

SECTION 400 – ASPHALT PAVEMENTS

SECTION 401 – QUALITY CONTROL/QUALITY ASSURANCE, QC/QA, HOT MIX ASPHALT, HMA, PAVEMENT

401.01 Description. This work shall consist of one or more courses of QC/QA HMA base, intermediate, or surface mixtures constructed on prepared foundations in accordance with 105.03.

401.02 Quality Control. The HMA shall be supplied from a certified HMA plant in accordance with ITM 583; Certified Volumetric Hot Mix Asphalt Producer Program. The HMA shall be transported and placed according to a Quality Control Plan, QCP, prepared and submitted by the Contractor in accordance with ITM 803; Contractor Quality Control Plans for Hot Mix Asphalt Pavements. The QCP shall be submitted to the Engineer at least 15 days prior to commencing HMA paving operations.

MATERIAL

401.03 Materials. Materials shall be in accordance with the following:

Asphalt Materials	
PG Binder.....	902.01(a)
Coarse Aggregates	904
Base Mixtures - Class D or Higher	
Intermediate Mixtures - Class C or Higher	
* Surface Mixtures - Class B or Higher	
Fibers.....	AASHTO MP 8
Fine Aggregates	904
* Surface aggregate requirements are listed in 904.03(d).	

401.04 Design Mix Formula. A design mix formula, DMF, shall be prepared in accordance with 401.05 and submitted in a format acceptable to the Engineer one week prior to use. The DMF shall state the maximum particle size in the mixture. The DMF shall state the calibration factor, test temperature and absorption factors to be used for the determination of binder content using the ignition oven in accordance with ITM 586, the binder content by extraction in accordance with ITM 571, and a Mixture Adjustment Factor (MAF). The DMF shall state the source, type, and dosage rate of any stabilizing additives. Approval of the DMF will be based on the ESAL and mixture designation. A mixture number will be assigned by the Engineer. No mixture will be accepted until the DMF has been approved.

The ESAL category identified in the pay item correlates to the following ESAL ranges:

ESAL CATEGORY	ESAL
1	< 300,000
2	300,000 to < 3,000,000
3	3,000,000 to < 10,000,000
4	10,000,000 to < 30,000,000
5	≥ 30,000,000

401.05 Volumetric Mix Design. The DMF shall be determined for each mixture from a volumetric mix design by a design laboratory selected from the Department's list of approved Mix Design Laboratories. A volumetric mixture shall be designed in accordance with the respective AASHTO and ASTM references as listed below.

Standard Specification for Superpave Volumetric Mix Design	AASHTO MP 2
Standard Specification for Designing Stone Matrix Asphalt (SMA)	AASHTO MP 8
Standard Practice for Short and Long Term Aging of Hot Mix Asphalt (HMA)	AASHTO R 30
Standard Practice for Designing Superpave HMA	AASHTO PP 28
Maximum Specific Gravity of Bituminous Paving Mixtures	AASHTO T 209
Resistance of Compacted Bituminous Mixture to Moisture Induced Damage	AASHTO T 283
Method for Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the SHRP Gyratory Compactor	AASHTO T 312
Bulk Specific Gravity of Compacted Bituminous Mixtures Using Automatic Vacuum Sealing	ASTM D 6752

The single percentage of aggregate passing each required sieve shall be within the limits of the following gradation tables.

	Dense Graded, Mixture Designation – Control Point (Percent Passing)				
	25.0 mm	19.0 mm	12.5 mm	9.5 mm	4.75 mm
Sieve Size					
50.0 mm					
37.5 mm	100.0				
25.0 mm	90.0 - 100.0	100.0			
19.0 mm	< 90.0	90.0 - 100.0	100.0		
12.5 mm		< 90.0	90.0 - 100.0	100.0	100.0
9.5 mm			< 90.0	90.0 - 100.0	95.0 - 100.0
4.75 mm				< 90.0	90.0 - 100.0
2.36 mm	19.0 - 45.0	23.0 - 49.0	28.0 - 58.0	32.0 - 67.0	
1.18 mm					30.0 - 60.0
600 μ m					
300 μ m					
75 μ m	1.0 - 7.0	2.0 - 8.0	2.0 - 10.0	2.0 - 10.0	6.0 - 12.0

PCS Control Point for Mixture Designation (Percent Passing)					
Mixture Designation	25.0 mm	19.0 mm	12.5 mm	9.5 mm	4.75 mm
Primary Control Sieve	9.5 mm	4.75 mm	4.75 mm	2.36 mm	NA
PCS Control Point	40	47	39	47	NA

Open Graded, Mixture Designation – Control Point (Percent Passing)		
	C19.0	C25.0
Sieve Size		
37.5 mm		100.0
25.0 mm	100.0	70.0 - 98.0
19.0 mm	70.0 - 98.0	50.0 - 85.0
12.5 mm	40.0 - 68.0	28.0 - 62.0
9.5 mm	20.0 - 52.0	15.0 - 50.0
4.75 mm	10.0 - 30.0	6.0 - 30.0
2.36 mm	15.0 $\pm$ 8.0	15.0 $\pm$ 8.0
1.18 mm	2.0 - 18.0	2.0 - 18.0
600 μ m	1.0 - 13.0	1.0 - 13.0
300 μ m	0.0 - 10.0	0.0 - 10.0
150 μ m	0.0 - 9.0	0.0 - 9.0
75 μ m	0.0 - 8.0	0.0 - 8.0
Percent of Binder	> 3.0	> 3.0

Dust/Calculated Effective Binder Ratio shall be from 0.6 to 1.2, when the aggregate gradation passes above the primary control sieve (PCS) control point and 0.8 to 1.6 when the aggregate gradation passes beneath the PCS. The Dust/Calculated Effective Binder Ratio for 4.75 mm mixtures shall be 0.9 to 2.0.

The optimum binder content for dense graded mixtures shall produce 4.0% air voids at N_{des} and for open graded mixtures shall produce 15.0% – 20.0% air voids at N_{des} . The design for dense graded mixtures shall have at least four points, including a minimum of two points above and one point below the optimum. A one point design

may be used for open graded mixtures. The maximum specific gravity of the uncompacted mixture shall be determined in accordance with AASHTO T 209.

The percent draindown of open graded mixtures shall not exceed 0.30% in accordance with AASHTO T 305. Open graded mixtures may incorporate fibers.

Dense graded mixture shall be tested for moisture susceptibility in accordance with AASHTO T 283 except that the loose mixture curing shall be replaced by short term aging for 2 h in accordance with AASHTO R 30. The minimum tensile strength ratio, TSR, shall be 80%. The 150 mm (6 in.) mixture specimens shall be compacted in accordance with AASHTO T 312. If anti-stripping additives are added to the mixture to be in accordance with the minimum TSR requirements, the dosage rate shall be submitted with the DMF.

The MAF equals the Gmm from the mixture design divided by the following: 2.465 for 9.5 mm mixtures and 2.500 for 12.5 mm, 19.0 mm, and 25.0 mm mixtures. If the MAF calculation results in a value where $0.960 \leq \text{MAF} \leq 1.040$, then the MAF shall be considered to be 1.000. If the calculated MAF is outside of the above range, then the actual calculated value shall be used.

Changes in the source or types of aggregates shall require a new DMF. A new DMF shall be submitted to the District Materials and Tests Engineer for approval one week prior to use.

Changes in the source of specified binders, except for PG 58-28 or PG 64-22, shall require a new DMF.

The mixture design compaction temperature for the specimens shall be $150 \pm 5^{\circ}\text{C}$ ($300 \pm 9^{\circ}\text{F}$) for dense graded mixtures and $125 \pm 5^{\circ}\text{C}$ ($260 \pm 9^{\circ}\text{F}$) for open graded mixtures.

Design criteria for each mixture shall be based on the ESAL shown in the contract documents and shall be as follows:

GYRATORY COMPACTION EFFORT					
ESAL	N _{ini} *	N _{des} *	N _{max} *	Max. % Gmm @ N _{ini}	Max. % Gmm @ N _{max}
DENSE GRADED					
< 300,000	6	50	75	91.5	98.0
300,000 to < 3,000,000	7	75	115	90.5	98.0
3,000,000 to < 10,000,000	8	100	160	89.0	98.0
10,000,000 to < 30,000,000	8	100	160	89.0	98.0
≥ 30,000,000	9	125	205	89.0	98.0
OPEN GRADED					
ALL ESAL	NA	20	NA	NA	NA

* N_{ini}, N_{des}, N_{max} - definitions are included in AASHTO PP 28.

VOIDS IN MINERAL AGGREGATE (VMA) CRITERIA @ N _{des}	
Mixture Designation	Minimum VMA, Percent
4.75 mm	16.0
9.5 mm	15.0
12.5 mm	14.0
19.0 mm	13.0
25.0 mm	12.0
C19.0 mm	NA
C25.0 mm	NA

VOIDS FILLED WITH ASPHALT (VFA) CRITERIA @ N _{des}	
ESAL	VFA, Percent
< 300,000	70 - 80
300,000 to < 3,000,000	65 - 78
3,000,000 to < 10,000,000	65 - 75
10,000,000 < 30,000,000	65 - 75
≥ 30,000,000	65 - 75

Note 1: For 9.5 mm mixtures, the specified VFA range shall be 73% to 76% for design traffic levels ≥ 3 million ESALs.

Note 2: For 25.0 mm mixtures, the specified lower limit of the VFA shall be 67% for design traffic levels < 0.3 million ESALs.

Note 3: For 4.75 mm mixtures, the specified VFA range shall be 75% to 78% for all design traffic levels ≥ 3 million ESALs.

Note 4: For C19.0 mm and C25.0 mm mixtures, VFA is not applicable.

401.06 Recycled Materials. Recycled materials may consist of reclaimed asphalt pavement, RAP, or asphalt roofing shingles, ARS, or a blend of both. RAP shall be the product resulting from the cold milling or crushing of an existing HMA pavement. The RAP shall be processed so that 100% will pass the 50 mm (2 in.) sieve when entering the HMA plant. ARS shall consist of waste from a shingle manufacturing facility. No tear-off materials from roofs will be allowed. ARS shall be stockpiled separately from other materials. The coarse aggregate in the recycled materials shall pass the maximum size sieve for the mixture being produced.

Recycled materials may be used as a substitute for a portion of the new materials required to produce HMA mixtures. When only RAP is used in the mixture, the RAP shall not exceed 25.0% by mass (weight) of the total mixture. When only ARS is used in the mixture, the ARS shall not exceed 5.0% by mass (weight) of the total mixture. For substitution or use, 1.0% of ARS is considered equal to 5.0% RAP. The percentages of recycled materials shall be as specified on the DMF.

Mainline surface or open graded mixtures shall not contain recycled materials.

The combined aggregate properties of a mixture with recycled materials shall be determined in accordance with ITM 584 and shall be in accordance with 904. Gradations of the combined aggregates shall be in accordance with 401.05.

Mixtures containing 15.0% or less RAP, shall use the same grade of binder as specified. The binder for mixtures containing greater than 15.0% and up to 25.0% RAP

shall be reduced by one temperature classification, 6°C, for both the upper and lower temperature classifications.

401.07 Lots and Sublots. Lots will be defined as 4000 Mg (4000 t) of base or intermediate mixtures or 2400 Mg (2400 t) of surface mixture. Lots will be further sub-divided into sublots not to exceed 1000 Mg (1000 t) of base or intermediate mixtures or 600 Mg (600 t) of surface mixture. Partial sublots of 100 Mg (100 t) or less will be added to the previous subplot. Partial sublots greater than 100 Mg (100 t) constitute a full subplot.

401.08 Job Mix Formula. A job mix formula, JMF, shall be developed by a certified HMA producer. A JMF used in the current or previous calendar year that was developed to N_{des} will be allowed. The mixture compaction temperature shall be $150 \pm 5^{\circ}\text{C}$ ($300 \pm 9^{\circ}\text{F}$) for dense graded mixtures and $125 \pm 5^{\circ}\text{C}$ ($260 \pm 9^{\circ}\text{F}$) for open graded mixtures. The JMF for each mixture shall be submitted to the Engineer and shall use the same MAF as the DMF.

401.09 Acceptance of Mixtures. Acceptance of mixtures for binder content, VMA at N_{des} , and air voids at N_{des} for each lot will be based on tests performed by the Engineer. Acceptance testing for surface mixtures will include tests for moisture content. The Engineer will randomly select the location(s) within each subplot for sampling in accordance with the ITM 802. An acceptance sample will consist of two plate samples with the first being at the random location and the second 0.6 m (2 ft) ahead station. A backup sample consisting of two plate samples shall be located 0.6 m (2 ft) towards the center of the mat from the acceptance sample. For surface mixtures, an additional sample shall be located 0.6 m (2 ft) back station from the random sample location.

Samples from each location shall be obtained from each subplot from the pavement in accordance with ITM 580.

The binder content will be determined in accordance with ITM 586 or ITM 571 as directed by the Engineer. The maximum specific gravity will be determined in accordance with AASHTO T 209. The Air Voids will be determined in accordance with AASHTO PP 28 based on the average bulk specific gravity from two gyratory specimens and the MSG for the subplot. The VMA will be determined in accordance with AASHTO PP 28 based on the average bulk specific gravity from two gyratory specimens, the percent aggregate in the mixture from the subplot and the BSG of the aggregate blend from the DMF/JMF as applicable. The gyratory pills will be prepared in accordance with AASHTO T 312.

The bulk specific gravity of gyratory specimens for dense graded mixtures will be determined in accordance with AASHTO T 166. The bulk specific gravity of gyratory specimens for open graded mixtures, C19.0, C25.0 will be determined in accordance with ASTM D 6752, except as follows. The duration of the test from initiating the vacuum extraction to weighing the specimen after the water bath will not exceed five minutes. The mass of water absorbed by the specimen while in the water bath will be subtracted from the mass of the specimen obtained in the water bath. Any test in which the mass of water absorbed by the specimen exceeds 2% of the sample mass is invalid.

The mixture properties for each subplot shall meet the requirements for the tolerances from the JMF as shown in the table as follows.

ACCEPTANCE TOLERANCES	
MIXTURE PROPERTIES	TOLERANCES FROM JMF
DENSE GRADED	
Air Voids	JMF $\pm$ 1.0 %
Binder Content	JMF $\pm$ 0.5 %
VMA	JMF $\pm$ 1.0 %
OPEN GRADED	
Air Voids *	JMF $\pm$ 3.0 %
Binder Content	JMF $\pm$ 0.5 %

* Gmb will be determined in accordance with ASTM D 6752

The maximum percent of moisture in the mixture shall not exceed 0.10 from plate samples.

A binder draindown test in accordance with AASHTO T 305 for open graded mixtures shall be completed once per lot in accordance with 401.07 and shall not exceed 0.50%.

The Engineer's acceptance test results for each subplot will be available when the testing is complete.

Air voids, binder content and VMA values will be reported to the nearest 0.1%. Moisture and draindown test results will be rounded to the nearest 0.01%. Rounding will be in accordance with 109.01(a).

Pay factors will be determined in accordance with 401.19(a).

The Contractor may request an appeal of the Engineer's test results in accordance with 401.20.

Fibers incorporated into the mixture will be accepted on the basis of a type A certification for the specified material properties for each shipment of fibers. Fibers from different manufacturers and different types of fibers shall not be intermixed.

In the event that an acceptance sample is not available to represent a subplot(s), all test results of the previous subplot will be used for acceptance. If the previous subplot is not available, the subsequent subplot will be used for acceptance.

CONSTRUCTION REQUIREMENTS

401.10 General. Equipment for HMA operations shall be in accordance with 409.

Fuel oil, kerosene, or solvents shall not be transported in open containers on equipment. Cleaning of equipment and small tools shall not be accomplished on the pavement or shoulder areas.

Segregation, flushing or bleeding of HMA mixtures will not be permitted. Corrective action shall be taken to prevent continuation of these conditions. Segregated, flushed or bleeding HMA mixtures shall be removed if directed. All areas showing an excess or deficiency of binder shall be removed and replaced.

All mixtures that become loose and broken, mixed with dirt, or is in any way defective shall be removed and replaced.

401.11 Preparation of Surfaces to be Overlaid. The subgrade shall be shaped to the required grade and sections, free from all ruts, corrugations, or other irregularities, and uniformly compacted and approved in accordance with 207. Milling of an existing pavement surface shall be in accordance with 306. Surfaces on which a mixture is placed shall be free from objectionable or foreign materials at the time of placement.

Compacted aggregate bases and rubblized pavements shall be primed in accordance with 405. PCCP, milled asphalt surfaces, and asphalt surfaces shall be tacked in accordance with 406. Contact surfaces of curbing, gutters, manholes, and other structures shall be tacked in accordance with 406.

401.12 Process Control. The Engineer and Contractor will jointly review the operations to ensure compliance with the QCP. Continuous violations of compliance with the QCP will result in suspension of paving operations.

401.13 Weather Limitations. HMA courses of less than 75 kg/m^2 (138 lb/syd) shall be placed when the ambient temperature and the temperature of the surface on which it is to be placed is 7°C (45°F) or above. No mixture shall be placed on a frozen subgrade.

401.14 Spreading and Finishing. The mixture shall be placed upon an approved surface by means of laydown equipment in accordance with 409.03(c). Prior to paving, both the planned quantity and lay rate shall be adjusted by multiplying by the MAF. When mixture is produced from more than one DMF or JMF for a given pay item, the MAF will be applied to the applicable portion of the mixture for each. The temperature of each mixture at the time of spreading shall not be more than 10°C (18°F) below the minimum mixing temperature as shown on the JMF for mixtures compacted in accordance with 402.15.

Planned HMA courses greater than 90 kg/m^2 (165 lb/syd) placed under traffic, shall be brought up even with each adjacent lane at the end of each work day. Planned HMA courses less than or equal to 90 kg/m^2 (165 lb/syd) shall be brought forward concurrently, within practical limits, limiting the work in one lane to not more than one work day of production before moving back to bring forward the adjacent lane. Traffic shall not be allowed on open graded mixtures.

Hydraulic extensions on the paver will not be permitted for continuous paving operations. Fixed extensions or extendable screeds shall be used on courses greater than the nominal width of the paver except in areas where the paving widths vary. Hydraulic extensions may be used in tapers and added lanes less than 75 m (250 ft) in length.

Automatic slope and grade controls shall be used as outlined in the QCP.

HMA mainline and HMA shoulders which are 2.4 m (8.0 ft) or more in width shall be placed with paving equipment in accordance with 409.03(c)1.

When laying mixtures with density not controlled by cores, the speed of the paver shall not exceed 15 m (50 ft) per min. Rollers shall be operated to avoid shoving of the HMA and at speeds not to exceed 4.5 km/h (3 mph). However, vibratory rollers will be limited to 4 km/h (2.5 mph).

The finished thickness of any course shall be at least two times but not more than four times the maximum particle size as shown on the DMF.

401.15 Joints. Longitudinal joints in the surface shall be at the lanelines of the pavement. Longitudinal joints below the surface shall be offset from previously constructed joints by approximately 150 mm (6 in.), and be located within 300 mm (12 in.) of the lane line.

Transverse joints shall be constructed by exposing a near vertical full depth face of the previous course. For areas inaccessible to rollers, other mechanical devices shall be used to achieve the required density.

If constructed under traffic, temporary transverse joints shall be feathered to provide a smooth transition to the driving surface.

401.16 Density. Acceptance will be based on lots and sublots in accordance with 401.07.

Density of the compacted dense graded mixture will be determined from cores except where:

- (a) the total planned lay rate to be placed over a shoulder existing prior to the contract award is less than 210 kg/m² (385 lb/syd); or
- (b) the first lift of material placed at less than 210 kg/m² (385 lb/syd) over a shoulder existing prior to the contract award.

Density of any random core location(s) in these areas will be assigned a value of 92.0 %MSG and compaction shall be in accordance with 402.15.

Open graded mixtures shall be compacted with six passes of a static tandem roller and will be assigned a value of 84.0% of MSG. Vibratory rollers shall not be used on open graded mixtures.

Density acceptance by cores will be based on samples obtained from two random locations selected by the Engineer within each subplot in accordance with ITM 802. One core shall be cut at each random location in accordance with ITM 580. The transverse core location will be located so that the edge of the core will be no closer than 75 mm (3 in.) from a confined edge or 150 mm (6 in.) from a non-confined

edge of the course being placed. The maximum specific gravity will be determined from the sample obtained in 401.09.

The Contractor shall obtain cores in the presence of the Engineer with a device that shall produce a uniform 150 mm (6 in.) diameter pavement sample. Coring shall be completed prior to the random location being covered by the next course. Surface courses shall be cored within two work days of placement. Damaged core(s) shall be discarded and replaced with a core from a location selected by adding 0.3 m (1.0 ft) to the longitudinal location of the damaged core using the same transverse offset.

The Contractor and the Engineer shall mark the core to define the course to be tested. If the core indicates a course thickness of less than 2.0 times the maximum particle size, the core will be discarded and a core from a new random location will be selected for testing.

The Engineer will take immediate possession of the cores. If the Engineer's cores are subsequently damaged, additional coring will be the responsibility of the Department. Subsequent core locations will be determined by subtracting 0.3 m (1.0 ft) from the random location using the same transverse offset.

The density for the mixture will be expressed as the percentage of maximum specific gravity (%MSG) obtained by dividing the average bulk specific gravity by the maximum specific gravity for the subplot, times 100. The Engineer will determine the BSG of the cores in accordance with AASHTO T 166. The maximum specific gravity will be determined in accordance with AASHTO T 209 from samples prepared in accordance with ITM 572. The target value for density of dense graded mixtures of each subplot shall be 92.0%MSG.

Within one work day of coring operations the Contractor shall clean, dry, and refill the core holes with HMA of similar or smaller size particles or other approved materials.

The test results for each subplot shall meet the requirements for the tolerances as shown in the table below:

DENSE GRADED ACCEPTANCE TOLERANCE	
Core Density	94.0 ± 2.0 %MSG

Pay factors will be determined in accordance with 401.19(b).

The Engineer's acceptance test results for each subplot will be available when the testing is complete. Acceptance of the pavement for density (%MSG) will be reported to the nearest 0.1%. Rounding will be in accordance with 109.01(a).

401.17 Shoulder Corrugations. Shoulder corrugations shall be in accordance with 606.

401.18 Pavement Smoothness. The pavement smoothness will be accepted by means of a profilograph, a 4.9 m (16 ft) long straightedge, or a 3 m (10 ft) long straightedge.

The profilograph shall be used where the following conditions are met:

- (a) the design speed is greater than 70 km/h (45 mph),
- (b) the pavement lanes are full width and 75 m (250 ft) or longer, and
- (c) the HMA is placed on a milled surface or the total planned lay rate is 180 kg/m² (330 lb/syd) or greater.

If a pay item, Profilograph, is included in the contract, the Contractor shall furnish, calibrate, and operate an approved profilograph in accordance with ITM 901. The profilogram produced shall become the property of the Department. The profilograph shall remain the property of the Contractor. When a profilograph is not included as a pay item, the Department will furnish, calibrate, and operate the profilograph.

The 4.9 m (16 ft) long straightedge shall be used on overlays where the profilograph is not specified. The 4.9 m (16 ft) long straightedge shall be used on all full width pavement lanes shorter than 75 m (250 ft), on tapers, within 15 m (50 ft) of bridge ends, and within 15 m (50 ft) of an existing pavement, which is being joined.

The 3 m (10 ft) long straightedge shall be used for transverse slopes, approaches, and crossovers.

All wavelike irregularities and abrupt changes in profile caused by paving operations shall be corrected.

Each finished course of base and intermediate shall be subject to approval. The pavement smoothness shall be checked on any new intermediate course located immediately below a surface course and the surface course at the locations as designated in ITM 901.

If grinding of the intermediate course is used for pavement smoothness corrections, the grinding shall not precede the surface placement by more than 30 calendar days if open to traffic.

When the 4.9 m (16 ft) straightedge is used on a surface course, the pavement variations shall be corrected to 6 mm (1/4 in.) or less. When the 3 m (10 ft) straightedge is used, the pavement variations shall be corrected to 3 mm (1/8 in.) or less.

When the profilograph is being used on a surface course, in addition to the requirements for the profile index, all areas having a high or low point deviation in excess of 8 mm (0.3 in.) shall be corrected. Courses underlying the surface courses that are exposed by corrective actions shall be milled to 25 mm (1 in.) and replaced with surface materials. The initial profile index shall be determined prior to any corrective action. The final profile index will be determined after all corrective action has been completed.

When the profilograph is being used on an intermediate course, all areas having a high or low point deviation in excess of 8 mm (0.3 in.) shall be corrected. When the 4.9 m (16 ft) or 3.0 m (10 ft) straightedge is being used on an intermediate course, all areas having a high or low point deviation in excess of 6 mm (1/4 in.) shall be corrected.

401.19 Pay Factors. A composite pay factor for each subplot based on test results for mixture properties and density is determined in a weighted formula as follows:

$$SCPF = 0.20(PF_{\text{BINDER}}) + 0.35(PF_{\text{VOIDS}}) + 0.10(PF_{\text{VMA}}) + 0.35 (PF_{\text{DENSITY}})$$

where:

SCP = Sublot Composite Pay Factor for Mixture and Density
 PF_{BINDER} = Sublot Pay Factor for Binder Content
 PF_{VOIDS} = Sublot Pay Factor for Air Voids at N_{des}
 PF_{VMA} = Sublot Pay Factor for VMA at N_{des}
 PF_{DENSITY} = Sublot Pay Factor for Density

If the SCPF for a subplot is less than 0.85, the Materials and Tests Division will evaluate the pavement. If the Contractor is not required to remove the mixture, quality assurance adjustments of the lot will be assessed or other corrective actions taken as determined by the Materials and Tests Division.

The quality assurance adjustment for mixture properties and density is calculated as follows.

$$q = \sum L \times U \times (SCPF - 1.00)$$

where:

q = quality assurance adjustment quantity
L = subplot quantity
U = unit price for the material, \$/Mg (\$/TON)
SCPF = subplot pay factor

The quality assurance adjustment points for smoothness will be calculated in accordance with 401.19(c).

The total quality assurance adjustments is to be calculated as follows:

$$Q = Q_s + (\sum q)/MAF$$

where:

Q = total quality assurance adjustment quantity
 Q_s = quality assurance adjustment for smoothness as calculated in 401.19(c)
q = quality assurance adjustment quantity

(a) Mixture. Sublot test results for mixture properties will be assigned pay factors in accordance with the following.

BINDER CONTENT	
Deviation from JMF ($\pm$ %)	Pay Factor
≤ 0.2	1.05
> 0.2 and ≤ 0.3	1.04
> 0.3 and ≤ 0.4	1.02
> 0.4 and ≤ 0.5	1.00
> 0.5 and ≤ 0.6	0.95
> 0.6 and ≤ 0.7	0.90
> 0.7 and ≤ 0.8	0.85
> 0.8	0.85 - 0.05 per each 0.1% over 0.8%

VMA	
Deviation from JMF ($\pm$ %)	Pay Factor
DENSE GRADED	
≤ 0.5	1.05
> 0.5 and ≤ 1.0	1.00
> 1.0 and ≤ 1.5	0.95
> 1.5 and ≤ 2.0	0.90
> 2.0 and ≤ 2.5	0.85
> 2.5	0.85 - 0.02 per each 0.1% over 2.5%
OPEN GRADED	
All	1.00

AIR VOIDS	
Deviation from JMF ($\pm$ %)	Pay Factor
DENSE GRADED	
≤ 0.5	1.05
> 0.5 and ≤ 1.0	1.00
> 1.0 and ≤ 1.5	0.95
> 1.5 and ≤ 2.0	0.85
> 2.0	Submitted to the Materials and Tests Division
OPEN GRADED	
≤ 1.0	1.05
> 1.0 and ≤ 3.0	1.00
> 3.0 and ≤ 3.5	0.95
> 3.5 and ≤ 4.0	0.85
> 4.0	Submitted to the Materials and Tests Division

* Test results will be considered and adjudicated as a failed material in accordance with normal Department practice as listed in 105.03.

For mixtures produced during a plant's adjustment period, pay factors based on the JMF with the above tolerances will be used to compute quality assurance adjustments.

(b) Density. Sublot test results for density will be assigned pay factors in accordance with the following:

DENSITY		
Percentages are based on %MSG	Pay Factors – Percent	
Dense Graded	Open Graded	
≥ 97.0		Submitted to the Materials and Tests Division
95.6 - 96.9		1.05 - 0.01 for each 0.1 % above 95.6
94.0 - 95.5		1.05
93.1 - 93.9		1.00 + 0.005 for each 0.1 % above 93.1
92.0 - 93.0	84.0	1.00
91.0 - 91.9		1.00 - 0.003 for each 0.1 % below 92.0
90.0 - 90.9		0.97 - 0.012 for each 0.1 % below 91.0
89.0 - 89.9		0.85 - 0.015 for each 0.1 % below 90.0
≤ 88.9		Submitted to the Materials and Tests Division

* Test results will be considered and adjudicated as a failed material in accordance with normal Department practice as listed in 105.03.

The pay factors shall be rounded to the nearest 0.01.

(c) Smoothness. When the pavement smoothness is tested with a profilograph, payment will be based on the final profile index in accordance with the following table. A Quality Assurance Pay Factor (PF_s) for smoothness will apply to the planned typical section including the aggregate base, and the HMA base, intermediate, and surface courses. The quality assurance adjustment for each section will include the total area of each pavement lane excluding shoulders for 0.16 km (0.1 mi) long section represented by the profile index calculated by the following formula:

$$q_s = (PF_s - 1.00) \sum_{i=1}^n \left(A \times \frac{S}{T} \times U \right)$$

where:

- q_s = quality assurance adjustment for smoothness for one section
- PF_s = pay factor for smoothness
- N = number of layers
- A = area of the section, m² (syd)
- S = spread rate for material, kg/m² (lb/syd)
- T = conversion factor: 1000 kg/Mg (2000 lb/ton)
- U = unit price for the material, \$/Mg (\$/ton)

The quality assurance adjustment for smoothness, Q_s, for the contract will be the total of the quality assurance adjustments for smoothness, q_s, on each section by the following formula:

$$Q_s = \sum q_s$$

SMOOTHNESS	
Design Speed Greater Than 70 km/hr (45 mph)	
Profile Index mm per 0.16 km (in./0.1 mi.)	Pay Factor
Over 0 to 5 mm (Over 0.00 to 0.20)	1.05
Over 5 to 10 mm (Over 0.20 to 0.40)	1.04
Over 10 to 20 mm (Over 0.40 to 0.80)	1.02
Over 20 to 25 mm (Over 0.80 to 1.00)	1.00
Over 25 to 28 mm (Over 1.00 to 1.10)	0.96
Over 28 to 30 mm (Over 1.10 to 1.20)	0.92
All pavement with a profile index greater than 30 mm (1.20) shall be corrected.	

Quality assurance pay factors greater than 1.00 will be applicable only to the initial measured profile index, prior to any corrective work. Quality assurance pay factors of 1.00 or less will be applied to pavement sections where corrective work has been completed.

401.20 Appeals. If the QC test results do not agree with the acceptance test results, a request, along with the QC test results, may be made in writing for additional testing. Additional testing may be requested for one or more of the following tests: MSG, BSG of the gyratory specimens, binder content, or BSG of the density cores. The request for the appeal for MSG, BSG of gyratory specimens, binder content or BSG of the density cores shall be submitted within seven calendar days of receipt of the Department's written results for that subplot. The subplot and specific test(s) shall be specified at the time of the appeal request. Only one appeal request per subplot is permitted. Upon approval of the appeal, the Engineer will perform additional testing as follows:

The backup or new sample(s) will be tested in accordance with the applicable test method for the test requested.

(a) MSG. The backup MSG sample will be dried in accordance with ITM 572 and tested in accordance with AASHTO T 209, Section 9.5.1.

(b) BSG of the Gyratory Specimen. New gyratory specimens will be prepared and tested in accordance with AASHTO T 312 from the backup sample.

(c) **Binder Content.** The backup binder content sample will be prepared and tested in accordance with the test method that was used for acceptance.

(d) **BSG of the Density Core.** Additional cores shall be taken within seven calendar days unless otherwise directed. Additional core locations will be determined by adding 0.3 m (1.0 ft) longitudinally of the cores tested using the same transverse offset. The appeal density cores will be tested in accordance with AASHTO T 166.

The appeal results will replace all previous test result(s) for acceptance of mixture in accordance with 401.09 and density in accordance with 401.16. The results will be furnished to the Contractor.

401.21 Method of Measurement. HMA mixtures will be measured by the megagram (ton) of the type specified, in accordance with 109.01(b). The mass (weight) accepted for payment will be divided by the MAF to determine the accepted quantity.

Milled shoulder corrugations will be measured in accordance with 606.02.

401.22 Basis of Payment. The accepted quantities for this work will be paid for at the contract unit price per megagram (ton) for QC/QA-HMA, of the type specified, complete in place.

Payment for furnishing, calibrating, and operating the profilograph, and furnishing profile information will be made at the contract lump sum price for profilograph, HMA.

Adjustments to the contract payment with respect to mixture, density, and smoothness for mixture produced will be included in a quality assurance adjustment pay item. The unit price for this pay item will be one dollar (\$1.00) and the quantity will be in units of dollars. The quantity is the total calculated in accordance with 401.19. An extra work order developed in accordance with 109.05 will be prepared to reflect contract adjustments.

Milled shoulder corrugations will be paid for in accordance with 606.03.

Payment will be made under:

Pay Item	Metric Pay Unit Symbol (English Pay Unit Symbol)
Profilograph, HMA.....	LS
QC/QA HMA, _____, _____, _____, _____ mm (ESAL ⁽¹⁾) (PG ⁽²⁾) (Course ⁽³⁾) (Mix ⁽⁴⁾)	Mg (TON)
Quality Assurance Adjustment.....	DOL

(1) ESAL Category as defined in 401.04

(2) Number represents the high temperature binder grade. Low temperature grades are -22.

(3) Surface, Intermediate, or Base

(4) Mixture Designation

Preparation of surfaces to be overlaid shall be included in the cost of other pay items.

Coring and refilling of the core holes shall be included in the cost of other pay items within this section.

No payment will be made for additional anti-stripping additives, appeal coring or traffic control expenditures related to coring operations.

Corrections for pavement smoothness shall be included in the cost of other pay items within this section.

The price for Profilograph, HMA, will be full compensation regardless of how often the profilograph is used or how many profilograms are produced.

If QC/QA-HMA intermediate over QC/QA-HMA base mixtures are specified, QC/QA-HMA intermediate mixture may be permitted as a substitute for the QC/QA-HMA intermediate and QC/QA-HMA base mixtures upon a written request by the Contractor. The request for the substitution shall be prepared in advance of the work. A computation will be made in order to obtain a unit price for the QC/QA-HMA intermediate mixture. The quantity and amount for QC/QA-HMA intermediate mixture shall equal the sum of the contract quantities and amounts shown for QC/QA-HMA intermediate and QC/QA-HMA base mixtures. The unit price for QC/QA-HMA intermediate mixture shall be equal to the sum of contract amounts divided by the sum of contract quantities. Payment for the QC/QA-HMA intermediate mixture will be made at the unit price per megagram (ton) for QC/QA-HMA intermediate mixture. No payment will be made for additional work or costs which may result due to this change.

SECTION 402 – HOT MIX ASPHALT, HMA, PAVEMENT

402.01 Description. This work shall consist of one or more courses of HMA base, intermediate, or surface mixtures and miscellaneous courses for rumble strips, and wedge and leveling constructed on prepared foundations in accordance with 105.03.

402.02 Quality Control. The HMA shall be supplied from a certified HMA plant in accordance with ITM 583; Certified Volumetric Hot Mix Asphalt Producer Program. The HMA shall be transported and placed according to a Quality Control Plan, QCP, prepared and submitted by the Contractor in accordance with ITM 803; Contractor Quality Control Plans for Hot Mix Asphalt Pavements. The QCP shall be submitted to the Engineer at least 15 days prior to commencing HMA paving operations.

MATERIALS

402.03 Materials. Materials shall be in accordance with the following:

Asphalt Materials

PG Binder, PG 58-28*, PG 64-22,

PG 64-28*, PG 70-22902.01(a)

Coarse Aggregates	904
Base Mixtures - Class D or Higher	
Intermediate Mixtures - Class C or Higher	
** Surface Mixtures - Class B or Higher	
Fine Aggregates	904
* Only for use in mixtures containing greater than 15% RAP. Refer to 402.05.	
** Surface aggregate requirements are listed in 904.03(d).	

402.04 Design Mix Formula. A DMF shall be prepared in accordance with 402.05 and submitted in a format acceptable to the Engineer one week prior to use. The DMF shall state the maximum particle size in the mixture, the calibration factor and test temperature to be used for the determination of binder content using ITM 586 or ITM 571, and a MAF. Approval of the DMF will be based on the ESAL and mixture designation as follows.

Mixture Type	Type A	Type B	Type C	Type D
Design ESAL	200,000	2,000,000	9,000,000	11,000,000
Surface	9.5 mm	9.5 mm	9.5 mm	9.5 mm
Surface - PG Binder	64-22	64-22	70-22	70-22
Intermediate	19.0 mm	19.0 mm	19.0 mm	19.0 mm
Intermediate - PG Binder	64-22	64-22	64-22	70-22
Base	25.0 mm	25.0 mm	25.0 mm	25.0 mm
Base - PG Binder	64-22	64-22	64-22	64-22

The Engineer will assign a mixture number. No mixture will be accepted until the DMF has been approved.

402.05 Volumetric Mix Design The DMF shall be determined for each mixture from a volumetric mix design in accordance with 401.05.

A DMF developed for a QC/QA HMA mixture may be used and the source or grade of the binder may be changed; however, the high temperature grade shall meet the minimum requirements of 402.04.

The MAF equals the Gmm from the mixture design divided by the following: 2.465 for 9.5 mm mixtures and 2.500 for 12.5 mm, 19.0 mm, and 25.0 mm mixtures. If the MAF calculation results in a value where $0.960 \leq \text{MAF} \leq 1.040$, then the MAF shall be considered to be 1.000. If the calculated MAF is outside of the above range, then the actual calculated value shall be used.

402.06 Job Mix Formula. The job mix formula, JMF, shall be an approved JMF in accordance with 401.08 of the same gyratory compaction effort ESAL category or higher, and submitted in a format acceptable to the Engineer and shall use the same MAF as the DMF. The JMF shall state the maximum particle size in the mixture and the calibration factor and test temperature to be used for the determination of binder content using the ignition oven. Approval of the JMF will be based on the ESAL and mixture designation. No mixture will be accepted until the JMF has been approved.

All changes in the type or source of aggregate shall require the submittal of a new DMF for approval.

For mixtures containing 0.0% to 15.0% RAP, changes in the source and grade of specified binders will be permitted; however the high temperature grade shall meet the minimum requirements of 402.04.

402.07 Mix Criteria.

(a) **Composition Limits for HMA Rumble Strip Mixtures.** Rumble strip mixtures shall be a type A surface in accordance with 402.04. A MAF in accordance with 402.05 will not apply. Aggregate requirements of 904.03(d) do not apply.

(b) **Composition Limits for HMA Wedge and Leveling Mixtures.** The mixture shall consist of surface or intermediate mixtures in accordance with 402.04. Aggregate requirements of 904.03(d) do not apply when the wedge and leveling mixture is covered by a surface or intermediate mixture.

(c) **Composition Limits for Temporary HMA Mixtures.** Temporary HMA mixtures shall be type B in accordance with 402.04. A MAF in accordance with 402.05 will not apply.

(d) **Composition Limits for HMA Curbing Mixes.** The mixture shall be HMA surface type A in accordance with 402 except 402.05 shall not apply and no RAP shall be used. The binder content shall be 7.0% and the gradations shall meet the following.

HMA Curbing Gradations	
Sieve Size	Percent Passing Sieves
12.5 mm (1/2 in.)	100.0
9.5 mm (3/8 in.)	80.0 - 100.0
4.75 mm (No. 4)	73.0 $\pm$ 5.0
600 μ m (No. 30)	20.0 - 50.0
75 μ m (No. 200)	6.0 - 12.0

A DMF shall be prepared in accordance with the above table and submitted in a format acceptable to the Engineer one week prior to use. The DMF shall state the calibration factor and test temperature to be used for the determination of binder content using ITM 586 or ITM 571.

402.08 Recycled Materials. Recycled materials may consist of reclaimed asphalt pavement, RAP, or asphalt roofing shingles, ARS, or a blend of both. RAP shall be the product resulting from the cold milling or crushing of an existing HMA pavement. The RAP shall be processed so that 100% will pass the 50 mm (2 in.) sieve when entering the HMA plant. ARS shall consist of waste from a shingle manufacturing facility. No tear-off materials from roofs will be allowed. ARS shall be stockpiled separately from other materials. The coarse aggregate in the recycled materials shall pass the maximum size sieve for the mixture being produced.

Recycled materials may be used as a substitute for a portion of the new materials required to produce HMA mixtures. When only RAP is used in the mixture, the RAP shall not exceed 25.0% by mass (weight) of the total mixture. When only ARS

is used in the mixture, the ARS shall not exceed 5.0% by mass (weight) of the total mixture. For substitution or use, 1.0% of ARS is considered equal to 5.0% RAP. The percentages of recycled materials shall be as specified on the JMF.

Recycled materials may be used in all mixtures except type C and type D surface mixtures.

The combined aggregate properties of a mixture with recycled materials shall be determined in accordance with ITM 584 and shall be in accordance with 904. Gradations of the combined aggregates shall be in accordance with 402.03.

The binder low temperature classification for mixtures containing greater than 15.0% and up to 25.0% RAP shall be -28°C, and the binder high temperature classification may be reduced by 6°C.

402.09 Acceptance of Mixtures. Acceptance of mixtures will be in accordance with the Frequency Manual on the basis of a type D certification in accordance with 916. The test results shown on the certification shall be the quality control tests representing the material supplied and include air voids and binder content. Air voids tolerance shall be $\pm 1.5\%$ and binder content tolerance shall be $\pm 0.7\%$ from DMF or JMF.

Single test values and averages will be reported to the nearest 0.1%. Rounding will be in accordance with 109.01(a).

Test results exceeding the tolerance limits will be considered as a failed material and adjudicated in accordance with 105.03.

CONSTRUCTION REQUIREMENTS

402.10 General. Equipment for HMA operations shall be in accordance with 409.

Fuel oil, kerosene, or solvents shall not be transported in open containers on any equipment at any time. Cleaning of equipment and tools shall not be accomplished on the pavement or shoulder areas.

Segregation, flushing or bleeding of HMA mixtures will not be permitted. Corrective action shall be taken to prevent continuation of these conditions. Areas of segregation, flushing or bleeding shall be corrected, if directed. All areas showing an excess or deficiency of asphalt materials shall be removed and replaced.

All mixtures that become loose and broken, mixed with dirt, or is in any way defective shall be removed and replaced.

Mixture shall not be dispatched from the plant that cannot be spread and compacted before sundown of that day, unless otherwise permitted.

402.11 Preparation of Surfaces to be Overlaid. The subgrade shall be shaped to the required grade and sections, free from all ruts, corrugations, or other irregularities, and uniformly compacted and approved in accordance with 207. Milling of an existing surface shall be in accordance with 306. Surfaces on which a mixture is placed shall be free from objectionable or foreign materials at the time of placement.

Compacted aggregate bases and rubblized bases shall be primed in accordance with 405. PCCP, milled asphalt surfaces, and asphalt surfaces shall be tacked in accordance with 406. Contact surfaces of curbing, gutters, manholes, and other structures shall be tacked in accordance with 406.

402.12 Weather Limitations. HMA courses less than 60 kg/m^2 (110 lb/syd) are to be placed when the ambient and surface temperatures are 16°C (60°F) or above. HMA courses equal to or greater than 60 kg/m^2 (110 lb/syd) but less than 120 kg/m^2 (220 lb/syd) are to be placed when the ambient and surface temperatures are 7°C (45°F) or above. HMA courses equal to or greater than 120 kg/m^2 (220 lb/syd) and HMA curbing are to be placed when the ambient and surface temperatures are 0°C (32°F) or above. Mixture shall not be placed on a frozen subgrade. However, HMA courses may be placed at lower temperatures, provided the density of the HMA course is in accordance with 402.16.

All partially completed sections of roadway that are 200 mm (8 in.) or less in thickness shall be proofrolled prior to the placement of additional materials the following spring. Proofrolling shall be accomplished in accordance with 203.26. The contact pressure shall be 480 to 550 kPa (70 to 80 psi). Soft yielding areas shall be removed and replaced.

402.13 Spreading and Finishing. The mixture shall be placed upon an approved surface by means of laydown equipment in accordance with 409.03(c). Prior to paving, both the planned quantity and lay rate shall be adjusted by multiplying by the MAF. When mixture is produced from more than one DMF or JMF for a given pay item, the MAF will be applied to the applicable portion of the mixture for each. Mixtures in areas inaccessible to laydown equipment or mechanical devices may be placed by other methods.

The temperature of each mixture at the time of spreading shall not be more than 10°C (18°F) below the minimum mixing temperature as shown on the DMF or JMF.

Planned HMA courses greater than 90 kg/m^2 (165 lb/syd) placed under traffic shall be brought up even with each adjacent lane at the end of each work day. Planned HMA courses less than or equal to 90 kg/m^2 (165 lb/syd) shall be brought forward concurrently, within practical limits, limiting the work in one lane to not more than one work day of production before moving back to bring forward the adjacent lane. Traffic shall not be allowed on open graded mixtures.

Hydraulic extensions on the paver will not be permitted for continuous paving operations. Fixed extensions or extendable screeds shall be used on courses greater than the nominal width of the paver except in areas where the paving widths vary. Hydraulic extensions may be used on approaches, tapers, and added lanes less than 75 m (250 ft) in length.

HMA shoulders which are 2.4 m (8.0 ft) or more in width shall be placed with automatic paving equipment.

HMA mixtures in hauling equipment shall be protected by tarps from adverse weather conditions or foreign materials. Adverse weather conditions include, but will not be limited to, precipitation or temperatures below 7°C (45°F).

The speed of the paver shall not exceed 15 m (50 ft) per min when spreading mixtures.

Automatic slope and grade controls shall be required except when placing mixtures on roadway approaches which are less than 60 m (200 ft) in length or on miscellaneous work. The use of automatic controls on other courses where use is impractical due to project conditions may be waived by the Engineer.

The finished thickness of each course shall be at least two times but not more than four times the maximum particle size as shown on the DMF or JMF. Feathering may be less than the minimum thickness requirements.

Rumble strips shall be placed to ensure uniformity of depth, width, texture, and the required spacing between strips. A tack coat in accordance with 406 shall be applied on the pavement surface prior to placing the mixture. The tack coat may be applied with a paint brush or other approved methods.

402.14 Joints. Longitudinal joints in the surface shall be at the lane lines of the pavement. Longitudinal joints below the surface shall be offset from previously constructed joints by approximately 150 mm (6 in.), and be located within 300 mm (12 in.) of the lane line.

Transverse joints shall be constructed by exposing a near vertical full depth face of the previous course.

If constructed under traffic, temporary transverse joints shall be feathered to provide a smooth transition to the driving surface.

402.15 Compaction. The HMA mixture shall be compacted with equipment in accordance with 409.03(d) immediately after the mixture has been spread and finished. Rollers shall not cause undue displacement, cracking, or shoving.

A roller application is defined as one pass of the roller over the entire mat. Compaction operations shall be completed in accordance with one of the following options:

Number of Roller Applications						
Rollers	Courses $\leq 240 \text{ kg/m}^2$ (440 lb/syd)				Courses $> 240 \text{ kg/m}^2$ (440 lb/syd)	
	Option 1	Option 2	Option 3	Option 4	Option 1	Option 2
Three Wheel	2		4		4	
Pneumatic Tire	2	4			4	
Tandem	2	2	2		4	
Vibratory Roller				6		8

A reduced number of applications on a course may be approved if detrimental results are being observed.

Compaction equipment shall be operated with the drive roll or wheels nearest the paver and at speeds not to exceed 4.5 km/h (3 mph). However, vibratory rollers will be limited to 4 km/h (2.5 mph). Rolling shall be continued until applications are completed and all roller marks are eliminated.

Compaction operations shall begin at the low side and proceed to the high side of the mat. The heaviest roller wheel shall overlap its previous pass by a minimum of 150 mm (6 in.).

Longitudinal joints shall be compacted in accordance with the following:

- (a) For confined edges, the first pass adjacent to the confined edge, the compaction equipment shall be entirely on the hot mat 150 mm (6 in.) from the confined edge.
- (b) For unconfined edges, the compaction equipment shall extend 150 mm (6 in.) beyond the edge of the hot mat.

All displacement of the HMA mixture shall be corrected at once by the use of lutes and/or the addition of fresh mixture as required. The line and grade of the edges of the HMA mixture shall not be displaced during rolling.

The wheels shall be kept properly moistened with water or water with detergent to prevent adhesion of the materials to the wheels.

Areas inaccessible to rollers shall be compacted thoroughly with hand tampers or other mechanical devices in accordance with 409.03(d)6 to achieve the required compaction. A trench roller, in accordance with 409.03(d)5, may be used to obtain compaction in depressed areas.

The final two roller applications shall be completed at the highest temperature where the mixture does not exhibit any tenderness.

Vehicular traffic will not be permitted on a course until the mixture has cooled sufficiently to prevent distortions.

Rumble strips shall be compacted with vibratory compacting equipment in accordance with 409.03(d)6 unless otherwise stated.

402.16 Low Temperature Density Requirements. Compaction for mixtures placed below the temperatures listed in 402.12, shall be controlled by air voids determined from a mixture plate sample and cores cut from the compacted pavement placed during a low temperature period. Samples shall be obtained in accordance with ITM 580. Acceptance will be based on a minimum of one plate sample and two cores. The Engineer will randomly select locations in accordance with ITM 802. The transverse core location will be located so that the edge of the core will be no closer than 75 mm (3 in.) from a confined edge or 150 mm (6 in.) from a non-confined edge of the course being placed.

For compaction of HMA during low temperature periods with quantities less than 100 Mg (100 t) per day, acceptance may be visual.

The Contractor shall obtain cores in the presence of the Engineer with a device that shall produce a uniform 150 mm (6 in.) diameter pavement sample. Coring shall be completed prior to the random location being covered. The final HMA course shall be cored within one work day of placement. Damaged core(s) shall be discarded and replaced with a core from a location selected by adding 0.3 m (1.0 ft) to the longitudinal location of the damaged core using the same transverse offset.

The Contractor, and the Engineer, shall mark the core to define the course to be tested. If the core indicates a course thickness of less than 2.0 times the maximum particle size, the core will be discarded and a core from a new random location will be selected for testing.

The Engineer will take immediate possession of the cores. If the Engineer's cores are subsequently damaged, additional coring within a specific section will be the responsibility of the Department. Subsequent core locations will be determined by subtracting 0.3 m (1.0 ft) from the random location using the same transverse offset.

The percent air voids of a section for the mixture shall be expressed as:

$$AV \% = (1.0 - BSG/MSG) \times 100$$

where:

AV % = percent air voids

BSG = average bulk specific gravity

MSG = maximum specific gravity

The Engineer will determine the bulk specific gravity of the cores in accordance with AASHTO T 166. The maximum specific gravity will be determined in accordance with AASHTO T 209. Air voids shall not be greater than 8.0%. Within one work day of coring operations, the Contractor shall clean, dry, refill, and compact the core holes with suitable HMA of similar or smaller size particles or other approved materials.

402.17 Shoulder Corrugations. Shoulder corrugations shall be in accordance with 606.

402.18 Pavement Smoothness. Pavement smoothness will be in accordance with 401.18 except profilograph requirements will not apply.

402.19 Method of Measurement. HMA mixtures will be measured by the megagram (ton) of the type specified, in accordance with 109.01(b). The mass (weight) accepted for payment will be divided by the MAF to determine the accepted quantity.

HMA rumble strips will be measured by the meter (linear foot) of each transverse strip, complete in place.

Milled shoulder corrugations will be measured in accordance with 606.02.

402.20 Basis of Payment. The accepted quantities for this work will be paid for at the contract unit price per megagram (ton) for HMA, of the type specified complete in place.

HMA rumble strips will be paid for at the contract unit price per meter (linear foot), of each transverse strip complete in place.

Milled shoulder corrugations will be paid for in accordance with 606.03.

Payment will be made under:

Pay Item	Metric Pay Unit Symbol (English Pay Unit Symbol)
HMA Surface, Type <u> </u> *	Mg (TON)
HMA Intermediate, Type <u> </u> *	Mg (TON)
HMA Base, Type <u> </u> *	Mg (TON)
HMA Rumble Strips.....	m (LFT)
HMA for Temporary Pavement	Mg (TON)
HMA Wedge and Level, Type <u> </u> *	Mg (TON)
* Mixture Type	

Preparation of surfaces to be overlaid shall be included in the cost of other pay items in this section.

No payment will be made for additional anti-stripping additives.

The cost of removing and replacing soft yielding areas discovered by proofrolling shall be included in the cost of other pay items in this section.

No payment will be made for coring operations and related traffic control expenditures required in 402.16.

Corrections for pavement smoothness including removal and replacement of pavement, shall be included in the cost of other pay items in this section.

If HMA intermediate over HMA base mixtures are specified, HMA intermediate may be permitted as a substitute for the HMA intermediate and HMA base mixtures upon a written request by the Contractor. The request for the substitution shall be prepared in advance of the work. A computation will be made in order to obtain a unit price for the HMA intermediate. The quantity and amount for HMA intermediate shall equal the sum of the contract quantities and amounts shown for HMA intermediate and HMA base mixtures. The unit price for HMA intermediate shall be equal to the sum of contract amounts divided by the sum of contract quantities. Payment for the HMA intermediate will be made at the unit price per megagram (ton) for HMA intermediate. No payment will be made for additional work or cost which may result due to this change.

SECTION 403 – COLD MIX ASPHALT, CMA, PAVEMENT

403.01 Description. This work shall consist of the construction of one or more courses of CMA base, intermediate, or surface for immediate use or stockpiled in accordance with 105.03.

MATERIALS

403.02 Materials. Materials shall be in accordance with the following:

Asphalt Materials	
For Immediate Use,	
Asphalt Emulsion AE-150, AE-90.....	902.01(b)
For Stockpiling, Asphalt Emulsion, AE-150	902.01(b)
Coarse Aggregates	904
Base, Class D or Higher	
Intermediate, Class C or Higher	
Surface, Class B or Higher	
Fine Aggregates	904

CONSTRUCTION REQUIREMENTS

403.03 Weather Limitations. CMA pavements shall not be placed on a wet surface, when the ambient temperature is below 4°C (40°F), or when other unsuitable conditions exist, unless approved by the Engineer.

403.04 Equipment. Mixing plant, hauling trucks, pavers, and rollers shall be in accordance with 409.

403.05 Preparation of Mixtures. The size of the aggregate and the grade of asphalt materials shall be as specified. The gradations and percent of asphalt shall be as follows:

Composition Limits for CMA Mixtures						
Sieve Size	Total Percent of Aggregates Passing Sieves Based on Total Mass (Weight) of Aggregates					
	Size 2	Size 5	Size 8	Size 9	Size 11	Size 5D
63 mm (2.5 in.)	100					
50 mm (2 in.)	95-100					
37.5 mm (1.5 in.)		100				100
25.0 mm (1 in.)	0-25	85-100	100			80-99
19.0 mm (3/4 in.)	0-10	60-90	75-100	100		68-90
12.5 mm (1/2 in.)	0-7	30-65	40-75	65-90	100	54-76
9.5 mm (3/8 in.)		15-50	20-55	30-65	75-100	45-67
4.75 mm (No. 4)		0-20	0-20	0-20	10-35	30-50
2.36 mm (No. 8)		0-15	0-15	0-15	0-15	20-45
600 μ m (No. 30)						7-28
75 μ m (No. 200)	0-5	0-5	0-5	0-6	0-6	0-6
Minimum Percent Crushed	95	95	95	95	95	95
Percent of Asphalt*	2.0-3.5	2.5-4.0	3.0-4.5	3.5-5.0	4.0-6.0	3.5-5.0

* Percent of asphalt shall be calculated on the basis of the total mass (weight) of the mixture, exclusive of water or solvent. When slag is used, the asphalt content will be adjusted to compensate for the specific gravity and surface area.

The moisture condition of the aggregate shall be such that the aggregate is uniformly coated and satisfactorily retains the required amount of asphalt during the stockpiling, hauling, and spreading operations. Mixtures shall not be produced at temperatures exceeding 80°C (180°F).

403.06 Preparation of Subgrade or Base. Mixtures for CMA base may be placed on an earth subgrade, on an existing pavement surface to be used as a base, or on a previously prepared base or subbase as specified. If such material is to be laid on a newly prepared subgrade, then all applicable requirements of 207 shall apply.

403.07 Spreading Mixture. The CMA mixture shall be spread in accordance with 402.13.

403.08 Curing. All CMA mixtures shall be allowed to cure sufficiently to prevent undue distortions under the roller wheels.

When a CMA mixture is allowed to cure under traffic, the surface shall be maintained and all damaged areas shall be satisfactorily repaired.

403.09 Compaction. Compaction shall be in accordance with 402.15. Satisfactory means to confine the mixture within the required limits shall be in place during the compaction operation.

403.10 Surface Tolerances. The smoothness requirements for CMA pavements shall be in accordance with 402.18.

403.11 Method of Measurement. CMA pavement will be measured by the megagram (ton), of the type and size specified, in accordance with 109.01(b).

403.12 Basis of Payment. The accepted quantities of CMA pavement will be paid for at the contract unit price per megagram (ton), of the type and size specified, for the mixture.

Payment will be made under:

Pay Item	Metric Pay Unit Symbol (English Pay Unit Symbol)
CMA Base _____ size	Mg (TON)
CMA Intermediate _____ size	Mg (TON)
CMA Surface _____ size	Mg (TON)

The cost of repairing damaged areas of mixture allowed to cure under traffic shall be included in the cost of the pay items in this section.

SECTION 404 – SEAL COAT

404.01 Description. This work shall consist of one or more applications of asphalt material, each followed by an application of cover aggregate in accordance with 105.03.

MATERIALS

404.02 Asphalt Material. The type and grade of asphalt material shall be in accordance with the following:

Asphalt Emulsion, RS-2, AE-90, AE-90S, or HFRS-2902.01(b)

404.03 Cover Aggregate. Aggregate shall be in accordance with the following requirements. When slag is used as an alternate to natural aggregate, adjustments will be made in accordance with 904.01, to compensate for differences in specific gravity.

Coarse Aggregates, Class B or Higher	
Size No. 8, 9, 11, or 12.....	904
Fine Aggregate	
Size No. 23 or 24	904

The types of seal coats shall be as follows:

TYPE	APPLICATION	COVER AGGREGATE SIZE NO.	RATES OF APPLICATION PER SQUARE METER (SQUARE YARD)	
			AGGREGATE kg (lb)	ASPHALT MATERIAL LITER (GALLON) AT 16°C (60°F)
1*	Single	23, 24	5.4-6.8 (12-15)	0.45-0.61 (0.12-0.16)
2	Single	12	6.4-7.7 (14-17)	1.09-1.25 (0.29-0.33)
3	Single	11	7.3-9.1 (16-20)	1.36-1.51 (0.36-0.40)
4	Single	9	12.7-14.5 (28-32)	2.38-2.57 (0.63-0.68)
5	Double	a. 11	7.3-9.1 (16-20)	1.36-1.51 (0.36-0.40)
		b. 12	7.3-8.6 (16-19)	1.25-1.40 (0.33-0.37)
6	Double	a. 9	12.7-14.5 (28-32)	2.38-2.57 (0.63-0.68)
		b. 11	8.2-10.0 (18-22)	1.55-1.74 (0.41-0.46)
7	Double	a. 8	12.7-14.5 (28-32)	2.38-2.57 (0.63-0.68)
		b. 11	8.2-10.0 (18-22)	1.55-1.74 (0.41-0.46)

* Only AE-90 or AE-150 shall be used for seal coat, type 1.

CONSTRUCTION REQUIREMENTS

404.04 Weather Limitations. Asphalt material shall not be applied on a wet surface, or when other weather conditions would adversely affect the seal coats. Seal coats shall not be placed when the ambient or base temperature is below 4°C (40°F). If seal coats are placed when the ambient or base temperature is between 4°C (40°F) and 16°C (60°F), the cover aggregate shall be heated to between 49°C (120°F) and 66°C (150°F).

404.05 Equipment. A distributor, rotary power broom, pneumatic tire roller, and aggregate spreader in accordance with 409.03, shall be used.

404.06 Preparation of Surface. Surfaces to be sealed shall be brought to proper section and grade, compacted, cleaned as required, and approved. Aggregate surfaces to be sealed shall be primed in accordance with 406.

404.07 Applying Asphalt Material. Asphalt material shall be applied in a uniform continuous spread over the section to be treated. The quantity of asphalt material to be applied per square meter (square yard) shall be as directed.

The asphalt material shall not be spread over a greater area than that which can be covered with the cover aggregate that is in trucks at the site. It shall not be spread more than 150 m (500 ft) ahead of the aggregate spreader.

The spread of the asphalt material shall be no wider than the width covered by the cover aggregate from the spreading device. Operations shall not proceed such that asphalt material is allowed to chill, set up, dry, or otherwise impair retention of the cover coat.

404.08 Application of Cover Aggregate. Immediately following the application of the asphalt material, cover aggregate shall be spread in quantities as directed. Spreading shall be accomplished such that the tires of the trucks or aggregate spreader do not contact the uncovered and newly applied asphalt material.

Rolling shall consist of at least three complete roller coverages and be completed within 30 min after the cover aggregate is applied. The rollers shall not be operated at speeds that will displace the cover aggregate from the asphalt material.

The seal coat shall be protected by the restriction of traffic or by controlling traffic speed until the asphalt material has cured or set sufficiently to hold the cover aggregate without displacement.

Excess cover aggregate shall be removed from the pavement surface by light brooming on the day following placement of the seal coat. The brooming shall not displace the imbedded cover aggregate.

404.09 Method of Measurement. Asphalt material and cover aggregate will be measured by the megagram (ton). Seal coat will be measured by the square meter (square yard).

If measurement of seal coat is made by the square meter (square yard), the quantity for each day's placement will be the least of the following:

- (a) the measured square meters (square yards) within the specified limits;
- (b) the calculated square meters (square yards) based on the amount of aggregate used, divided by the minimum amount of aggregate per square meter (square yard) specified in 404.03; or
- (c) the calculated square meters (square yards) based on the amount of asphalt material used, divided by the minimum amount of asphalt material per square meter (square yard) specified in 404.03.

404.10 Basis of Payment. The accepted quantities of asphalt material and cover aggregate will be paid for at the contract unit price per megagram (ton). Seal coat will be paid for at the contract unit price per square meter (square yard) complete in place. If slag is used as a cover aggregate, and payment will be made per megagram (ton), the pay quantity will be adjusted in accordance with 904.01.

If seal coat is paid for by the square meter (square yard) and if so directed, asphalt material in excess of the limits set out in 404.03 will be paid for at the Contractor's invoice price, plus 20%.

Payment will be made under:

Pay Item	Metric Pay Unit Symbol (English Pay Unit Symbol)
Asphalt for Seal Coat.....	Mg (TON)
Cover Aggregate, Seal Coat.....	Mg (TON)
Seal Coat, _____ type	m2 (SYS)

SECTION 405 – PRIME COAT

405.01 Description. This work shall consist of preparing and treating an existing or newly constructed aggregate surface or rubblized PCCP with asphalt material and cover aggregate in accordance with 105.03.

MATERIALS

405.02 Asphalt Material. The type and grade of asphalt material shall be in accordance with the following:

Asphalt Emulsion, AE-PMP902.01(b)

405.03 Cover Aggregate. Aggregate shall be in accordance with the following:

Coarse Aggregate, Class B or Higher,
Size No. 12904
Fine Aggregate, Size No. 23 or 24904

CONSTRUCTION REQUIREMENTS

405.04 Weather Limitations. Asphalt material shall not be applied on a wet surface, when the ambient temperature is below 10°C (50°F), or when other unsuitable conditions exist, unless approved by the Engineer.

405.05 Equipment. A distributor and aggregate spreader in accordance with 409.03 shall be used.

405.06 Preparation of Surface. The existing surface to be treated shall be shaped to the required grade and section; free from all ruts, corrugations, or other irregularities; uniformly compacted; and approved.

405.07 Application of Asphalt Material. AE-PMP shall be uniformly applied at the rate of 2.2 to 3.3 L/m² (0.50 to 0.75 gal./syd) placed in a single application. When placing material on a rubblized base, a carpet drag shall be utilized behind the distributor.

When traffic is to be maintained within the limits of the section, approximately half of the width of the section shall be treated in one application. Complete coverage of the section shall be ensured. Treated areas shall not be opened to traffic until the asphalt material has been absorbed.

405.08 Cover Aggregate. If the asphalt material fails to penetrate and the primed surface must be used by traffic, cover aggregate shall be spread to provide a dry surface.

405.09 Method of Measurement. Asphalt for prime coat will be measured by the megagram (ton), or by the square meter (square yard). Cover aggregate will be measured by the megagram (ton).

405.10 Basis of Payment. The accepted quantities of prime coat will be paid for at the contract unit price per megagram (ton), or per square meter (square yard) for asphalt for prime coat. The accepted quantities of cover aggregate will be paid for at the contract unit price per megagram (ton), complete in place.

Payment will be made under:

Pay Item	Metric Pay Unit Symbol (English Pay Unit Symbol)
Asphalt for Prime Coat.....	Mg (TON) m2 (SYS)
Cover Aggregate, Prime Coat	Mg (TON)

SECTION 406 – TACK COAT

406.01 Description. This work shall consist of preparing and treating an existing pavement or concrete surface with asphalt material in accordance with 105.03.

MATERIALS

406.02 Asphalt Material. The type and grade of asphalt material shall be in accordance with the following:

Asphalt Emulsion, AE-T, AE-PMT	902.04(b)
PG Asphalt Binder, PG 64-22	902.01(a)

CONSTRUCTION REQUIREMENTS

406.03 Equipment. A distributor in accordance with 409.03(a) shall be used.

406.04 Preparation of Surface. The existing surface to be treated shall be free of foreign materials deemed detrimental by the Engineer.

406.05 Application of Asphalt Material. The asphalt material shall be uniformly applied at the rate of from 0.14 to 0.36 L/m² (0.03 to 0.08 gal./syd), or as otherwise specified or directed.

Tack coat shall not be applied to a wet surface. The rate of application, temperature, and areas to be treated shall be approved prior to application. Excessive tack coat shall be corrected to obtain an even distribution.

406.06 Method of Measurement. Asphalt for tack coat will be measured by the megagram (ton) or by the square meter (square yard).

406.07 Basis of Payment. The accepted quantities of tack coat will be paid for at the contract unit price per megagram (ton), or per square meter (square yard) for asphalt for tack coat, complete in place.

Payment will be made under:

Pay Item	Metric Pay Unit Symbol (English Pay Unit Symbol)
Asphalt for Tack Coat.....	Mg (TON) m2 (SYS)

SECTION 407 – DUST PALATIVE

407.01 Description. This work shall consist of preparing and treating an existing aggregate surface with asphalt material in accordance with 105.03.

MATERIALS

407.02 Asphalt Material. The type and grade of asphalt material shall be in accordance with the following:

Asphalt Emulsion, AE-PL.....902.01(b)

CONSTRUCTION REQUIREMENTS

407.03 Weather Limitations. Asphalt material shall not be applied on a wet surface, when the ambient temperature is below 10°C (50°F), or when other unsuitable conditions exist, unless approved by the Engineer.

407.04 Equipment. A distributor in accordance with 409.03(a) shall be used.

407.05 Preparation of Surface. The surface to be treated shall be shaped to the required section, and be free from all ruts, corrugations, or other irregularities.

407.06 Application of Asphalt Material. The asphalt material shall be uniformly applied at the rate of 1.5 to 5 L/m² (0.25 to 1.00 gal./syd) in a uniform continuous spread over the section to be treated or as directed.

When traffic is to be maintained within the limits of the section, approximately half of the width of the section shall be treated in one application. Complete coverage of the section shall be ensured. Treated areas shall not be opened to traffic until the asphalt material has been absorbed.

407.07 Method of Measurement. Asphalt for dust palative will be measured by the megagram (ton).

407.08 Basis of Payment. The accepted quantities of this work will be paid for at the contract unit price per megagram (ton) for asphalt for dust palative, complete in place.

Payment will be made under:

Pay Item	Metric Pay Unit Symbol (English Pay Unit Symbol)
Asphalt for Dust Palative	Mg (TON)

SECTION 408 – SEALING CRACKS AND JOINTS

408.01 Description. This work shall consist of sealing longitudinal and transverse cracks and joints in existing asphalt pavement in accordance with 105.03.

MATERIALS

408.02 Materials. Materials shall be in accordance with the following:

Asphalt Emulsion for	
Crack Sealing, AE-90, AE-90S, AE-150	902.01(b)
Fine Aggregates, No. 23 or 24	904
Sealant for Routed Cracks and Joints	ASTM D 3405

CONSTRUCTION

408.03 Equipment. A distributor in accordance with 409.03 shall be used when crack sealing and an indirect-heat double boiler kettle with mechanical agitator shall be used when routing and sealing. Air compressors shall be capable of producing a minimum air pressure of 690 kPa (100 psi).

408.04 Weather Limitations. Sealing operations shall not be conducted on a wet surface, when the ambient temperature is below 4°C (40°F), or when other unsuitable conditions exist, unless approved by the Engineer.

408.05 Routing. Cracks and joints shall be routed with a vertical-spindle router with carbide-tipped or diamond router bits to form a reservoir not exceeding 13 mm x 13 mm (0.5 in. x 0.5 in.), when required. The operation shall be coordinated such that routed materials do not encroach on pavement lanes carrying traffic and all routed materials are disposed of in accordance with 104.07.

408.06 Sealing Cracks and Joints. Cracks and joints shall be cleaned by blowing with compressed air or by other suitable means. Asphalt material shall be placed utilizing a "V" shaped wand tip, to allow the penetration of the materials into the cracks and joints. The cracks and joints shall be completely filled or overbanded not to exceed 125 mm (5 in.), or as required. All excess asphalt material shall be removed from the pavement. The sealed cracks and joints shall be covered with sufficient fine aggregate to prevent tracking of the asphalt materials. All excess cover material shall be removed from the pavement.

Application of asphalt materials shall be completed without covering existing pavement markings. When traffic is to be maintained within the limits of the section, temporary traffic control measures in accordance with 801 shall be used. Treated areas shall not be opened to traffic until the asphalt material has been absorbed.

408.07 Method of Measurement. Sealing cracks and joints in asphalt pavements will be measured by the megagram (ton) of asphalt material used. Routing of cracks and joints will not be measured.

Temporary traffic control measures will be measured in accordance with 801.17.

408.08 Basis of Payment. Sealing cracks and joints in asphalt pavements will be paid for by the megagram (ton) of asphalt material used for the type specified.

Temporary traffic control measures will be paid for in accordance with 801.18.

Payment will be made under:

Pay Item	Metric Pay Unit Symbol (English Pay Unit Symbol)
Cracks and Joints in Asphalt Pavement, Seal	Mg (TON)
Cracks and Joints in Asphalt Pavement, Rout and Seal	Mg (TON)

The cost of all materials, cover aggregate, cleaning, and all necessary incidentals shall be included in the cost of the pay items in this section.

SECTION 409 – EQUIPMENT

409.01 Production, Transportation, and Laydown of Asphalt Mixtures. For production of asphalt mixtures, the Contractor shall provide all equipment necessary for the production, transportation, and laydown operations.

409.02 Mixing Plant. The mixing plant shall be capable of producing a uniform mixture.

(a) Certified HMA Plant.

A Certified HMA Plant shall be in accordance with ITM 583.

(b) CMA Mixing Plant.

The mixing plant shall be of sufficient capacity and coordination to adequately handle the proposed CMA construction. The mixing unit shall be a twin shaft pugmill or other approved mixer, including the drum type capable of producing a consistent uniform mixture. The outlet of the mixer shall be such that it prevents segregation of the material when discharged.

A certified HMA plant in accordance with 409.02(a) may be utilized as a CMA mixing plant.

409.03 HMA Laydown Operations.

(a) Distributor. The distributor shall be equipped, maintained, and operated to provide uniform heating and application rates as specified. The distributor shall have a volume measuring device and a thermometer to monitor the asphalt material.

Distributors shall also be equipped with a power unit for the pump and with a full circulation spray bar with vertical controls.

(b) Hauling Equipment. The mixtures shall be transported to the laydown operation in trucks that have tight, clean, and smooth beds.

Truck beds may be treated with approved anti-adhesive agents. The truck beds shall be raised after application of non-foaming anti-adhesive agents to drain the liquids from the bed prior to HMA being loaded into the truck. The Department will maintain a list of approved Anti-Adhesive Materials.

Hauling equipment shall be equipped with a watertight cover to protect the mixture.

(c) Laydown Equipment.

1. Paver. The paver shall be self-propelled, and equipped with a material receiving system, and equipped with heated and vibrating screeds. The paver may also include automatic slope and grade controls, extendable screeds and extendable augers.

Automatic control devices shall be separated from the paver screeds, paver tracks or wheels and be capable of adjusting both sides of the screeds automatically to maintain a constant angle of attack in relation to the grade leveler device or grade line.

A grade leveling system may be used to activate the control devices on each HMA course, including matching lays. The leveling system shall be attached to the paver and operated parallel to the paver's line of travel.

Extendable screeds shall be rigid, heated, and vibrating, and be capable of maintaining the cross slope, and line and grade of the pavement, to produce uniform placement of the materials.

Auger extensions shall be used when required to distribute the HMA uniformly in front of the screed.

2. Widener. A device capable of receiving, transferring, spreading, and striking off materials to the proper grade and slope.

3. Other Mechanical Devices. Inaccessible or short sections of HMA may be placed with specialty equipment approved by the Engineer.

(d) Compaction Equipment. Compaction equipment shall be self-propelled, steel wheel or pneumatic tire types, in good condition, and capable of reversing direction without backlashing. All roller wheels shall be equipped with scrapers to keep the wheels clean, have water spraying devices on the wheels, and steering devices capable of accurately guiding the roller.

1. Tandem Roller. A roller having two axles and a minimum mass (weight) of 9 Mg (10 t).

2. Three Wheel Roller. A roller having three wheels with a minimum bearing of 5.3 kg/mm (300 lb/in.) on the rear wheels. The crown of the wheels shall not exceed 63 mm (2.5 in.) in 5.5 m (18 ft).

A tandem roller which has a drive wheel bearing of no less than 5.3 kg/mm (300 lb/in.) may be used in lieu of the three wheel roller.

3. Pneumatic Tire Roller. A pneumatic tire roller shall have a minimum rolling width of 1.65 m (5.5 ft). The roller shall be equipped with compaction tires, minimum size 7:50 by 15, exerting a uniform, average contact pressure from 345 to 620 kPa (50 to 90 psi) uniformly over the pavement by adjusting ballast and tire inflation pressures. The wheels on at least one axle shall be fully oscillating vertically, and mounted as to prevent scuffing of the pavements during rolling or turning operations. Charts or tabulations showing the contact areas and pressures for the full range of tire inflation pressures and for the full range of tire loadings for each compactor shall be furnished to the Engineer.

4. Vibratory Roller. A vibratory roller shall be equipped with a variable amplitude system, a speed control device, and have a minimum vibration frequency of 2000 vibrations per min. A reed tachometer shall be provided for verifying the frequency of vibrations.

5. Trench Roller. A trench roller shall have a compaction wheel bearing of no less than 5.3 kg/mm (300 lb/in.).

6. Specialty Roller/Compactor. Inaccessible or short sections of HMA may be compacted with specialty equipment approved by the Engineer.

(e) Miscellaneous Equipment.

1. **Aggregate Spreader.** A spreader shall be self-propelled, pneumatic tired-motorized unit with a front loading hopper and a transportation system for distributing the aggregates uniformly across the pavement.

2. **Rotary Power Broom.** A motorized, pneumatic tired unit with rotary bristle broom head.

(f) Smoothness Equipment.

1. **Profilograph.** The profilograph shall be in accordance with ITM 901.

2. **Straightedge - 4.9 m (16 ft).** A 4.9 m (16 ft) straightedge shall be a rigid beam mounted on two solid wheels on axles 4.875 m (16 ft) apart. The straightedge has a mounted push bar to facilitate propelling the device along or across the pavement. Tolerance points are located at the 1/4, 1/2, and 3/4 points and may be composed of threaded bolts capable of being adjusted to the tolerance required.

3. **Straightedge - 3 m (10 ft).** A 3 m (10 ft) straightedge is the same as a 4.9 m straightedge except that the wheels are mounted 3.048 m (10 ft) apart. A handheld rigid beam may be substituted.

SECTION 410 – Blank