	0.2	-	0.2
<b>Distillation Test:</b>								
Distillate, % by volume of total distillate to 360°C								
- to 190°C	10	-	-	-	-	-	-	-
- to 225°C	50		35	-	15	-	-	-
- to 260°C	70		60	-	45	-	25	-
- to 315°C	85		80	-	75	-	70	-
Residue from distillation to 360°C volume percentage of sample by difference	55	-	65	-	75	-	80	-
Volume percentage of sample by difference	600	2400	600	2400	600	2400	600	2400
Tests on residue from distillation Absolute viscosity at 60°C poises	100	-	100	-	100	-	100	-
Ductility, 5 cm/min. at 25 °C cm	99	-	99	-	99	-	99	-
Solubility in Trichloroethylene, %								
<b>Spot Test with:</b>								
Standard naphtha	Negative for all grades							
Naphtha-xylene solvent, - % xylene	Negative for all grades							
Heptane-xylene solvent, - % xylene	Negative for all grades							

**TABLE 4.1.6: PROPERTIES OF M.C. CUTBACK BITUMEN**

	MC-30		MC-70		MC-250		MC-800		MC-3000	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Kinematic Viscosity at 60°C centistokes	30	60	70	140	250	500	800	1600	3000	6000
Flash Point (Tag, open- cup) °C	38	-	38	-	66	-	66	-	66	-
Water, %	-	0.2	-	0.2	-	0.2	-	0.2	-	0.2
<b>Distillation Test:</b>										
Distillate, % by volume of total distillate to 360°C										
- to 225°C	-	25	0	20	0	10	-	-	-	-
- to 260°C	40	70	20	60	15	55	0	35	0	15
- to 315°C	75	93	65	90	60	87	45	80	15	75
Residue from distillation to 360°C volume percentage of sample by difference	50	-	55	-	67	-	75	-	80	-
Tests on residue from distillation Absolute viscosity at 60°C poises	300	1200	300	1200	300	1200	300	1200	300	1200
Ductility, 5 cm/min. at 25 °C cm	100	-	100	-	100	-	100	-	100	-
Solubility in Trichloroethylene, %	99	-	99	-	99	-	99	-	99	-
<b>Spot Test with:</b>										
Standard naphtha	Negative for all grades									
Naphtha-xylene solvent, - % xylene	Negative for all grades									
Heptane-xylene solvent, - % xylene	Negative for all grades									

**TABLE 4.1.7: PROPERTIES OF S.C. CUTBACK BITUMEN**

	<u>SC - 70</u>		<u>SC - 250</u>		<u>SC - 800</u>		<u>SC - 3000</u>	
	Min	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Kinematic Viscosity at 60 °C centistokes	70	140	250	500	800	1600	3000	6000
Flash Point (Cleveland open-cup) °C	66	-	79	-	93	-	107	-
Distillation test:								
Total distillate to 360°C, volume %	10	30	4	20	2	12	-	5
Solubility in trichloroethylene %	99.	-	99.	-	99.	-	99.	-
Kinematic viscosity on distillation residue at 60°C, St	4	70	8	100	70	160	40	350
Asphalt residue:								
Residue of 100 penetration %	50	-	60	-	70	-	80	-
Ductility of 100 penetration	100	-	100	-	100	-	100	-
Residue at 25°C, cm Water, %	-	0.5	-	0.5	-	0.5	-	0.5

**TABLE 4.1.8: PROPERTIES OF ANIONIC EMULSIFIED BITUMEN (SLOW SETTING)**

	<u>SS-1</u>		<u>SS-1h</u>	
	Min.	Max.	Min.	Max.
Test on emulsions:				
Viscosity, Saybolt Furol at 25° C,s	20	100	20	100
Viscosity, Saybolt Furol at 50° C,s	-	-	-	-
Storage stability test, 24-h, %	-	1	-	1
Cement mixing test, %	-	2.0	-	2.0
Sieve test, %	-	0.1	-	0.1
Residue by distillation, %	57	-	57	-
Tests on residue from distillation test:				
Penetration, 25°C, 100g, 5 s	100	200	40	90
Ductibility, 25°C 5 cm/min. cm	40	-	40	-
Solubility in trichloroethylene %	97.5	-	97.5	-



**TABLE 4.1.9: PROTECTION OF CATIONIC EMULSIFIED BITUMEN**

	<b>Slow-Setting CSS-1</b>	
	<b>Min.</b>	<b>Max.</b>
Tests on emulsions:		
Viscosity, Saybolt Furol at 25°C, s	200	100
Storage stability test, 24-h, %	1	
Particle charge test		Positive
Sieve test, %		
Cement mixing test, %		0.10
Distillation:		2.0
Residue, %	57	
Tests on residue from distillation test:		
Penetration, 25°C, 100 g, 5 s	100	250
Ductibility, 25°C, 5 cm/min, cm	40	
Solubility in trichloroethylene %	97.5	

#### **4.01.7 MEASUREMENT**

Items listed in this Section shall be measured as prescribed in the appropriate sections of these Specifications.

## **SECTION 4.02 BITUMINOUS PRIME AND TACK COATS**

### **4.02.1 SCOPE**

The work covered in this section consists of furnishing and applying MC cutback bitumen prime coat to a previously constructed subgrade, aggregate base course, highway shoulders, or concrete pavement; and furnishing and applying RC cutback bitumen or emulsified bitumen as a tack coat to a previously constructed bituminous base or wearing surface to provide a bond for a superimposed bituminous course as and where shown on the Drawings.

### **4.02.2 MATERIALS**

#### **A. Medium-Curing Cutback Bitumen**

MC cutback bitumen (for prime coats) shall be as recommended by ASTM D2399-83. MC 70 shall be used unless otherwise specified.

#### **B. Rapid-Curing Cutback Bitumen**

RC cutback bitumen (for tack coats) shall be Grades RC-70 or RC-250 as appropriate and as specified in Section 4.01 - Materials for Bituminous Construction or as specified in the Drawings.

#### **C. Slow-Curing Emulsified Bitumen**

Slow-setting emulsified bitumen (for tack coats) shall be slow-setting Grades SS-1, SS-1h, CSS-1, or CSS-1h, as appropriate and as specified in Section 4.01 - Materials for Bituminous Construction or as specified in the Drawings..

### **4.02.3 EQUIPMENT**

Equipment used for diluting emulsified bitumen, heating cutback bitumen, spraying cutback and emulsified bitumen and for the application of blotting material to prime coats shall conform to the requirements of Part 1 of Specification Section 4-4 - Contractor's Plant and Equipment.

### **4.02.4 CONSTRUCTION OF TRIAL SECTIONS**

**A.** The Engineer shall, if necessary, instruct trial sections to be constructed prior to the commencement of on-Site prime or tack coat applications. The Contractor shall construct trial sections using varying application rates of bitumen as selected by the Engineer. Each trial section shall be 2 lanes wide by 50 metres long, at approved locations on or close to the Site.

**B.** Each trial section shall be constructed using the same materials, mixing and spraying equipment and construction procedures proposed for use in the Works.

**C.** The objectives of these trials shall be to determine the adequacy of the Contractor's equipment and the most suitable application rates for cutback bitumen prime and tack coats.

**D.** The Contractor shall not proceed with any site coat applications until the methods and procedures established in the trials have been approved by the Engineer.

#### **4.02.5 APPLICATION PROCEDURES**

##### **A. General**

**A.1** All equipment used for surface cleaning, heating bitumen and application of prime and tack coats shall be suitable for the purposes intended and shall be approved by the Engineer before use.

**A.2** All surfaces to receive prime or tack coats shall conform to the specified tolerances and compaction requirements and shall be properly cleaned using power brooms or power blowers. Surfaces shall be approved before applying any bitumen material.

**A.3** Prime coats and tack coats shall be applied only when the surface to be treated is sufficiently dry for tack coats and sufficiently moist for prime coats and when the ambient temperature is above 10°C for the application of tack coat and 15°C for the application of prime coat. Prime and tack coats shall not be applied during fog, rain, strong winds, generally dusty conditions or dust storms.

**A.4** The surfaces of all structures, kerbs, gutters and other highway appurtenances shall be protected to prevent them from being splattered or stained with bitumen or damaged during equipment operation. The Contractor shall be responsible for making good any such staining or damage to the satisfaction of the Engineer.

**A.5** Traffic shall not be permitted on surfaces after they have been cleaned and prepared for prime or tack coat application.

**A.6** If there are undue delays in applying prime or tack coats or subsequent paving thereafter, the surface tolerances and compaction of the granular course shall be reverified, deficient areas corrected and or replaced and prime or tack coats reapplied in accordance with the Engineer's instructions and at the Contractor's expense.

**A.7** The Contractor shall maintain prime coats and tack coats intact until they are covered by the subsequent pavement course. Any area where the coats have been damaged shall be cleaned of all loose material, surface defects repaired and the coat re-applied at the Contractor's expense. Traffic control measures shall conform to the relevant requirements of Section 6.07 - Maintenance of Traffic and Detours.

## **B. Prime Coat Application**

**B.1** If required by the Engineer, when the surface is an untreated subgrade or a granular surface, the cleaned surface shall be given a light application of water and allowed to dry to the condition deemed appropriate by the Engineer before the bituminous material is applied.

**B.2** Heating of MC cutback bitumen and its temperature at the time of application shall conform to the relevant requirements of Section 4.01 - Materials for Bituminous Construction.

**B.3** Areas to be primed shall be as shown on the Drawings and shall include 200 mm widths outside the edges of the pavement line, the top of embankment slopes to the pavement lines and between kerbs or gutter edges at bridges and viaducts.

**B.4** Application rates for prime coat shall be determined by the Engineer from the trial sections and shall be generally within the following ranges:

### **Range of Application Rates for Prime Coat**

<b><u>Type of Surface</u></b>	<b><u>Litres/ m<sup>2</sup></u></b>
Untreated subgrade surfaces, shoulders base course:	0.75 - 2.0
Bridge wearing surfaces, concrete pavements:	0.1 - 0.4
Other surfaces:	As determined from field tests or trials

**B.5** The Engineer may order additional trial sections and/or alter the previously established rates of application during progress of the Works.

**B.6** Prime coat shall be applied using pressure distributors operated by skilled workmen. The spray nozzles and spray bar shall be adjusted and frequently checked so that a uniform distribution is ensured. Spraying shall cease immediately if any nozzle ceases to spray and corrective measures taken before spraying is resumed.

**B.7** Hand spraying shall be used only for priming small patches or inaccessible areas that cannot be primed by the normal operation of the pressure distributor.

**B.8** Application of prime between separate areas of priming shall not be excessive. Any excess prime coat shall be removed from the surface and any skipped areas or recognized deficiencies shall be corrected using hand sprays.

**B.9** When required by the Engineer, a light covering of blotting material shall be applied to the prime coat 48 hours after spraying and when it has not dried sufficiently to withstand damage by traffic. The blotting material shall be a smooth fine sand or other material approved by the Engineer.

**B.10** Prime coats shall be cured for 3 days before traffic is allowed on it or before the succeeding pavement layer is placed, or as directed by the Engineer.

**C. Tack Coat Application**

**C.1** Tack coat application shall be as shown on the Drawings and on clean dry surfaces and the application rate shall be as instructed by the Engineer. Emulsified bitumen shall be diluted and thoroughly mixed with an equal amount of water before application.

**C.2** Heating of RC cutback bitumen and its temperature at the time of application shall conform to the relevant requirements of Section 4.03: Bituminous Courses. Where slow-curing emulsified bitumen (SS or CSS Type) is used for tack coat, it shall not require heating except in temperatures below 20°C.

**C.3** The rate of application shall be approved by the Engineer between 0.1 and 0.6 kg. /sq m. depending on whether RC cutback or emulsified bitumen is used and on the surface condition of the bituminous course on which the tack coat is to be sprayed. The Engineer shall alter the previously established rates of application during progress of the Works, if he deems it necessary.

**C.4** The tack coat shall be allowed to dry only until it is in a suitable tacky condition to receive the superimposed bituminous course. Tack coat applications shall not proceed so far in advance of the following course that it dries out completely.

**C.5** Spraying procedures shall be as specified for prime coat application.

**C.6** Blotting material shall not be applied to tack coats.

**4.02.6 MEASUREMENT**

**A.** Bituminous Prime Coat shall be measured by the square metre of the areas primed at the appropriate rate specified by the Engineer.

**B.** Bituminous Prime Coat for Temporary Diversions shall be measured separately as shown in the Bill of Quantities.

**C.** Bituminous Tack Coat shall be measured by the square metre of the areas applied at the appropriate rate specified by the Engineer.

**D.** Surface preparation, protective measures to avoid staining or damage to appurtenances, blotting of prime coats when required and cleaning stains and repairing damage caused by equipment, etc shall not be measured for direct payment, but shall be considered as subsidiary work; the costs of which shall be deemed to be included in the Contract prices for the Pay Items.

## **SECTION 4.03 BITUMINOUS COURSES**

### **4.03.1 SCOPE**

**A.** The work covered in this Section consists of the general requirements for furnishing materials, mixing at a central mixing plant, spreading and compacting the various bituminous concrete and other bituminous mixes including the installation of reinforcing fabric when specified, all as and where shown on the Drawings.

**B.** Requirements with particular application to bituminous base courses, wearing courses, levelling courses, macadam courses, cold mix courses and recycled bituminous base course, are specified in the respective sections relating to such courses.

### **4.03.2 MATERIALS**

**A.** Bituminous mixes shall comprise of coarse and fine mineral aggregate, mineral or cement filler and penetration grade bitumen with mix additives if specified. Bitumen shall either be cutback or emulsified as appropriate to the type of bituminous course to be constructed.

**B.** All materials shall conform to the relevant requirements of Section 4.01 - Materials for Bituminous Construction.

### **4.03.3 JOB MIXES AND PROJECT MIXES**

**A.** At least 30 days prior to the date the Contractor intends to begin production at the mixing plant and after receiving approval of the aggregates and delivery to the Site of the bitumen specified, the Contractor shall submit for the Engineer's approval his proposed Job Mix Formula.

**B.** The Job Mix Formula shall stipulate a single combined grading of all aggregate and filler materials showing the specific percentages by weight passing each sieve size and of each material to be used in the total mix.

**C.** The Job Mix Formula shall be established by the Contractor, under the supervision of the Engineer, in the field laboratory. Mix design procedures shall conform to the Marshall method of mix design and relevant procedures contained in Asphalt Institute Manual MS-2, Sixth Edition. All trial mixes shall be prepared and tested by the Contractor in the presence of the Engineer.

**D.** The Job Mix Formula shall specify a combination of mineral aggregates including filler and bitumen (plus bitumen modifier if required) in such proportions to produce a Job Mix which is within the limits of the specified grading and bitumen content ranges and which meets the Marshall test requirements, as prescribed for each particular type of bitumen course. It shall also stipulate the mixing temperature at discharge from the mixer which, unless otherwise agreed by the Engineer, shall be 170°C.

**E.** The Marshall Test procedure shall be used to determine the percentage of bitumen to be incorporated in the mix. The Job Mix Formula shall take into consideration the absorption of bitumen into the aggregates. Air voids shall be calculated in accordance with the procedure given in the Asphalt Institute Manual, MS-2.

**F.** When compacting specimens in accordance with the Marshall Test procedure, the number of blows applied with the compaction hammer shall be 75 on each side, unless otherwise specified on the Drawings or instructed by the Engineer.

**G.** In order to meet the requirements, an approved additive such as Portland cement, hydrated lime or liquid antistripping agent, may be used in the Job Mix. Portland cement shall meet the requirements of AASHTO M 85. Hydrated lime shall meet the requirements of ASTM C 207, Type N. Cement or hydrated lime will normally be required in the approximate range of 2-3% by weight of the aggregates and shall be added at the cold feed in dry or slurry form as directed. Liquid antistripping agent shall be provided in the range of 0.6-1.0% by weight of the bitumen, or according to the manufacturer's specifications.

**H.** Upon receipt of approval of the Job Mix Formula, the Contractor shall adjust his mixing plant to supply in the correct proportion the individual aggregates, mineral filler and bitumen to produce a final project mix within the job mix gradation limits given in Table 4.3.1.

**TABLE 4.3.1: MAXIMUM VARIATIONS OF PROJECT MIX  
FROM APPROVED JOB MIX**

<b>Sieve Designation (Square Openings)</b>	<b>Specified Tolerances</b>
9.5 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%
0.18 mm (No. 80):	+/- 4.0%
0.075 mm (No. 200):	+/-1.0%
Bitumen Content:	to be recommended by designer
Temperature of Mix on discharge:	+/- 5°C

**I.** Any deviation from these limits shall be made only with the approval of the Engineer.

**J.** Conformance to gradation requirements shall be determined on the extracted aggregate in accordance with AASHTO T 30. The bitumen content shall be determined in accordance with AASHTO T 164.

**K.** The Engineer shall test the project mix at least twice daily during plant operation and, if necessary, direct the Contractor to readjust the plant to conform to the Job Mix Formula. If, due to differing cold feed or hot bin gradations, the Contractor cannot consistently produce a project mix meeting the Job Mix requirements, production shall cease, the Job Mix shall be redesigned and reapproved by the Engineer and the plant readjusted to produce a new Job Mix.

**L.** The participation of the Engineer in the preparation of the Job Mix Formula shall not relieve the Contractor of his responsibility for producing project mixes meeting the specified requirements.

#### **4.03.4 EQUIPMENT**

##### **A. General**

Plant and equipment for mixing, transporting, spreading and compacting bituminous mixes shall conform with the requirements set in Volume 1 and to the Contractor's approved Work Programme.

##### **B. Mixing Plant**

**B.1** Bituminous mixes shall be produced in a batch mixing plant of adequate size with a minimum capacity of not less than 80 tons/hr and a mixer capacity of not less than a 750 kg batch. The plant shall conform to the relevant requirements of AASHTO M 156.

**B.2** A mechanical batch counter shall be installed as part of the timing device and shall be designed to register only completely mixed batches.

**B.3** The mixing plant shall be fully equipped to control the gradation of hot dry aggregates and of cold damp aggregates. A suitable dust collection system shall be installed, capable of returning all dust to the mixture whenever required. Suitable filters shall be incorporated whenever the mixing plant is in the vicinity of inhabited areas, or whenever they are required by law.

**B.4** The cold feed system shall be a continuous belt feed type or other system approved by the Engineer. It shall be easily modified to allow hydrated lime slurry to be added to the mix prior to heating and dry powdered lime to be added after heating.

**B.5** An approved type automatic weighing, cycling and monitoring system shall be installed as part of the batching equipment. Facilities for easy sampling of the aggregates from the hot bins whilst the plant is in operation shall also be provided.

**B.6** The use of a continuous mixing plant shall only be considered in special circumstances. If the Contractor proposes to use a continuous mixing plant for all or part of the bituminous mixing, full details of the plant including its in-service record and the manufacturer's specifications shall be submitted for approval by the Engineer before proceeding with the purchase or delivery to Site of such plant.



**B.7** The Contractor shall systematically inspect and verify in the presence of the Engineer the following key operational aspects of the mixing plant on a weekly basis or whenever suspect,:

- The state of repair of the screens and their frame mountings
- Proper working of cold and hot bin gates
- The accuracy of batching scales for filler, aggregates and bitumen.
- Proper working of the nozzles of the mixer bitumen sprayer
- The state of repair of the paddle tips and liners of the mixer

**B.8** The Contractor shall furnish for reference and retention by the Engineer one complete set of the manufacturer's instruction and operating manuals for the mixing plant intended for use.

**B.9** At the commencement of the Contract, 2 copies each of the latest editions of the Asphalt Institute Specification SS-1 and Manuals MS-2, MS-3, MS-8 and MS-22 shall be furnished by the Contractor for use by the Engineer's supervisory staff and one copy of each shall be issued to each of the Contractor's senior staff involved in bituminous works. At the end of the Contract all the copies shall become the property of the Employer.

## **C. Spreading and Finishing Equipment**

**C.1** Bituminous courses shall be spread and finished using self-contained, power-propelled pavers of sufficient capacity to be capable of laying up to 80 ton/hr. Pavers shall be provided with electronically controlled vibratory screed or strike-off assemblies with devices for heating the screed and shall be capable of spreading and finishing the various courses of bituminous plant mix to the correct thickness and lane and shoulder widths applicable to the typical cross sections shown on the Drawings and in incremental widths down to 2.4 metres minimum and up to 8 metres maximum.

**C.2** Pavers shall employ mechanical devices such as equalizing runners, straightedge runners, evener arms or other compensating devices to maintain the correct grade and confine the edges of the mix to the specified edge lines without the use of stationary side forms. Joint levelling devices shall be provided for smoothing and adjusting longitudinal joints between lanes.

**C.3** Pavers shall be equipped with receiving hoppers having sufficient capacity for a uniform spreading operation. Hoppers shall be equipped with a distribution system to place the mix uniformly in front of the full length of the screed.

**C.4** The screed or strike-off assemblies and extensions shall effectively produce a finished surface of the required evenness and texture without tearing, shoving or gouging the mix.

**C.5** The paver shall be capable of being operated at forward speeds consistent with satisfactory laying of the mix. The speed shall be fully adjustable between 3 and 6 metres/minute.

**C.6** Automatic controls shall consist of automatic linkage arrangements such that, through the process of adjusting the screed thickness control, the mix can be placed and finished to a predetermined grade and a uniform crown or cross section. Articulated averaging beams shall be at least 9 metres in length.

**C.7** If during construction, the spreading and finishing equipment in operation leaves in tracks or indented areas or other irregularities in the pavement surface that are not satisfactorily corrected by scheduled operations, the use of such equipment shall be discontinued and other satisfactory spreading and finishing equipment shall be provided by the Contractor.

**C.8** The Contractor shall make available for reference by the Engineer the manufacturer's instruction and operating manuals for each paver intended for use.

#### **4.03.5 CONSTRUCTION OF TRIAL SECTIONS**

**A.** Immediately prior to finalization of the Job Mix Formula, the Contractor shall lay trial sections of the various bituminous mixes intended for use in the Works. Each trial section shall be 2 lanes wide by 50 metres long at approved locations close to the Site. Each trial section shall be laid using the same materials, Job Mix, mixing, spreading and compaction plant and spreading and compaction procedures proposed for use in the Works.

**B.** Each trial section shall serve as a field verification of the Job Mix design. The mix density achievable and the air voids at that density shall be determined and, if less than required, the Job Mix Formula shall be adjusted accordingly.

**C.** Each trial section shall also demonstrate the adequacy of hauling, spreading and compaction equipment and the suitability of the construction method and organization proposed.

**D.** If the trial section meets the required specification, the Job Mix Formula shall be approved by the Engineer.

**E.** The trial section shall be carried out at the Contractor's expense and shall be removed from Site, if so required by the Engineer.

#### **4.03.6 MIXING PROCEDURES**

**A.** Each aggregate ingredient shall be heated and dried such that the temperature recorded in the hot fines bin after screening shall not exceed 170 °C. If any aggregates contain excess moisture that may cause foaming in the mixture or their temperature is in excess of 170 °C, they shall be removed from the bins and disposed of as directed by the Engineer.

**B.** Immediately after heating, the aggregates shall be screened into at least 3 sizes and conveyed to separate bins ready for batching and mixing with the bitumen. When the aggregates furnished are of such size and grading that separating into 3 bins is impractical, the number of required separations may, if approved by the Engineer, be reduced to 2 only. Screening operations shall produce, at plant operating capacity, gradations in each of the sizes of heated and dried aggregates that are reasonably uniform and will result in the production of a mix conforming to the Job Mix requirements.

C. The dried and heated aggregate and (cold) mineral filler shall be combined in the plant in the proportionate amounts as determined by the Job Mix. Immediately prior to bitumen entering the mixer, bitumen modifier or antistripping additive, if required, shall be thoroughly mixed with the bitumen which shall then be introduced into the pugmill mixer in the proportionate amounts determined by the Job Mix.

D. The temperature of the bitumen upon entering the pugmill shall be within 15°C of the aggregate temperature. Unless otherwise directed, the bitumen temperature shall be as given in Table 4.3.2.

**TABLE 4.3.2: BITUMEN PROPERTIES**

<b><u>Type and Grade of Bitumen</u></b>	<b><u>Viscosity (Centistokes)</u></b>	<b><u>Max. Temperature °C Immediately after discharge from Pugmill</u></b>
85 - 100 pen.	170 + 20	160
60 - 70 pen.	170 + 20	165
40 - 50 pen.	170 + 20	170

E. Any mix subjected to higher temperatures than those shown in Table 4.3.2 shall be rejected.

F. The mixing time required in order to obtain a homogeneous mix and adequate coating of the aggregates with bitumen shall be determined by the Contractor in the presence of the Engineer. This time shall be redetermined whenever the source of aggregate for the mix changes.

G. In batch plants, mixing time shall begin upon entry of bitumen into the pugmill.

H. Mixing time for continuous mixing plants shall be determined by the following formula or other approved method agreed with the Engineer:

$$\text{Mixing time (sec)} = \text{Pugmill dead capacity (kg) divided by pugmill output (kg/sec)}$$

#### **4.03.7 SURFACE PREPARATION**

A. When the bituminous mix is to be placed on a prepared subgrade, subbase or base, the surface shall be prepared to meet the appropriate specified compaction and surface tolerance requirements. The surface shall then be primed as specified in Section 4.02 - Bituminous Prime and Tack Coats. No bituminous mix shall be laid on a prime coat until it has been inspected and approved by the Engineer.

B. When the bituminous mix is to be placed on an existing bituminous surface, the surface shall be cleaned of all foreign material and broomed free of dust. Any loose, broken or shattered bituminous material along the edges of the existing surface shall be removed and the exposed subgrade, and a sufficient width of the shoulder adjacent to the edge of the existing surface, shall be shaped, bladed, compacted and broomed to provide a uniform firm subgrade for the new surface course.

**C.** Broken, soft or unstable areas of existing bituminous surface, base or subgrade shall be removed and replaced. The areas shall be excavated to a depth as directed by the Engineer and refilled with the specified bituminous mix.

**D.** Prior to placing of the bituminous mix on an existing bituminous surface a tack coat as specified in Section 4.02 - Bituminous Prime and Tack Coats shall be applied to the existing surface at the rate determined by the Engineer. No mixture shall be laid on a tack coat until it has been inspected and approved by the Engineer.

#### **4.03.8 DELIVERY, SPREADING AND FINISHING**

##### **A. Delivery of Mix to Site**

**A.1** A sufficient number of haul vehicles shall be provided so that adequate supplies of mix are delivered to ensure paving is a continuous operation.

**A.2** Hauling equipment for aggregates and bituminous mixes shall consist of trucks having dump bodies suitable for tipping materials in a windrow or in spreader boxes. The bodies shall be constructed so that volume measurements can be accurately determined. They shall be constructed and maintained such that loss of materials during hauling operations will not occur. Dump controls shall be capable of operation from the driver's seat.

**A.3** Hauling equipment for hot bituminous mixes shall have tight, clean, smooth metal surfaces which are periodically thinly coated with a lime solution or other approved material to prevent adherence of the mix. All hauling units shall be equipped with a canvas or other approved type cover which shall be used to cover the hot material upon loading at the mixing plant and shall not be removed until the mix is discharged into the paver. Hot mix material may be transported without such cover only when permitted by the Engineer and in special circumstances.

**A.4** The dispatching of the hauling vehicles to the Site shall be scheduled so that all material delivered is placed at least 90 minutes before sunset to allow sufficient time for compaction, unless the use of artificial light has been approved by the Engineer. Delivery of material shall be at a uniform rate and in an amount well within the capacity of the paving and compacting equipment.

**A.5** The mix at delivery to the paver shall be not more than 10°C below the discharge temperature at the mixing plant. The minimum temperature for the commencement of compaction is 120°C. Mix loads with temperatures less than 120°C shall not be accepted, and the load shall be disposed of and another load used. If there is a consistent failure to meet the temperature requirement the Engineer shall order paving operations to stop until suitable measures are taken by the Contractor to ensure that temperature requirements are met.

**A.6** Each haul vehicle shall be weighed after each loading at the mixing plant and accurate records shall be kept of the gross and net weight, date and time of loading for each load.

## **B. Setting Out and Reference Lines**

**B.1** The Contractor shall survey the centreline profile and crown of the existing surface or base and determine a reference grade line which shall be submitted to the Engineer for approval. A reference line of wire or suitable cord shall be installed at a uniform grade parallel to the approved reference grade line such that conformance with the required geometrics, surface tolerance and minimum thickness requirements shall be ensured. The reference line shall be supported at 8 metre maximum spacing unless there is noticeable sag in the line or the pavement surface, in which case the maximum spacing shall be 4 metres.

**B.2** The reference line shall be maintained taut and free from sags at all times during spreading and initial compacting operations.

**B.3** Except where the paver is matching a previously placed layer, a wire or cord reference line shall be installed on both sides of the paver for the initial bituminous course being laid. Thereafter only one reference line shall be required if the paver is equipped with adequate automatic superelevation control.

## **C. Spreading and Finishing**

**C.1** Bituminous mixes shall only be laid when the air temperature is at least 5 °C or above and the surface temperature of the underlying course is at least that specified in Table 4.3.3, when the existing surface is free from moisture and when the weather is not foggy, rainy, dusty or excessively windy. The temperature requirements shall only be waived when so directed by the Engineer.

**TABLE 4.3.3: MINIMUM SURFACE TEMPERATURES FOR ASPHALT CONSTRUCTION**

<u>Asphalt Course Thickness</u>	<u>Minimum Surface Temperature °C</u>
75 mm or greater	4
Greater than 25mm but less than 75mm	7
25mm or less	10

**C.2** After completion of surface preparation the bituminous mix shall be spread and finished true to crown and grade by approved automatically controlled bituminous pavers. The mix shall only be spread and finished by approved hand methods when Engineer determines that machine methods are impracticable. Hand methods shall include heated hand tampers of at least 10 kg weight and mechanical (vibratory) tampers of types approved by the Engineer.

**C.3** The paver shall spread the bituminous mix without tearing the surface and shall strike a finish that is smooth, true to cross section, uniform in density and texture and free from hollows, transverse corrugations and other irregularities.

**C.4** The paver shall be operated at a speed which gives the best results for the type of paver being used and which coordinates satisfactorily with the rate of delivery of the mix to the paver. A uniform rate of placement shall be achieved without repeated intermittent operation of the paver.

**C.5** The mix shall be delivered to the paver in time to permit completion of spreading, finishing and compaction of the mix during daylight hours.

**C.6** If during laying the paver is repeatedly delayed because of lack of supply or if the paver stands at one location for an extended period resulting in the (unrolled) mat under and adjacent to the rear of the spreader falling below the minimum temperature for breakdown rolling, the affected portion of mat shall be cut out and discarded and a transverse joint constructed. Paving shall not recommence until the Engineer is satisfied that paving can proceed without interruption.

**C.7** Contact surfaces of kerbing, gutters, manholes and similar structures shall be painted with a thin, uniform coating of tack coat material. The bituminous mixture shall be placed uniformly high near the contact surfaces so that after compaction it will be 10 mm above the edge of such structure.

**C.8** If during the paving operations the spreading and finishing equipment in operation leaves surface tracks or indented areas or other objectionable irregularities in the pavement that are not satisfactorily corrected by the scheduled operations, the use of the equipment shall be discontinued, until faults are corrected to the approval of the Engineer. If this is not possible, other satisfactory spreading and finishing equipment shall be provided by the Contractor.

**C.9** Where successive bituminous layers are to be placed, the surface of each existing layer shall be swept clean with a power broom, or by other approved means and a tack coat applied at the rate designated by the Engineer and in accordance with the relevant requirements of Section 4.02 - Bituminous Prime and Tack Coats.

**C.10** Transverse joints in succeeding layers shall be offset by at least 2 metres. Longitudinal joints shall be offset at least 150 mm.

**C.11** The bituminous mix shall be spread in one or more layers in order that after rolling the nominal thickness of each layer of the compacted bituminous material does not exceed 3 times the maximum size of aggregate. This maximum thickness may be increased slightly when such an increase is more appropriate to total pavement thickness and provided the Engineer determines that such an increased thickness will not be detrimental to the quality of the finished bituminous course and the Contractor can show that the required density is attained throughout the layer thickness.

**C.12** Transitions and structure approaches shall meet the design criteria for geometry and surface tolerance specifications and shall not be visually discontinuous or abrupt in appearance.

**C.13** Side roads, entrances and lay-bys shall be paved in accordance with the details shown on the Drawings.

## **D. Joints and Edges**

**D.1** All joints between old and new pavements or between successive days' work shall provide thorough and continuous bonds between the old and new material.

**D.2** Before placing a fresh mix against previously laid or against old pavement, the contact surface shall be cut back to a near vertical face and shall be sprayed or painted with a thin uniform coat of tack coat material unless otherwise directed by the Engineer. Longitudinal joints shall be made by overlapping the paver screed on the previously laid material (cut back as necessary) and depositing a sufficient amount of fresh mix so that the joint formed is smooth and tight.

**D.3** The Contractor shall schedule paving operations to minimize exposure of longitudinal joints prior to the completion and compaction of joints. The leading lane shall not be laid in advance of the adjacent trailing lane by more than one half day of paving and the leading lane shall not be laid more than 0.5 km ahead of the trailing lane without the Engineer's approval. In the event of failure to conform to these requirements, the Engineer shall suspend paving on the leading lane.

**D.4** Unsupported edges of bituminous layers shall be rolled immediately following the rolling of the longitudinal joint. The material along the unsupported edge may, with the Engineer's approval, be raised slightly by hand methods to ensure that the full weight of the roller will bear fully on the edge material.

**D.5** On completion the longitudinal edges of bituminous pavement shall be true to the width and alignment as shown on the Drawings. The edges shall be cut back if necessary prior to rolling, additional mix placed manually in a longitudinal strip adjoining each pavement edge and the edge rolled down to a neat 3:1 (H:V) slope or as shown on the Drawings.

**D.6** Transverse joints shall be carefully constructed and thoroughly compacted to provide a smooth riding surface. Joints shall be straight-edged and string-lined to assure smoothness and a true alignment. If the joint is formed with a bulkhead, such as a board, to provide a straight line and vertical face, it shall be checked with a straight edge before fresh material is placed against it to complete the joint. If a bulkhead is not used to form the joint and the roller carries over the end of the new material, the line shall be cut back a sufficient distance to provide a true surface and cross-section. If the joint has been distorted by traffic or by other means, it shall be trimmed to line. In either case, the joint face shall be painted with a thin coating of bitumen before the fresh material is placed against it.

## **E. Compaction**

**E.1** Rollers shall be operated by competent and experienced operators in accordance with the manufacturer's instructions, copies of which shall be submitted to the Engineer. Rollers shall be kept in operation continuously during paving operations so that all parts of the pavement receive substantially equal compaction at the time desired.

**E.2** After spreading and strike-off and as soon as the mix conditions permit the rolling to be performed without excessive shoving or tearing, the mixture shall be thoroughly and uniformly compacted using approved types, sizes and numbers of rollers. Rolling shall not be prolonged to the point where cracks appear or shoving or displacement occurs.

**E.3** All rollers shall be self-propelled vibratory steel wheel, 2-axle tandem steel-tired and pneumatic-tired types in proper operating condition, capable of reversing without backlash or tearing of the surface and shall be operated at speeds slow enough to avoid displacement of the bituminous mix. The minimum numbers of rollers required is 3, of which one shall be a pneumatic type. The Contractor shall select a suitable method and pattern of rolling that will achieve the required compaction, to the Engineers approval.

**E.4** Prior to use on site of pneumatic-tired rollers, the Contractor shall furnish, for reference and retention by the Engineer, manufacturers' charts or tabulations showing the contact areas and contact pressures for the full range of tyre inflation pressures and for the full range of tyre loadings for each type and size of compactor tire to be used. The Contractor shall ensure that tyre pressures are maintained at all times in conformity with such charts or tabulations. The maximum allowable tolerances shall be plus or minus 35 kN/m<sup>2</sup>.

**E.5** Rollers shall move at a slow but uniform speed with the drive roll or wheels nearest the paver. Recommended speeds are shown in Table 4.3.4.

**TABLE 4.3.4 RECOMMENDED SPEEDS OF ROLLERS (Km/Hr)**

	<b>Breakdown</b>	<b>Intermediate</b>	<b>Finish</b>
Steel Tired Static Weight Rollers	3	5	5
Pneumatic Tired Rollers	5	5	9
Vibratory Rollers	4.5	4.5	-

**E.6** If vibratory rollers are used the vibration mechanism shall be turned off before changing direction before the roller has stopped and turned on again on completion of the manoeuvre.

**E.7** Rolling shall begin as soon as the mixture will bear the roller weight without undue displacement. The minimum temperature of the mat at which rolling shall be allowed to start is 120°C.

**E.8** Breakdown rolling shall consist of 3 complete coverages unless otherwise directed. Rolling shall be longitudinal, beginning at the low side of the spread of material and proceeding towards the high side, overlapping on successive trips by at least one half the width of the rear wheels. Alternate passes of the rollers shall be of slightly differing lengths.

**E.9** The speed of the rollers, rolling pattern and, in the case of vibratory rollers, the frequency and amplitude of vibration shall be approved by the Engineer. To prevent adhesion of the mix to the rollers, the wheels shall be kept properly and lightly moistened with water. An excessive use of water shall not be permitted.



**E.10** The rolling pattern, type and number of rollers shall be established by a site trial to achieve the required compaction. The established rolling pattern shall be follows.

**E.11** The initial or breakdown rolling shall be followed by intermediate rolling involving passes with pneumatic-tired rollers unless otherwise specified. Tyre contact pressure shall be as approved by the Engineer.

**E.12** Finishing rolling shall be carried out by means of tandem power steel rollers unless otherwise agreed by the Engineer. If the specified density is not achieved, changes shall be made in size and number of rollers being used to ensure the compaction requirements are met.

**E.13** The compacted density for all bituminous courses shall be equal to or greater than 97% of the average Marshall bulk specific gravity for each day's production unless otherwise directed by the Engineer.

**E.14** Any mix that becomes loose, broken, mixed with foreign material or which is defective in finish or density or which does not conform in all other respects with the specified requirements shall be removed and replaced with suitable material and properly finished.

#### **4.03.9 SAMPLING AND TESTING**

**A.** Sampling and testing shall conform to the relevant requirements of Part 1 of the Specifications, Section 4-6 "Samples and Approvals", and Table 4.3.5.

**TABLE 4.3.5: TESTS FOR BITUMINOUS PAVEMENTS: MINIMUM REQUIREMENTS**

Work Item	Test at Source of Material	Frequency	Test at Road Site	Frequency
4-1 Materials used in Asphalt Mix  (at Batching plant)	1-Specific gravity and water absorption 2- Abrasion test 3- Chert content 4- Clay lumps and friable particles 5- Flaky and elongated particles 6- Soundness	For each source <b>and</b> When material quality changes <b>and</b> When requested by the Engineer		
4-2 Materials used in Asphalt mix  (from hot bins)	1- Gradation 2- Specific gravity and water absorption 3- Plasticity index 4- Sand equivalent 5- Stripping with asphalt	For each source <b>and</b> When material quality changes <b>and</b> When requested by the Engineer		
4-3 Asphalt Mix Design (each layer)  (At Batching Plant)	1- Complete mix design 2- Loss of stability	For each Project <b>and</b> When material quality changes <b>and</b> When results are not consistent with the mix design results <b>and</b> When requested by the Engineer		
4-4 Asphalt for each layer	<u>At Batching Plant</u> 1- Stability 2- Flow 3- Binder content and gradation 4- Air voids 5- Voids in mineral aggregates 6- Daily Marshall density	Every 3 working days <b>and</b> For each batching plant <b>and</b> When requested by the Engineer	<u>Behind Spreader</u> 1- Stability 2- Flow 3- Binder content & gradation 4- Air voids 5- Voids in mineral aggregates 6- Marshall density	Every working day <b>and</b> Test for each batch <b>and</b> When requested by the Engineer
	7- Loss of Stability	Every week <b>and</b> When requested by the Engineer	7- Road density and thickness (after final compaction)	Every 200m per lane and each layer <b>and</b> When requested by the Engineer

**B.** The Marshall bulk specific gravity shall be determined in accordance with AASHTO T 166. The Marshall specimens shall be prepared from the same material used in the construction, taken from samples of fresh bituminous mix at the mixing plant or from trucks delivering mix to the Site. Oven heating for up to 30 minutes to maintain the heat of the sample is permissible.

**C.** The bulk specific gravity of the mix as placed and compacted in situ shall be determined from 100 mm nominal diameter core samples or slab samples cut from each compacted layer on the road at locations selected by the Engineer. The Engineer reserves the right to instruct additional tests to determine the limits of areas deficient in density or for verification.

**D.** Samples for in situ bulk specific gravity determinations shall be taken in sets of two from each pavement location. The minimum frequency of sampling for each bituminous layer shall be one set/lane/500 m, with a minimum of one set per day of placed bituminous layers.

**E.** The Contractor shall cut the samples with an approved core drill in the presence of the Engineer. The equipment shall be capable of cutting the mixture without shattering the edges or otherwise disturbing the density of the specimen.

**F.** The Contractor shall, when necessary, furnish and apply cold water, ice, or other cooling substance to the surface of the pavement to prevent the sampling from shattering or disintegrating. The Contractor shall fill and compact all test holes at his own expense.

#### **4.03.10 SURFACE TOLERANCES**

**A.** The fully compacted and completed bituminous course shall conform to the lines, grades and cross sections as shown on the Drawings.

**B.** The elevations of the finished course shall be checked by the Contractor in the presence of the Engineer at maximum intervals of 10 metres and at intermediate points as directed.

**C.** When the finished surface is tested with a 3 metre long straightedge, placed parallel to, or at right angles to the centreline, the maximum deviation of the surface from the testing edge between any two contact points shall not exceed the tolerances specified for each type of bituminous course laid.

**D.** All areas which exceed the specified tolerances shall be corrected by removing the defective sections of bituminous course and reconstructing them or by adding new material and recomposing and finishing to the specified standard or increasing the thickness of the succeeding course.

**E.** The tolerances specified for evenness of finished surfaces for all types of bituminous courses shall not invalidate the tolerances specified for construction thickness and elevations of such courses.

#### **4.03.11 DETERMINATION OF LAYER COURSE THICKNESSES.**

**A.** The Contractor shall compensate for minor deficiencies in the thickness of any bituminous course in the pavement structure by increasing the thickness of the subsequent bituminous course.

After completion of the final (wearing) course any deficiencies in the thickness of any course which have not been compensated for by increasing the thickness of a subsequent course, shall be considered as deficiencies in the final (wearing) course.

**B.** Cylinder core samples shall be taken as specified for in situ bulk specified gravity core samples.

**C.** Thicknesses of bituminous courses shall be determined by calliper measurements of cores, rounded upwards to the nearest mm.

**D.** Paved sections to be measured separately shall consist of 300 metre sections in each traffic lane. The last section in each traffic lane shall be 300 metres plus the fractional part of the 300 metres remaining. Other areas such as intersections, entrances, crossovers and ramps shall be measured as one section and the thickness of each shall be determined separately. Small irregular unit areas may be included as part of another section.

**E.** One core shall be taken from each section by the Contractor at locations approved by and in the presence of the Engineer. When the measurement of the core from any paved section is not deficient by more than 5 mm from the specified thickness, the core shall be deemed to be of the specified thickness as shown on the Drawings.

**F.** When the measurement of the core from any paved section is deficient by more than 5 mm but not more than 20 mm, 2 additional cores spaced at not less than 100 metres shall be taken and used together with the first core to determine the average thickness of such a section.

**G.** When the measurement of the core from any paved section is less than the specified thickness by more than 20 mm, the average thickness of such section shall be determined by taking additional cores at not less than 5 metre intervals parallel to the centreline in each direction from the affected location until, in each direction, a core is taken which is not deficient by more than 20 mm. Exploratory cores for deficient thicknesses shall not be used in average thickness determinations.

**H.** Any deficiencies in the total thickness of bituminous courses shall be subject to a proportional reduction in the volume of final (wearing) course measured for payment. Alternatively, the Contractor shall construct, at his own expense, a wearing course overlay if practicable in the judgement of the Engineer. Any such overlay shall be a minimum of 40 mm compacted thickness and to the specified standard of the course it is overlaying.

**I.** If the deficiency in total asphalt layers thickness is from 0 - 3mm, full payment will be made, on condition that deficiencies are not found in more than 10% of the total project. For deficiencies between 3mm and 10mm, 80% of the full payment for the bituminous courses shall be made.

#### **4.03.12 MEASUREMENT**

**A.** Bituminous Courses shall be measured as prescribed in each of the respective Sections for each type of bituminous course constructed and accepted. Measurement shall not include the rolled edge strips of bituminous courses placed outside the edge of paving as shown on the Drawings.

**B.** Bituminous prime and tack coats shall be measured as prescribed in Section 4.02 - Bituminous Prime and Tack Coats.

**C.** Bituminous overlays constructed to correct deficiencies in total thickness of bituminous courses or to compensate for major deficiencies in the thickness of any underlying bituminous course, shall not be measured for direct payment, but shall be considered as subsidiary work; the costs of which shall be deemed to be included in the Contract Prices for Pay Items.

**D.** Establishment of the Job Mix Formula, surface preparation, construction of joints, hand painting of contact surfaces, remedial treatment of surface irregularities, cutting of cores and slabs for testing or measurement purposes, reinstatement of core and slab areas of pavement, rolled down longitudinal bituminous edge strips, additional thicknesses of bituminous courses in excess of the specified thickness and other ancillary items shall not be measured for direct payment, but shall be considered as subsidiary work; the costs of which shall be deemed to be included in the Contract Prices for Pay Items.

## **SECTION 4.04 BITUMINOUS BASE COURSE**

### **4.04.1 SCOPE**

The work covered in this Section consists of furnishing materials, mixing at a central mixing plant and spreading and compacting bituminous base course on an approved granular base, subbase or subgrade as and where shown on the Drawings.

### **4.04.2 MATERIALS**

- A.** All materials shall conform to the relevant requirements of Section 4.01 - Materials for Bituminous Construction.
- B.** Unless otherwise shown on the Drawings, bitumen for base course construction shall be 60/70 penetration graded bitumen.
- C.** When an approved modifier is to be added and mixed with the bitumen, the bitumen used shall not be of lower penetration than 80/100 grade.

### **4.04.3 JOB MIX AND PROJECT MIX**

- A.** The Job Mix Formula shall be established by the Contractor in accordance with the procedures and requirements of Section 4.03 - Bituminous Courses.
- B.** The Job Mix for bituminous base course shall conform to the following composition limits shown in Table 4.4.1.

**TABLE 4.4.1:JOB MIX REQUIREMENTS FOR BITUMINOUS BASE COURSE**

Marshall Stability at 60°C (Kg)	700
Flow (mm)	2 - 3.5
Voids in Mineral Aggregate (VMA)	12 (min)
Air Voids (%)	4 - 8

- C.** After the Job Mix Formula has been established and approved by the Engineer, all mixes furnished shall conform to it within the stated tolerances.
- D.** The Job Mix Formula shall be re-established if the source of aggregate, filler or bitumen changes.

#### **4.04.4 EQUIPMENT**

Plant and equipment for mixing, hauling, placing and compacting bituminous base course material shall conform to the relevant requirements of Section 4.03 - Bituminous Courses.

#### **4.04.5 CONSTRUCTION OF TRIAL SECTIONS**

Trial sections shall be constructed as and where directed by the Engineer and in accordance with the relevant requirements of Section 4.03 - Bituminous Courses.

#### **4.04.6 MIXING PROCEDURES**

Handling and mixing of bitumen (including modifier and antistripping agent, if any) and aggregates (including mineral filler if required) shall be in accordance with the relevant requirements of Section 4.03 - Bituminous Courses.

#### **4.04.7 SURFACE PREPARATION**

Preparation of the surfaces upon which the bituminous base course mix is to be laid shall be appropriate to the type and condition of such surfaces and shall conform to the relevant requirements of Section 4.03 - Bituminous Courses.

#### **4.04.8 DELIVERY, SPREADING AND FINISHING**

##### **A. General**

The delivery, spreading and finishing of bituminous mix for base course shall conform with the relevant requirements of Section 4.03 - Bituminous Courses and to the following particular requirements.

##### **B. Rollers**

**B.1** Initial breakdown rolling shall be carried out using 2 dual-drum vibrating steel-wheeled vibrating rollers each of a minimum weight of 7,000 kg and with vibrating frequency of 2,000-3,000 cycles/min. These rollers shall be purpose-made for compaction of hot bituminous courses.

**B.2** Intermediate rolling shall be carried out using least 2 self-propelled, tandem pneumatic smooth-tired rollers each capable of exerting contact pressures of up to 690 kN/mm<sup>2</sup> and ballast - adjustable to ensure uniform wheel loadings.

**B.3** Final rolling shall be carried out using two 2-axle tandem steel-tired rollers each of minimum weight 10,000 kg, capable of exerting contact pressures of up to 65 kg/cm.

**B.4** The number of rollers used for any stage of rolling may be reduced by the Engineer to one, provided that the base course width being compacted is less than 5.5 m in width, and provided an equivalent standby roller is available on Site as a replacement in the event of breakdown of the operating roller.

**C. Standard of Compaction**

The compacted density of the bituminous base course shall be equal to or greater than 97% of the average Marshall bulk density for each day's production.

**4.04.9 SAMPLING AND TESTING**

Sampling and testing shall conform to the relevant requirements of Section 4.03 - Bituminous Courses, and Table 4.3.4.

**4.04.10 SURFACE TOLERANCES**

**A.** Surface tolerances shall conform with the relevant requirements of Section 4.03 - Bituminous Courses and to the following particular requirements.

**B.** The tolerances on elevations of the finished bituminous base course surface shall be not greater than plus 10 mm or less than minus 10 mm.

**C.** When the finished surface is tested with a 3 metre long straightedge, placed parallel to, or at right angles to the centreline, the maximum deviation of the surface from the testing edge between any two contact points shall not exceed 8 mm.

**4.04.11 DETERMINATION OF THICKNESS**

**A.** Procedures for determining the average compacted thickness of bituminous base course shall conform with the relevant requirements of Section 4.03 - Bituminous Courses and to the following particular requirements.

**B.** Cores for thickness measurements shall be used to determine if changes are necessary in the constructed thickness of succeeding bituminous layers to rectify any thickness deficiencies in the bituminous base course.

**C.** Where the bituminous base course is not to be covered by a superimposed wearing course, the base course shall be deemed to be the final (wearing) course for the purposes of determining the proportion of wearing course volume measured for payment or for the purposes of any overlay ordered to correct deficiencies.



**4.04.12 MEASUREMENT**

- A.** Bituminous Base Course shall be measured by the cubic metre of mix furnished, spread, compacted, completed and accepted. Measurements shall be based on the areas and thickness as shown on the Drawings or as otherwise directed by the Engineer.
- B.** Where Bituminous Base Course is intended to serve as a wearing course, any deficiencies in thickness shall, unless an overlay is constructed at the Contractor's expense, result in a proportion only of the base course volume being measured for payment. Proportions shall be determined in accordance with the thickness deficiencies presented in Section 4.03 - Bituminous Courses.
- C.** The rate for Bituminous Base Course used in temporary diversions shall also include for removal and disposal of the base course material and reinstatement of the temporary diversion, to the satisfaction of the Engineer, on completion of use.
- D.** Bituminous prime and tack coats shall be measured as prescribed in Section 4.02 - Bituminous Prime and Tack Coats.

## **SECTION 4.05 BITUMINOUS WEARING COURSE**

### **4.05.01 SCOPE**

**A.** The work covered in this Section consists of furnishing materials, mixing at a central mixing plant and spreading and compacting bituminous wearing course on an approved base course as and where shown on the Drawings.

**B.** Bituminous wearing course material consists of a surface course composed of mineral aggregate, filler and bituminous material mixed in a central mixing plant and placed on a prepared lower asphalt or road base course in accordance with these Specifications and conforming to the lines, grades, thicknesses and typical cross sections shown on the Drawings or as indicated by the Engineer.

### **4.05.02 MATERIALS**

All materials shall conform to the relevant requirements of Section 4.01 - Materials for Bituminous Construction and the following:

#### **A. Aggregate**

##### **A.1 Coarse Aggregate**

A.1.1 Coarse aggregate shall show the following properties:

<b>Property</b>	<b>Material</b>		
	<b>Limestone</b>	<b>Basalt</b>	<b>Other</b>
Los Angeles Abrasion (ASTM C 131)	30% maximum	20% maximum	20% maximum
Sodium Sulphate Soundness (ASTM C 88)	12% maximum, 9% maximum on sites over 1000m above sea level	6% maximum	12% maximum, 9% maximum on sites over 1000m above sea level
Magnesium Sulphate Soundness (ASTM C 88)	18% maximum, 14% maximum on sites over 1000m above sea level	9% maximum	18% maximum, 14% maximum on sites over 1000m above sea level
Polish Stone Value	40 minimum	45 minimum	45 minimum

A.1.2 The aggregate shall not contain more than 8% by weight of flat or elongated pieces. A flat particle is one having a ratio of width to thickness greater than three; an elongated particle is one having a ratio of length to width greater than three.

A.1.3 If instructed by the Engineer or detailed in the Contract Documents and Drawings coarse aggregate shall consist wholly or partly of unweathered basalt rock meeting all the requirements of A.1.1 and A.1.2 above.

**A.2 Fine Aggregate**

A.2.1 Fine aggregate shall consist of clean, sound, durable, angular particles produced by crushing stone that meets the requirements for wear and soundness specified for coarse aggregate. The aggregate particles shall be free from coatings of clay, silt and other deleterious substances and shall contain no clay particles. The fine aggregate, including any blended filler, shall have a plasticity index of not more than 4% when tested in accordance with ASTM D 424 and a liquid limit of not more than 25% when tested in accordance with ASTM D 423.

A.2.2 If necessary natural sand may be used to obtain the target gradation of aggregate blend or workability. Beach sand shall not be used in any asphalt mix. The amount of sand to be added shall be adjusted to produce mixtures conforming to the requirements of this section. If it is necessary to add natural sand, the percentage shall be kept below 10% of the weight of the mix.

**A.3 Sampling and Testing**

A.3.1 Sampling and testing shall conform to the relevant requirements of Section 4.03: - Bituminous Courses and the following.

A.3.2 ASTM D 75 shall be used for sampling coarse and fine aggregate and ASTM C 183 for sampling mineral filler.

**A.4 Sources of Aggregates**

A.4.1 To ensure consistency in the quality of supply of aggregates sourced from remote quarries, materials sourced more than 50 Km from site and/or from other countries shall be delivered to site and stockpiled prior to construction in order for sufficient compliance testing to be carried out on all the material before its incorporation into the Works.

A.4.2 The Contractor shall monitor all aggregate extraction, crushing and testing at the source quarries. A method statement shall be prepared by the Contractor and approved by the Engineer detailing his proposed staffing at the source quarries by competent personnel as part of the materials approvals process.

**B. Filler**

B.1 If additional filler is necessary, it shall meet the requirements of ASTM D 242.

B.2 The maximum amount of lime or cement replacing natural filler in the mix to aid adhesion shall be 2% by weight of filler.

### **C. Bitumen Binder**

The type, grade, controlling specifications and maximum mixing temperatures for the bitumen binders for wearing course are as follows:

- Penetration grade (roads below 1000 m): 40-50
- Penetration grade (roads above 1000 m): 60-70
- Specification: ASTM D 946
- Maximum mixing temperature °C: 170

### **4.05.03 JOB MIX AND PROJECT MIX**

Wearing course job mixes shall be formulated in accordance with the relevant requirements of Section 4.03 - Bituminous Courses and the following:

#### **A. Air Voids Analysis**

**A.1** The design range of air voids (3 to 5%) shall be the level desired after several years of traffic.

**A.2** The laboratory compactive effort shall be selected for the expected traffic demand. For reference the design air voids range will normally be achieved if the mix is designed at the correct compactive effort and the percentage air voids after construction is about 8%. Some consolidation with traffic is expected and desired. Mixtures that ultimately consolidate to less than 3% air voids can be expected to rut and shove if placed in heavy traffic locations. Brittleness, premature cracking, ravelling and stripping can occur if the final air voids content is above 5% or if the pavement is constructed with over eight percent air voids.

**A.3** The overall objective shall be to limit adjustments of the design asphalt content to less than 0.5 percent air voids from the median of the design criteria in Table 4.5.1.

#### **B. Mix Design**

**B.1** The bituminous mixture shall be designed using procedures contained in Chapter 5, Marshall Method of Mix Design, of the Asphalt Institute's Manual Series No. 2 (MS-2), sixth edition, and shall meet the requirements of Tables 4.5.1 and 4.5.2 overleaf.

**B.2** The Contractor shall prepare a series of test specimens with a range of different binder contents so that the test data show a well-defined curve. Tests shall be scheduled on the basis of 0.5% increments of binder content, with at least two binder contents above optimum and at least two below optimum.

**B.3** Triplicate test specimens shall be prepared for each binder content mix to be tested.

**B.4** The mineral aggregate shall be of such a size that the percentage composition by weight, as determined by laboratory sieves, shall conform to the gradation or gradations specified in Table 4.5.3 overleaf, when tested in accordance with ASTM Standard C 136 (dry sieve only). The percentage by weight for the bituminous material shall be within the limits specified.

**TABLE 4.5.1: MARSHALL DESIGN CRITERIA**

<b><u>Test</u></b>	<b><u>Value</u></b>
Number of blows	75
Stability, minimum in kilograms	900
Flow, in mm	2 – 3.5
Percent air voids	3% Normal Traffic (< 1 m ESAL) 4% Heavy Traffic (1- 5 m ESAL) 5% Very Heavy Traffic (>5 m ESAL)
Percent voids in mineral aggregate	See table 4.5.2
VFA %	65 – 75% (Normal to Heavy Traffic) 65-73% (Very Heavy Traffic)
Dust to bitumen ratio	1.2 maximum

**TABLE 4.5.2: MINIMUM PERCENT VOIDS IN MINERAL AGGREGATE**

<b>ASTM SIEVE</b>	<b>MAXIMUM PARTICLE SIZE mm</b>	<b>MINIMUM VOIDS IN MINERAL AGGREGATE PERCENT DESIGN AIR VOIDS</b>		
		<b>3%</b>	<b>4%</b>	<b>5%</b>
13 mm	12.5	13	14	15
18 mm	19.0	12	13	14
25 mm	25.0	11	12	13
37 mm	37.5	10	11	12

**TABLE 4.5 3: AGGREGATE GRADING LIMITS - ASPHALT WEARING COURSE**

ASTM Sieve Size	Percentage by Weight Passing Sieves		
	<u>25mm</u>	<u>18mm</u>	<u>13mm</u>
38mm	100	-----	-----
25mm	90 - 100	100	-----
18mm	-----	90-100	100
13mm	56 - 80	-----	90 - 100
No. 4	-----	56 - 80	-----
No. 8	29 - 59	35 - 65	44 - 74
No. 16	19 - 45	23 - 49	28 - 58
No. 30	-----	-----	-----
No.50	-----	-----	-----
No.100	5 - 17	5 - 19	5 - 21
No. 200	1-7	2-8	2-10
Bitumen Content %	4.5 - 7.0	5.0 - 7.5	5.5 - 8.0

**B.5** Bitumen content shall be calculated by weight of total mixture.

**B.6** The compacted thickness of any layer shall be at least twice the maximum nominal size of the aggregate band for wearing course unless otherwise directed by the Engineer.

**B.7** In considering the total grading characteristics of a bituminous paving mixture, a higher percentage of material passing the No. 8 (2.36 mm) sieve will result in pavement surfaces having a comparatively fine texture, while coarse gradings approaching the minimum amount passing the No. 8 sieve will result in surfaces with comparatively coarse texture.

**B.8** The gradations in Table 4.5.3 represent the limits which shall determine the suitability of aggregate for use from the sources of supply. The selection of any of the gradations shown in table 3 shall be such that the maximum size aggregate used shall not be more than one-half of the thickness of the layer of the course being constructed. The maximum aggregate size that shall be used in surface course shall be 25mm unless otherwise directed by the Engineer.

**B.9** The aggregate shall have a gradation within the limits designated in Table 4.5.3 and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve, or vice versa, but shall be uniformly graded from coarse to fine.

**B.10** The job mix tolerances shall be as shown in table 4.5.4 overleaf and shall be applied to the Job Mix Formula to establish a job control grading band. The limits of the master grading band as specified in table 4.5.3 shall apply if the application of the job mix tolerances results in a job control grading band outside the master grading band.

**TABLE 4.5 4: JOB MIX FORMULA TOLERANCES - ASPHALT WEARING COURSE**

<b><u>Material</u></b>	<b><u>Tolerance</u></b>
Aggregate passing No.1/2" (12.5 mm) sieve	± 8%
Aggregate passing No.3/8" and No. 4 sieves	± 7%
Aggregate passing Nos. 8, 16, No. sieves	± 6%
Aggregate passing Nos. 30 and 50 sieves	± 5%
Aggregate passing No. 200 sieve	± 3%
Bitumen %, weight % by total mix	0.50%
Temperature of mix	11 °C

**B.11** The aggregate gradation may be adjusted within the limits of table 4.5.3 without adjustments to the Contract unit prices.

**B.12** Should a change in source of materials be made, a new Job Mix Formula shall be established before the new material is used. Deviation from the final approved design for bitumen content and gradation of aggregates shall not be greater than the tolerances permitted and tests for bitumen content and aggregate gradation shall be made at least twice daily. The mixture shall be tested for bitumen content in accordance with ASTM D 2172 and for aggregate gradation in accordance with ASTM C 136.

**B.13** If the index of retained strength of the specimens of composite mixture, as determined by ASTM D 1075, is less than 75 the aggregates shall be rejected or the asphalt shall be treated with an approved anti-stripping agent. The amount of anti-stripping agent added to the asphalt shall be sufficient to produce an index of retained strength of not less than 75.

#### **4.05.4 EQUIPMENT**

Plant and equipment for mixing, hauling, placing and compacting bituminous wearing course materials shall conform to the relevant requirements of Section 4.03 - Bituminous Courses.

#### **4.05.5 CONSTRUCTION OF TRIAL SECTIONS**

Trial sections shall be constructed as and where directed and in accordance with the relevant requirements of Section 4.03 - Bituminous Courses.

#### **4.05.6 MIXING PROCEDURES**

Handling and mixing of bitumen (including modifier and antistripping agent, if any) and aggregates (including mineral filler if required) shall be in accordance with the relevant requirements of Section 4.03 - Bituminous Courses.

#### **4.05.7 SURFACE PREPARATION**

Preparation of the surface upon which the bituminous wearing course mix is to be laid and the use of prime and tack coats shall be appropriate to the type and condition of such surfaces and shall conform with the relevant requirements of Section 4.03 - Bituminous Courses.

#### **4.05.8 DELIVERY, SPREADING AND FINISHING**

##### **A. General**

The delivery, spreading and finishing of bituminous mixes for wearing course shall conform with the relevant requirements of Section 4.03 - Bituminous Courses and to the following particular requirements.

##### **B. Rollers**

**B.1** Initial rolling shall be carried out by use of two dual-drum vibrating steel-wheeled vibrating rollers each of minimum weight 7,000 kg and with vibrating frequency of 2,000-3,000 cycles/minute. These rollers shall be purpose made for compaction of hot bituminous courses.

**B.2** Intermediate rolling shall be carried out by use of at least two self-propelled, tandem pneumatic smooth-tired rollers each capable of exerting contact pressures of up to 690 kN/m<sup>2</sup> and ballast - adjustable to ensure uniform wheel loadings.

**B.3** Final rolling shall be carried out by use of two, 2-axle tandem steel-tired rollers each of minimum weight 10,000 kg, capable of exerting contact pressures of up to 650 kN/m<sup>2</sup>.

**B.4** The number of rollers used for any stage of rolling may be reduced by the Engineer to one, provided that the course being compacted is less than 5.5m in width and provided an equivalent standby roller is available on Site as replacement in the event of breakdown of the operating roller.

##### **C. Standard of Compaction**

The compacted density of the bituminous wearing course shall be not less than 97% of the average Marshall Bulk Density for each day's production.

#### **4.05.9 SAMPLING AND TESTING**

Sampling and testing shall conform to the relevant requirements of Section 4.03 - Bituminous Courses.

#### **4.05.10 SURFACE TOLERANCES**

**A.** Surface tolerances shall conform with the relevant requirements of Section 4.03 - Bituminous Courses and to the following particular requirements.



**B.** The tolerances on elevations of the final bituminous wearing course surface shall not be greater than  $\pm 6\text{mm}$ .

**C.** When the finished wearing course surface is tested with a 3m long straightedge, placed parallel to, or at right angles to the centreline, the maximum deviation of the surface from the testing edge between any two contact points shall not exceed 6 mm.

**D.** The combination of the permitted tolerances in the levels of the different pavement layers, excluding aggregate base course, shall not result in a reduction of thickness by more than 10mm from the specified thickness shown on the Drawings or a reduction in the final wearing course thickness by more than 5mm from that specified or shown on the Drawings.

#### **4.05.11 DETERMINATION OF THICKNESS**

**A.** Procedures for determining the average compacted thickness of bituminous wearing course shall conform with the relevant requirements of Section 4.03 - Bituminous Courses and to the following particular requirements.

**B.** Cores for thickness measurements of the bituminous base course shall be used to determine if changes are necessary in the constructed thickness of the wearing course to rectify any thickness deficiencies in the bituminous base course.

#### **4.05.12 MEASUREMENT**

**A.** Bituminous Wearing Course shall be measured by the cubic metre of mix furnished, spread, compacted, completed and accepted. Measurements shall be based on the areas and thickness as shown on the Drawings or otherwise directed by the Engineer. Separate measurements shall be made for Bituminous Wearing Course containing basalt or other hard aggregate when specified elsewhere in the Contract Documents or Drawings or by the Engineer.

**B.** Deficiencies in thickness of the wearing course shall, unless an overlay is constructed at the Contractor's expense, result in a proportion only of the wearing course area being measured for payment. Proportions shall be determined in accordance with the thickness deficiencies presented in Section 4.03 - Bituminous Courses.

**C.** The rate for bituminous wearing course used in temporary diversions shall also include for removal and disposal of the wearing course material and reinstatement of the temporary diversion, to the satisfaction of the Engineer, on completion of use.

**D.** Bituminous prime and tack coats shall be measured as prescribed in Section 4.02 - Bituminous Prime and Tack Coats.

## **SECTION 4.06: BITUMINOUS SEAL COATS AND SURFACE DRESSINGS**

### **4.06.01 SCOPE**

**A.** The work covered in this section consists of the furnishing of materials for one or more applications of cutback bitumen and stone aggregate material or a single application of emulsified bitumen or spreading emulsified bitumen slurry to a previously prepared base or wearing course surface as and where shown on the Drawings.

**B.** Bituminous Slurry Seal Coat (**BSSC**) shall consist of spreading and screeding a mixture of emulsified bitumen, sand, aggregate and water.

**C.** Single Bituminous Surface Dressing (**SBSD**) shall consist of a single application of cutback or straight run bitumen and stone or sand aggregate as specified.

**D.** Double Bituminous Surface Dressing (**DBSD**) shall consist of an application of cutback or straight run bitumen and (coarse graded) aggregate followed not less than 5 days later by a second application of cutback or straight run bitumen and (medium graded) aggregate as specified.

### **4.06.02 MATERIALS**

#### **A. Bitumen**

**A.1** Bitumen for SBSDB and DBSD applications shall be Rapid-Curing RC-800 Grade conforming to the relevant requirements of Section 4.01 - Materials for Bituminous Construction and AASHTO M-81.

**A.2** Bitumen for BSSC (slurry) applications shall be cationic slow setting emulsified bitumen Grade CSS-1 or CSS-1h conforming to the relevant requirements of Section 4.01 - Materials for Bituminous Construction.

#### **B. Aggregates**

**B.1** Surface dressing aggregates shall consist of screenings of crushed stone. Aggregate for slurry seals shall consist of crushed stone fines or natural sand blended with not less than 50% crushed fines. For heavy duty applications slurry aggregate shall consist of 100% crushed fines.

**B.2** The properties of cover and slurry seal aggregates and their gradations shall be in accordance with the relevant requirements of Section 4.01 - Materials for Bituminous Construction.

#### **4.06.03 EQUIPMENT**

All plant and equipment used for pugmill mixing of slurry mixes, heating and spraying of cutback and emulsified bitumen, spreading, rolling and brooming of cover aggregate and applying and spreading slurry seals shall conform with the requirements of Part 1, Section 4-4 - Contractor's Plant and Equipment.

#### **4.06.04 CONSTRUCTION OF TRIAL SECTIONS**

**A.** Before commencement of site seal coat applications, the Contractor shall construct trial sections using varying application rates for bitumen and for aggregates, as selected by the Engineer. Each trial section shall be 2 lanes wide by 50 metres long at locations approved by the Engineer on or close to the Site.

**B.** Each trial section shall be constructed using the same materials, mixing, spraying, spreading, rolling and brooming equipment and construction procedures proposed for use in the Works. Trial sections for slurry seals shall be along existing bituminous pavements in the vicinity of the Site.

**C.** The objectives of these trials shall be to determine the adequacy of the Contractor's equipment, the most suitable application rates for cutback bitumen, emulsified bitumen and the various gradations of aggregate and the most suitable consistency of slurry seal to fill cracks and leave a residual coating of 3 mm over the entire bituminous wearing surface.

**D.** The Contractor shall not proceed with any seal coat applications until the methods and procedures established in the trials have been approved by the Engineer.

#### **4.06.05 RATES OF APPLICATION**

**A.** Application rates for cutback and emulsified bitumen and for aggregates shall be determined by the Engineer from the trial sections and shall be generally within the ranges given in Table 4.6.1.

**Table 4.6.1: TYPICAL SEAL COAT APPLICATION RATES**

Types of Seal Coat	Rate of Application	
	Aggregate (Kg/m <sup>2</sup> )	Binder (Kg/m <sup>2</sup> )
Coarse aggregate seal coat	12.5- 20.0	1 .00- 1.80
Medium aggregate seal coat	10.0-15.0	0.90- 1.80
Slurry seal	Between 5-6 Kg/m <sup>2</sup> for the mix	

**B.** The Engineer reserves the right to order additional trial sections and alter the previously established rates of application during progress of the Works.

#### **4.06.06 CONSTRUCTION**

##### **A. General**

**A.1** Applications of bitumen and aggregate and subsequent rolling shall be completed between sunrise and sunset and under favourable weather conditions as determined by the Engineer. The atmospheric temperature shall be above 15 °C and the weather shall not be foggy, rainy, dusty or unduly windy.

**A.2** Where the seal coat is to carry traffic prior to final sweeping, appropriate signs shall be erected to control the speed of traffic. Provision for traffic control shall be in accordance with the relevant requirements of Section 6.07 - Maintenance of Traffic and Detours.

**A.3** When bituminous coatings are applied to sections of road which are to be promptly opened to traffic and the ambient temperature is contributing to slow curing and excessive pickup, the Contractor shall suspend operations until the Engineer approves continuation of sealing works.

**A.4** The surface to be treated shall be dry or slightly damp and the moisture content of aggregates at the time of application to the coated surface shall not exceed 3% by weight.

**A.5** Unless otherwise directed by the Engineer, the minimum time interval between successive seal coats, in DBSD applications, shall be 5 days.

##### **B. Surface Preparation**

**B.1** Granular surfaces shall be primed in accordance with the requirements of Section 4.02 - Bituminous Prime and Tack Coats prior to construction of the surface treatment. If there are delays in scheduling the seal coating resulting in deterioration of the surface, the Engineer shall inspect the affected area and order appropriate repairs or corrective treatment prior to the commencement of the seal coat application.

**B.2** When coatings are applied to existing pavement surfaces, all pavement repairs shown on the Drawings or instructed by the Engineer shall first be completed. Where applicable, the positions of traffic markings shall be surveyed and recorded to enable their accurate replacement after the seal coats have been applied.

**B.3** Immediately before applying any bituminous material, all dirt, dust and other objectionable material shall be removed from the surface and cracks shall be repaired or sealed as directed by the Engineer. If required, the surface shall be slightly dampened with a light application of water immediately prior to the application of bitumen.

**B.4** Surfaces to be slurry sealed shall be lightly sprayed immediately prior to spreading the slurry with a slow-curing 3:1 water: emulsion mixture applied at the rate of 0.4 - 0.8 Kg/ m<sup>2</sup>

### **C. Heating of Bitumen**

The temperature of cutback bitumen and of emulsified bitumen at the time of application shall be as specified in Section 4.01 - Materials for Bituminous Construction.

### **D. Spreading Slurry Seal**

**D.1** Spreading of slurry seals shall be by a spreader box approved by the Engineer, capable of spreading over at least one traffic lane width. It shall have flexible rubber strips fastened on each side to prevent loss of slurry and shall have baffles incorporated into the box to ensure a uniform application. A rear flexible, adjustable strike-off blade shall also be provided.

**D.2** Areas inaccessible to the slurry spreader box shall be slurry scaled using hand or other methods approved by the Engineer.

**D.3** The slurry seal coat shall be uniform and homogeneous after spreading and shall not show signs of separation of the emulsion and aggregate after setting.

### **E. Spraying of Bitumen**

**E.1** The cutback or emulsified bitumen for seal coats shall be applied by means of a pressure distributor uniformly and continuously over the section to be treated. The rate of application shall be as shown on the Drawings or as designated by the Engineer.

**E.2** A strip of building paper or heavy polyethylene sheeting, at least one metre in width and with a length equal to that of the spray bar of the distributor plus 300 mm shall be used at the beginning of each application. If the cut-off is not positive, the paper shall be used at the end of each spread. The paper shall be removed and disposed of after use. The distributor shall move forward at the correct application speed at the time the spray bar is opened. Any skipped areas or deficiencies shall be corrected immediately as directed by the Engineer.

**E.3** The length of spray run shall not exceed that which can be covered by the aggregate spreading equipment.

**E.4** The application width of bitumen shall be not more than 150 mm wider than the width covered by the aggregate spreader. Operations shall not proceed if the bitumen is allowed to chill, dry or otherwise impair retention of the aggregate.

**E.5** The Contractor shall keep a complete record of bitumen used based on distributor tank measurements and on areas to which the bitumen has been applied. These records shall be submitted to the Engineer as verification of the accuracy of the tachometer and application rates designated by the Engineer.

**E.6** Distribution of bitumen shall be regulated and sufficient material left in the distributor at the end of each application to ensure a uniform distribution across the spray bar. The distributor shall not expel air with the bitumen causing uneven coverage.

**E.7** The angle of the spray nozzles and the height of the spray bar shall be adjusted and regularly checked to ensure uniform distribution. The height of the spray bar above the pavement surface should remain constant throughout the spraying process. Distribution shall cease immediately upon any clogging or partial blocking of any nozzle and corrective measures shall be taken before application is resumed.

**F. Application of Aggregate**

**F.1** If directed by the Engineer, aggregates shall be washed prior to use in order to eliminate or reduce any dust coatings or salts before delivery to the spreader.

**F.2** Operation of the aggregate spreader at speeds which cause the particles to roll over after striking the bitumen covered surface shall not be permitted.

**F.3** Immediately upon application of bitumen, aggregate of the required gradation shall be spread at the rate designated by the Engineer. Spreading shall be accomplished in such a manner that the tyres of the hauling unit or aggregate spreader do not come into contact with the uncovered bitumen surface.

**F.4** Where adjacent applications are to be made, the first aggregate application shall not extend closer than 150 mm to the edge of the applied bitumen. The adjacent application of bitumen shall overlap this 150 mm and complete aggregate coverage shall be achieved with the second application.

**F.5** Immediately after the aggregate has been applied, deficient areas shall be covered by additional aggregate. Piles, ridges or uneven distributions of aggregate shall be removed and corrected to avoid permanent ridges, bumps or depressions in the completed surface. Additional aggregate shall be carefully spread to prevent pick-up by rollers or traffic; after which the surface shall be rolled as directed by the Engineer.

**F.6** The Contractor shall take measures to prevent aggregate from entering ditches or inlets of any type. The Contractor shall be responsible for removal of any such aggregate materials and other accumulated debris arising out of his operations.

**G. Rolling and Brooming**

**G.1** Aggregate shall not be spread more than 150 metres ahead of initial rolling operations.

**G.2** Rollers shall not stop, start or turn on the surface being rolled. Any damage to the surface arising out of non-compliance with this requirement shall be made good as directed by the Engineer and at the Contractor's expense.

**G.3** Initial breakdown rolling shall proceed behind the spreader (after any adjustments by hand methods to correct for uneven distribution). One complete coverage shall be achieved using 2-axle self-propelled steel-wheeled rollers of 6-8 tons weight and operating at a maximum speed of 5 km/h. Initial rolling shall be completed within 30 minutes of spreading aggregate.

**G.4** The Engineer shall order the use of pneumatic-tyred rollers for initial rolling if the achievement of adequate embedment of the aggregate is liable to result in excessive crushing when steel-wheeled rollers are used.

**G.5** Immediately following completion of the initial rolling, the surface shall be rolled using self-propelled pneumatic-tyred rollers operated at a maximum speed of 8 Km/h, until at least 3 complete coverages have been achieved.

**G.6** If necessary during rolling operations, additional screenings shall be lightly spread by hand methods and re-rolled to make good any small areas visibly deficient in cover material.

**G.7** Light drag brooming of the surface shall be carried out 24 hours after completion of rolling to embed aggregate particles. Brooming shall result in a uniform distribution of loose screenings over the surface which shall then be re-rolled using pneumatic-tyred rollers until at least 2 complete coverages have been achieved.

**G.8** Light drag brooming and re-rolling shall be repeated 24 hours after the initial brooming, if so directed by the Engineer.

**G.9** Excess (surplus) screenings shall be collected and stockpiled or disposed of as directed by the Engineer.

## **H. Maintenance and Protection of Sealed Surfaces**

**H.1** BSSC shall be protected from traffic until such time as, in the opinion of the Engineer, the coatings have cured sufficiently and will not be damaged by, adhere to or be picked up by the tyres of vehicles.

**H.2** Each coat of SBSB and DBSD shall be maintained and protected from excess traffic speeds for at least 3 days after completion of rolling.

**H.3** At the end of the 3-day maintenance period for each seal coat, or earlier if directed by the Engineer, the surface shall be finally swept using a rotary broom to remove loose screenings. Surplus screenings shall be stockpiled or disposed of as directed by the Engineer.

**H.4** Adequate traffic control (including speed control measures) shall be taken during the construction of bituminous seal coats and surface dressings in accordance with the relevant requirements of Section 6.07 - Maintenance of Traffic and Detours.

## **4.06.07 TOLERANCES AND RECORDS**

**A.** The Contractor shall be responsible for the accurate calibration of pressure distributors and for the correct rates of application of bitumen as designated by the Engineer.

- B.** Readings shall be taken of the volume and temperature of each bitumen tanker load and temperature immediately prior to and immediately upon completion of each spraying run and the actual application rate in kg/m<sup>2</sup> shall be calculated. Complete records shall be maintained of all such measurements and the specific location, width and length of each the respective run.
- C.** The tolerances on temperature adjusted application rates of cutback bitumen shall be plus or minus 5% of the designated rate.
- D.** Applications of cutback bitumen varying by more than 5% but less than 10%, after temperature adjustment, below the specified rate of application shall, if the work is accepted by the Engineer, be subject to a 10% reduction in quantity or area measurements as appropriate.
- E.** Applications of cutback bitumen varying after temperature adjustment by more than 5% but less than 10% above the specified rate of application shall, if the work is accepted by the Engineer, be measured on the basis of the designated application rate.
- F.** Applications of cutback bitumen varying by more than 10%, after temperature adjustment, above or below the specified rate of application shall be rejected and the unsatisfactory material replaced or made good as directed by the Engineer, at the Contractor's expense.
- G.** The Contractor shall maintain on a daily basis complete records of the volumes and tonnages of each type of aggregate delivered to the Site and used in each section of the Works for seal coat and surface dressing applications.
- H.** All records and calculations of bitumen applications and aggregate delivery and use shall be submitted to the Engineer at the end of each day when seal coat and surface dressing applications have been carried out. No measurements will be accepted of bitumen applications which are not supported by adequate, verifiable records.

#### **4.06.08 MEASUREMENT**

The quantity of seal coats and surface dressings to be paid for shall be the number of square metres for each application as entered in the Bill of Quantities. No separate payment shall be made for bituminous material or cover aggregates.



## **SECTION 4.07      BITUMINOUS LEVELLING COURSE**

### **4.07.1      SCOPE**

The work covered in this section consists of furnishing materials, mixing at a central mixing plant, spreading and compacting bituminous wearing course on an existing pavement surface as and where shown on the Drawings or as directed by the Engineer.

### **4.07.2      MATERIALS**

- A.** All materials shall conform to the relevant requirements of Section 4.01 - Materials for Bituminous Construction.
- B.** Unless otherwise shown on the Drawings, materials shall also conform to the requirements of Section 4.05 - Bituminous Wearing Course.

### **4.07.3      JOB MIX AND PROJECT MIX**

- A.** The Job Mix Formula shall be established by the Contractor in accordance with the procedures and requirements of Section 4.03 - Bituminous Courses and Section 4.05 - Bituminous Wearing Course.
- B.** The Job Mix for bituminous levelling courses shall conform to the requirements of Section 4.05 - Bituminous Wearing Course.

### **4.07.4      EQUIPMENT**

Plant and equipment for mixing, hauling, placing and compacting bituminous levelling course materials shall conform to the relevant requirements of Section 4.03 - Bituminous Courses.

### **4.07.5      CONSTRUCTION OF TRIAL SECTIONS**

Trial Sections shall be constructed as and where directed by the Engineer and in accordance with the relevant requirements of Section 4.03 - Bituminous Courses.

#### **4.07.6 SURFACE PREPARATION**

**A.** Damaged pavement surfaces shall be repaired by patching prior to receiving the bituminous levelling course in accordance with the relevant requirements of Section 4.08: Pavement Repairs, Trench Excavation and Reinstatement Works. The nature and extent of patching shall be as shown on the Drawings or as directed by the Engineer.

**B.** In areas where levelling courses are required, either as shown on the Drawings or as directed by the Engineer, the Contractor shall take cross sections of the existing pavement after completing any patching. The cross sections shall be taken at intervals of 10 metres or as directed by the Engineer. When the survey has been approved, the Engineer shall determine and inform the Contractor of the locations, grades and thicknesses of levelling courses required to obtain the desired surface.

**C.** Prior to placing levelling courses the existing pavement surface shall be prepared in accordance with the relevant requirements of Section 4.03 - Bituminous Courses, including the use of prime and tack coats as appropriate.

#### **4.07.7 DELIVERY, SPREADING AND FINISHING**

**A.** The delivery, spreading and finishing of levelling courses, including compaction, shall conform to the relevant requirements of Section 4.05 - Bituminous Wearing Course.

**B.** In areas where a specific grade and superelevation are to be achieved by the levelling courses, setting out and level control shall be based on a reference line installed in accordance with the relevant requirements of Section 4.03 - Bituminous Courses. In areas of minor levelling such as filling of potholes or small isolated areas, a mobile reference line or alternative control system may be approved by the Engineer.

#### **4.07.8 SAMPLING AND TESTING**

**A.** Sampling and testing of levelling courses shall conform to the relevant requirements of Section 4.03 - Bituminous Courses.

**B.** Where sampling and testing are not feasible due to thickness or other constraints, the Engineer shall determine specification compliance based on an approved rolling pattern or another method.

#### **4.07.9 SURFACE TOLERANCES**

Surface Tolerances for levelling courses shall conform to the relevant requirements for Binder Courses in Section 4.04 - Bituminous Base Course.

#### **4.07.10 DETERMINATION OF THICKNESS**

The Engineer shall use thickness measurements, spread rates, cross section or other methods as appropriate to verify quantities placed. Thickness measurements shall be in accordance with the relevant requirements of Section 4.03 - Bituminous Courses.

#### **4.07.11 MEASUREMENT**

**A.** Bituminous levelling courses shall be measured by the cubic metre of mix furnished, spread, compacted, completed and accepted. Measurements shall be based on the areas and thicknesses shown on the Drawings or as otherwise directed by the Engineer.

**B.** Patching shall be measured by the cubic metre of mix furnished, spread, compacted, completed and accepted. Measurements shall be based on the areas and thicknesses shown on the Drawings or as directed by the Engineer.

**C.** Bituminous Tack Coat shall not be measured or paid for separately but the costs shall be deemed to be included in associated rates and items.

**D.** All other incidental items shall not be measured for direct payment, as prescribed in Section 4.03 - "Bituminous Courses".

## **SECTION 4.08: PAVEMENT REPAIRS, TRENCH EXCAVATION AND RESTATEMENT WORKS**

### **4.08.1 SCOPE**

A. The work covered in this section consists of repairs to damaged or defective pavement and the excavation and reinstatement of road openings on existing highways, streets and footpaths as and where shown on the Drawings or as directed by the Engineer.

B. Repairs to existing pavement include:

- Pothole repairs and patching
- Crack sealing
- Removal and replacement of defective pavement layers

C. Road openings include: -

- The breaking up or opening up of a street or other highway for the purpose of: -
  - i). Laying, repairing, adjusting, altering or removing any utility or apparatus, or
  - ii). Examining subsoil conditions or any existing utility or apparatus:
- Any work which is preparatory or incidental to any works referred to in the paragraphs above, such as the temporary storage or deposition of any building materials, debris, temporary foundation or the placing of any equipment.

### **4.08.2 MATERIALS**

A. All pavement materials shall conform to the relevant requirements of Section 3.01 – Materials for Sub-Base and Base Courses and Section 4.01 – Materials for Bituminous Construction.

Subgrade materials shall conform to the relevant requirements of Section 2.07 – Subgrade Construction.

### **4.08.3 EQUIPMENT**

All plant and equipment shall conform to the relevant requirements of Part 1 of the Specifications, Section 4-4 – Contractor's Plant and Equipment

#### **4.08.4 GENERAL REQUIREMENTS**

##### **A. Full Time Site Supervisor**

The Contractor shall nominate from his site staff a full – time site supervisor responsible for road openings and reinstatement works, who shall be contactable by the Engineer and all other affected parties at all times during the period of the reinstatement works including the duration of traffic management. The supervisor shall be capable of responding to any emergency or other situation that arises as a consequence of the rehabilitation and reinstatement work and shall be the Contractor's first point of contact on safety issues arising out of these works.

##### **B. Position, Extent and Protection of Excavation**

The Contractor shall take the following into account when preparing method statements for road openings:-

- The extent of road opening at any one time shall not exceed 60 metres in length
- The occupation of a carriageway for road opening shall be restricted to one traffic lane width.
- Measures to protect the nearby road surface, existing structures, apparatus and road- related facilities during the course of the road opening and reinstatement work
- A maximum of two trial holes shall be permitted at any one time. No additional trial holes shall be opened until the existing trial holes are properly reinstated to the satisfaction of the Engineer.
- The road surface shall be protected from damage from construction vehicles. Any damage to the surrounding road surface shall be made good to the satisfaction of the Engineer at the Contractor's expense

#### **4.08.5 PREPARATION OF PAVEMENT**

**A** Cracks in bituminous pavement which, in the opinion of the Engineer, do not require reconstruction shall be prepared by wire brushing and blowing out with compressed air.

**B** Defective bituminous pavement which, in the opinion of the Engineer, requires reconstruction shall be cut back to good material using pneumatic cutting tools. The cut edges shall be square or rectangular and in line with the direction of traffic. The depth of cut shall be determined by the Engineer and may include asphalt layers, base and sub – base layers and subgrade layers (in the case of failed pavement, excavation shall include a minimum of 300 mm of subgrade material). All excavated materials shall be removed and disposed of off site. When the bottom of the excavation consists of earth or granular material, it shall be thoroughly compacted using mechanical compactors to the satisfaction of the Engineer. Excavated bituminous surfaces shall be thoroughly cleaned and wire brushed prior to receiving repair materials.

**C** Utility trench reinstatements in bituminous pavements shall be prepared in the same way as defective bituminous pavement. Excavation shall include a minimum of 300 mm of subgrade material.

#### **4.08.6 PLACING AND FINISHING REPAIR MATERIALS**

**A** Cracks less than 3 mm wide shall be saturated with a 1:1 diluted emulsified bitumen unless otherwise directed by the Engineer. Cracks shall be filled to the road surface level. Any excess bitumen shall be removed with a squeegee and the bitumen surface shall be sprinkled liberally with coarse sand.

**B** Cracks of 3 mm width or more shall be filled with clean, coarse sand and then saturated with a 1:1 diluted emulsified bitumen or as directed by the Engineer. Cracks shall be filled to the road surface level. Any excess bitumen shall be removed with a squeegee and the bitumen surface shall be sprinkled liberally with coarse sand.

**C** Excavations below subgrade level shall be filled to a level specified by the Engineer with subgrade material in layers not exceeding 150 mm and compacted using mechanical compactors to conform to the requirements of Section 2.07 – Subgrade Construction and to the satisfaction of the Engineer.

**D** Sub-base and/or base course, if required, shall be placed in layers not exceeding 150 mm and compacted using mechanical compactors. They shall conform to the relevant requirements of Section 3.02 – Granular Sub – Base Courses or Section 3.03 –Aggregate Base Courses and shall be to the grading shown on the Drawings or as specified by the Engineer.

**E** Prior to receiving bituminous material the excavations shall be thoroughly cleaned. Subgrade, sub-base or base course material shall be primed with a light coating of MC cutback or emulsified bitumen and existing bitumen surfaces shall be lightly painted with emulsified bitumen, all in accordance with the requirements of Section 4.02 – Bituminous Prime and Tack Coats.

**F** The excavation shall be filled with bituminous pavement materials placed in layers not exceeding 70 mm and compacted using vibratory compactors. Unless otherwise ordered by the Engineer, the top layer shall be compacted by a steel wheeled roller, by first compacting the 150 mm strips adjacent to the traffic edges and then rolling in the direction of traffic. Bituminous materials shall conform to the relevant requirements of Section 4.04 – Bituminous Base Course and Section 4.05 –Bituminous Wearing Course and shall be to the gradings shown on the Drawings or as specified by the Engineer.

**G** New utility trenches shall be backfilled to the details shown on the Drawings or as instructed by the Engineer and may include surround, haunching or protective materials. Construction of subgrade and pavement shall be as for pavement repairs.

**H** No excavated areas shall remain open overnight.

#### **4.08.7        ADDITIONAL REQUIREMENTS FOR REPAIRS TO EXISTING PAVEMENT**

##### **A        Work Programme/ Schedule**

A Work Programme / Schedule shall be submitted to the Engineer for approval prior to the start of repair work. The programme may be in the form of bar/ Gantt charts that indicate the areas of work and show the extent and duration of works and the sequence of partial road closures.

##### **B        Temporary Traffic Management Proposals**

The proposed traffic control plans for the various stages of work that affects traffic, including pedestrians, shall be submitted. The plans shall include temporary signing details and forms of traffic control to be used. The proposed plans shall comply with the requirements of the Health, Safety and Environmental Regulations in Volume 1 and current LIBNOR Standards.

#### **4.08.8        ADDITIONAL REQUIREMENTS FOR ROAD OPENINGS**

##### **A        Duties and Responsibilities – Road Opening**

The Contractor shall be responsible for coordination with the relevant service provider. All trench reinstatement works shall be performed in accordance with these specifications and the regulations of the relevant service provider

##### **B        Application for Road Opening**

The Contractor shall submit written proposals to the Engineer for approval prior to carrying out road opening works. The application shall comply with the requirements of the Health, Safety and Environmental Regulations in Volume 1 and current LIBNOR Standards and include the following:

###### Detailed Plans

Plans showing details of the opening work including the following: -

- Location of road opening
- Existing and proposed manhole positions
- Lines and levels of other services that may be affected by the works
- Position of trees and road facilities
- Existing road lines and other road markings

###### Photographs

Photographs of existing conditions.

#### Temporary Traffic Management Proposals

The proposed traffic control plans for the various stages of opening that affect traffic, including pedestrians. The plans shall include temporary signing details and, if necessary, forms of traffic control to be used.

#### Work Programme/ Schedule

A Work Programme / Schedule shall be submitted to the Engineer prior to commencement of road opening works. The programme may be in the form of bar/ Gantt charts that indicate the different stages of openings and show the duration of works and the extent of road affected.

#### Statutory Authority Approval

Written confirmation from the relevant service provider that the proposed crossing has been checked and approved.

### **4.08.9            SAMPLING AND TESTING**

Testing of repair materials shall conform to the relevant requirements of Section 2.07 – Subgrade Construction, Section 3.02 – Granular Sub – Base Courses, Section 3.03 –Aggregate Base Courses and Section 4.03 – Bituminous Courses. Sampling shall be as ordered by the Engineer.

### **4.08.10          SURFACE TOLERANCES**

- A       Levels shall be checked by straight edge in relation to the adjacent existing pavement.
- B       Surface tolerances for bituminous layers shall conform to the relevant requirements of Section 4.04 – Bituminous Base Course and Section 4.05 –Bituminous Wearing Course.
- C       Any deficiency in the wearing course surface shall be corrected by cutting out and replacing.

### **4.08.11          MEASUREMENT**

Sealing of cracks shall not be measured for direct payment unless otherwise specified in the Contract Documents.

Pavement repairs shall be measured by the square metre of repair, prepared, filled, compacted, completed and accepted. Measurement shall be of the areas shown on the Drawings or ordered by the Engineer.

Trench reinstatements shall be measured by the square metre of reinstatement prepared, filled, compacted, completed and accepted by the Engineer. Measurements shall be of the areas shown on the Drawings or ordered by the Engineer.

No separate payments shall be made for excavation, prime or tack coats or pavement materials



All other incidental items shall not be measured for direct payment but shall be considered as subsidiary works, the costs of which will be deemed to be included in the Contract prices for the pay items.

## **SECTION 4.09 ROAD PLANING AND GRINDING**

### **4.09.01 SCOPE**

The work covered in this Section includes cold planing, including milling, of the existing asphalt pavement and grinding of concrete pavement and surfaces of structures to a specified depth at the locations shown on the Drawings or as directed by the Engineer in order to obtain the required levels and grades and to prepare the surface for receiving the subsequent asphalt overlay or to improve the skid resistance of the existing surface. The Contractor shall be responsible for all traffic management during the execution of the works.

### **4.09.02 EQUIPMENT**

- A.** All plant and equipment shall conform to the relevant requirements of Part 1 of the Specifications, Section 4-4 – Contractor's Plant and Equipment and the following
- B.** Planing shall be carried out using a purpose built machine capable of planing to the specified depth and within the tolerances stated in this section.
- C.** Grinding shall be performed with abrasive grinding equipment with diamond cutting blades.

### **4.09.03 ROAD PLANING AND GRINDING OPERATIONS**

- A.** Except on structures, the entire area of pavement in locations designated on the Drawings or as directed by the Engineer shall be planed or ground to the depth as detailed.
- B.** Ground surfaces shall not be smooth or polished and shall have a coefficient of friction of not less than 0.30.
- C. Planing of Asphalt Surfaces**
  - C.1** Existing asphalt pavement shall be planed to the depth specified on the Drawings or instructed by the Engineer so that the finished surface shall not vary from a true plane to allow a 3 mm thick shim 80 mm wide to pass under a straightedge 3m long laid parallel to the centreline. The transverse slope of the finished surface shall not allow a 6mm thick shim 80mm wide will to pass under a straightedge 3 metres long.
  - C.2** Residue from planing asphalt pavement shall be disposed of or recycled in accordance with Section 4.12, Recycling of Pavement Materials, as detailed in the Drawings or as approved or instructed by the Engineer.

## **D. Grinding of Concrete Surfaces**

**D.1** Existing concrete pavement shall be ground so that the pavement surface on both sides of all transverse joints and cracks has essentially the same depth of texture and does not vary from a true plane enough to permit a 2 mm thick shim 80 mm wide to pass under a 1 metre straight-edge adjacent to either side of the joint or crack when the straightedge is laid on the pavement parallel to centreline with its midpoint on the joint or crack. After completion of grinding the pavement shall conform to the straightedge and profile requirements specified in 4.3.10 of Specification Section 4.03.

**D.2.** Areas identified by or agreed with the Engineer as abnormally depressed due to subsidence or other localized causes shall be excluded from testing with the straightedge, if the accumulated total of all such excluded areas does not exceed 5 percent of the total area to be ground. Straightedge testing shall end 10 metres prior to such excluded areas and shall resume 10 metres following.

**D.3** The noise level created by the combined grinding operation shall not exceed 86 dBA at a distance of 15 metres at right angles to the direction of travel.

**D.4** Ground areas on structures, approach slabs and the adjacent 15 metres of approach pavement shall conform to the requirements for smoothness and concrete cover over reinforcing steel specified in Part 5: Concrete Works.

**D.5** Concrete removal and replacement operations shall not disturb the adjacent concrete pavement, base and subgrade. If such material is disturbed, concrete surfaces shall be made good to the satisfaction of the Engineer and base and subgrade recompact to relative densities of not less than 100 and 95% respectively; all at the Contractor's expense.

**D.6** Residue from grinding operations shall be collected using a vacuum attachment on the grinding machine and not left on the surface of the pavement.

**D.7** Residue from grinding concrete pavement shall be disposed of as detailed in the Drawings or as instructed by the Engineer.

### **4.09.04 PREPARATION OF PLANED SURFACE FOR RESURFACING**

**A.** When a new asphalt mix is to be placed on an existing bituminous surface, the surface shall be cleaned of all foreign material and broomed free of dust. Any loose, broken or shattered asphalt material along the edges of the existing surface shall be removed and the exposed unbound material and a sufficient width adjacent to the edge of the existing surface shall be shaped, bladed, compacted and broomed to provide a uniform firm subgrade base for the new surface course. Broken, soft or unstable areas of existing asphalt surface, base or subgrade shall be removed and replaced. The areas shall be excavated to a depth as directed and refilled with the specified asphalt mix. Any cracks encountered in the exposed bituminous surface, shall be prepared as specified in accordance with Parts 4.08.6A or B of Section 4.08: Trench Reinstatement and Pavement Repairs before laying the new asphalt layer.

**B.** When detailed on the Drawings or instructed by the Engineer, prior to placing of the asphalt mix on an existing asphalt surface, a tack coat as specified in Section 4.02: Bituminous Prime and Tack Coats shall be applied to the existing surface at the rate determined by the Engineer. No mixture shall be laid on a tack coat until it has been inspected and approved by the Engineer.

**C.** When the asphalt mix is to be placed on an existing aggregate base course surface, the surface shall be recompact to 100% maximum dry density (AASHTO Modified Proctor).

**D.** In locations where the aggregate base course consists of gap-graded aggregate and contains excess fines or moisture or does not comply with the specified base course material quality and cannot be compacted to the above required density: then it shall be replaced to a depth of 150 mm with suitable aggregate base course material in order to meet the Specifications and the Engineer's approval.

**E.** Prior to placing of the asphalt mix on an existing or replaced aggregate base course, a prime coat as specified in Section 4.02: Bituminous Prime and Tack Coat shall be applied to the surface at the rate determined by the Engineer. No mixture shall be laid on a prime coat until it has been inspected and approved by the Engineer.

#### **4.09.05 MEASUREMENT**

**A.** Planing of the existing asphalt shall be measured by the square metre of the planed area to the specified depth. No additional payment shall be made for planing to a greater depth or area than specified. All surface preparation and cleaning works specified above shall be deemed included in this pay item.

**B.** Refilling the planed or ground area with bituminous wearing course shall be paid separately to the specified depth in accordance with Section 4.05: Bituminous Wearing Course or Section 4.04 Bituminous Base Course as appropriate.

**C.** Prime coat under the new bituminous layers shall also be paid separately as specified under Section 4.02: Bituminous Prime and Tack Coats.

**D.** Pavement grinding shall be measured by the square metre. The quantity of pavement grinding to be measured for payment will be determined by multiplying the width of the area ground by the length ground. No additional payment shall be made for grinding to a greater depth or area than specified. All surface preparation and cleaning works specified above shall be deemed included in this pay item.

**E.** The Contract price paid per square metre for planing and grinding existing surfaces shall include full compensation for furnishing all labour, materials, tools, equipment, and incidentals and for all work involved in planing or grinding the existing pavement and removing and disposing of residue, including furnishing water for washing the pavement, as shown on the Drawings, as specified in these specifications and as directed by the Engineer.