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Advisory Circular

FILE

Subject: Change 23 to STANDARDS FOR
SPECIFYING CONSTRUCTION OF AIRPORTS--
New Standard for Plant Mix Bituminous
Materials

Date: 2/29/84

AC No: 150/5370-10

Initiated by: AAS-200

Change: 23

1. **PURPOSE.** The new standard Item P-401, Plant Mix Bituminous Pavements, combines Item P-201, Bituminous Base Course, and Item P-401, Bituminous Surface Course, into a single standard.

2. **PRINCIPAL CHANGES.** The principal changes include:

- a. Gradations have been revised to more nearly approximate the maximum density gradation and are the same for aircraft with gross weights above and below 60,000 pounds.
- b. Job mix formula tolerances for aggregates have been modified.
- c. The compaction temperature for Marshall specimens has been changed to 250°F.
- d. Acceptance of pavements for density has been revised to incorporate a statistically based specification. The specification includes price adjustment factors.
- e. Requirements for the mixing plant have been deleted and reference made to ASTM D 995.

PAGE CONTROL CHART

Remove Pages	Dated	Insert Pages	Dated
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265-292	5/31/77	124-1 - 124-8	2/29/84

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Director, Office of Airport Standards

ITEM P-401 PLANT MIX BITUMINOUS PAVEMENTS

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1. DESCRIPTION

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1.1 This item shall consist of a [** _____] course composed of mineral aggregate and bituminous material mixed in a central mixing plant and placed on a prepared course in accordance with these specifications and shall conform to the lines, grades, thicknesses, and typical cross sections shown on the plans.

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Each course shall be constructed to the depth, typical section, or elevation required by the plans and shall be rolled, finished, and approved before the placement of the next course.

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The Engineer shall specify surface or base course.

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2. MATERIALS

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2.1 AGGREGATE. Aggregates shall consist of crushed stone, crushed gravel, or crushed slag with or without sand or other inert finely divided mineral aggregate. The portion of materials retained on the No. 8 sieve shall be known as coarse aggregate, the portion passing the No. 8 sieve and retained on the No. 200 sieve as fine aggregate, and the portion passing the No. 200 sieve as mineral filler.

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(a) Coarse Aggregate. Coarse aggregate shall consist of sound, tough, durable particles, free from adherent films of matter that would prevent thorough coating with the bituminous material. The percentage of wear shall not be greater than [** _____] percent when tested in accordance with ASTM C131. [The sodium sulfate soundness loss shall not exceed [** _____] percent, after five cycles, when tested in accordance with ASTM C88.]

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1. Percentage of wear shall not exceed 40 for surface course and 50 for base course; sodium sulfate loss should not exceed 9 percent. In certain specific cases, where aggregates complying with these maximums cannot economically be obtained, aggregates with a higher percentage loss or wear may be specified, provided a satisfactory service record under similar conditions of service and exposure shall have been demonstrated.

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2. The sodium sulfate soundness test need only be performed on initial samples from sources where quality of the aggregates is unknown by reason of no prior use or lack of service behavior dates.

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Aggregate shall contain at least [****** _____] percent by weight of crushed pieces having two or more fractured faces and [****** _____] percent having at least one fractured face. The area of each face shall be equal to at least 75 percent of the smallest midsectional area of the piece. When two fractured faces are contiguous, the angle between the planes of fractures shall be at least 30 degrees to count as two fractured faces. Fractured faces shall be obtained by artificial crushing.

For pavements designed for aircraft gross weights of 60,000 pounds (27,000 Kg) or more the Engineer shall specify 70 percent for two fractured faces and 85 percent for one fractured face. For pavements designed for aircraft gross weights less than 60,000 pounds the Engineer shall specify 50 percent for two fractured faces and 65 percent for one fractured face.

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

Slag shall be air-cooled, blast furnace slag, and shall have a compacted weight of not less than 70 pounds per cubic foot (1.12 Mg/m³) when tested in accordance with ASTM C29.

(b) Fine Aggregate. Fine aggregate shall consist of clean, sound, durable, angular particles produced by crushing stone, slag, or gravel that meets the requirements for wear and soundness specified for coarse aggregate. The aggregate particles shall be free from coatings of clay, silt, or other objectionable matter and shall contain no clay balls. The fine aggregate, including any blended filler, shall have a plasticity index of not more than six when tested in accordance with ASTM D424, and a liquid limit of not more than 25 when tested in accordance with ASTM D423.

Natural sand may be used to obtain the gradation of the aggregate blend or to improve the workability of the mix. The amount of sand to be added will be adjusted to produce mixtures conforming to requirements of this specification.

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 The addition of natural sand to a mix containing coarse and 140
 fine aggregates of excessive angularity will normally 141
 increase its workability and compactability. However, the 143
 addition of excessive amounts of natural sand tends to 143
 decrease the stability of the mixture. 143
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(c) Sampling and Testing. ASTM D75 shall be used in 150
 sampling coarse and fine aggregate, and ASTM C183 shall be used 151
 in sampling mineral filler. The Contractor shall furnish 152
 documentation to the Engineer confirming that the aggregates meet 153
 specification requirements. 153

(d) Sources of Aggregates. Sources of aggregates shall be 156
 selected well in advance of the time the materials are required 157
 in the work. When the aggregates are obtained from a previously 158
 approved source or an existing source producing aggregates that 159
 has a satisfactory service record in airport bituminous pavement 160
 construction for at least five years, samples shall be submitted 161
 [**_____] days prior to start of production. An inspection of 164
 the producer's operation will be made by the Engineer. When new 165
 sources are to be developed, the Contractor shall indicate the 166
 sources and shall submit a plan for operation [**_____] days in 168
 advance of starting production. Samples from test pits, borings, 170
 and other excavations shall be submitted at the same time. 171
 Approval of the source of aggregate does not relieve the 172
 Contractor in any way of the responsibility for delivery at the 173
 job site of aggregates that meet the requirements specified 174
 herein. 174

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 Recommended time periods are 14 days for previously approved 179
 aggregates and 30 days for new sources of aggregates, 180
 however the time periods chosen must allow sufficient time 181
 for shipping and testing. 182
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(e) Samples of Aggregates. Samples of aggregates shall be 189
 furnished by the Contractor at the start of production and at 190
 intervals during production of bituminous mixtures. The sampling 191
 points and intervals will be designated by the Engineer. The 192
 samples will be the basis of approval of specific lots of 192
 aggregates from the standpoint of the quality requirements of 193
 this section. 193

2.2 FILLER. If filler, in addition to that naturally present in 197
 the aggregate, is necessary, it shall meet the requirements of 199
 ASTM D242. 199

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2.3 BITUMINOUS MATERIAL. Bituminous material shall conform to the following requirements: [** _____] 202
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The Engineer shall specify the type and grade of bituminous material, based on geographical location and climatic conditions, as well as the controlling specification. Types of materials are listed below. 207.1
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Type and Grade		Specification	
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<u>Asphalt Cement</u>			218
			219
Penetration Grade	60-70	ASTM D946	220
	85-100		221
	100-120		222
			223
Viscosity Grade	AC-5	ASTM D3381	224
	AC-10		225
	AC-30		226
	AC-20		227
	AC-40		228
			229
Viscosity Grade	AR-1000	ASTM D3381	230
	AR-2000		231
	AR-4000		232
	AR-8000		233
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<u>Tar</u>			235
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	RT-10	ASTM D490	237
	RT-11		238
	RT-12		239
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The Contractor shall furnish vendor's certified test reports for each tankload of bitumen shipped to the project. The report shall be delivered to the Engineer before permission is granted for use of the material. The furnishing of the vendor's certified test report for the bituminous material shall be the basis for final acceptance. 246
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3. COMPOSITION

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3.1 COMPOSITION OF MIXTURE. The bituminous plant mix shall be composed of a mixture of aggregate, filler if required, and bituminous material. The several aggregate fractions shall be sized, uniformly graded, and combined in such proportions that the resulting mixture meets the grading requirements of the job mix formula.

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3.2 JOB MIX FORMULA. No bituminous mixture for payment shall be produced until a job mix formula has been approved by the Engineer. The formula shall be submitted in writing by the Contractor to the Engineer at least [**] days prior to the start of paving operations and shall indicate the definite percentage of each sieve fraction of aggregate, the percentage of bitumen, and the temperature of the completed mixture when discharged from the mixer. All test data used to develop the job mix formula shall also be submitted. The job mix formula for each mixture shall be in effect until modified in writing by the Engineer. Should a change in sources of materials be made, a new job mix formula must be established before the new material is used.

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The Engineer shall specify the number of days. A minimum of ten days is recommended.

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The bituminous mixture shall be designed using procedures contained in Chapter III, MARSHALL METHOD OF MIX DESIGN, of the Asphalt Institute's Manual Series No. 2 (MS-2), current edition, and shall meet the requirements of Tables 1 and 2. The temperature of the mix immediately prior to compaction shall be 250 degrees ± 5 degrees F (121 degrees ± 3 degrees C).

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The Marshall Design Criteria applicable to a project shall be specified by the Engineer from the information shown below and inserted into Table 1. Asterisks denote insert points.

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Test Property	: Pavements designed for: : aircraft gross weights: : of 60,000 lbs. or more: : or tire pressure : greater than 100 psi	: Pavements designed for: : aircraft gross weights : less than 60,000 lbs. : or tire pressure less : than 100 psi	
Number of Blows	75	50	307 308 309 310 311 312 313
Stability, pounds (newtons) minimum	1800 (8000)	1000 (4450)	314 315 316 317 318 319
Flow, 0.01 in. (0.25mm)	8-16	8-20	320 321 322
Percent air voids surface base	3-5 3-5	3-5 3-5	323 324 325 326
Percent voids in mineral aggregate	See Table 2	See Table 2	327 328 329

***** 331.2

TABLE 1. MARSHALL DESIGN CRITERIA

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Test Property	:	*	338 339 340 341
Number of Blows	:	*	342 343 344
Stability, minimum pounds (newtons)	:	*	345 346 347
Flow, 0.01 in. (0.25mm)	:	*	348 349
Percent air voids	:	*	350 351
Percent voids in mineral aggregate	:	See Table 2	352 353 354

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TABLE 2. MINIMUM PERCENT VOIDS IN MINERAL AGGREGATE

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Maximum Particle Size (Table 3)		:	Minimum Voids in Mineral Aggregate	
in.	mm	:	percent	
1/2	12.5	:	16	359
3/4	19.0	:	15	360
1	25.0	:	14	361
1-1/4	31.25	:	13	362
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The mineral aggregate shall be of such size that the percentage composition by weight, as determined by laboratory screens, will conform to the gradation or gradations specified in Table 3 when tested in accordance with ASTM Standard C136 d(dry sieve). The percentage by weight for the bituminous material shall be within the limits specified.

The gradations in Table 3 represent the limits which shall determine the suitability of aggregate for use from the sources of supply. The aggregate, as finally selected, shall have a gradation within the limits designated in Table 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.

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TABLE 3. AGGREGATE - BITUMINOUS PAVEMENTS

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Sieve	:	Percentage by Weight Passing Sieves	
Size	:	*	
1-1/4 in. (31.25 mm)	:	*	395
1 in. (25.0 mm)	:	*	396
3/4 in. (19.0 mm)	:	*	397
1/2 in. (12.5 mm)	:	*	398
3/8 in. (9.5 mm)	:	*	399
No. 4 (4.75 mm)	:	*	400
No. 8 (2.36 mm)	:	*	401
No. 16 (1.18 mm)	:	*	402
No. 30 (0.60 mm)	:	*	403
No. 50 (0.30 mm)	:	*	404
No. 100 (0.15 mm)	:	*	405
No. 200 (0.075 mm)	:	*	406
Bitumen percent	:		407
Stone or gravel	:	*	408
Slag	:	*	409
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1. The aggregate gradation band(s) applicable to a project shall be specified by the Engineer from the gradations shown in this note. The gradation shall be inserted into Table 3. Asterisks denote insert points. 423
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 2. The selection of any of the gradations shall be such that the maximum size aggregate used shall not be more than one-half of the thickness of the course being constructed. 429
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 3. Where locally-available aggregates cannot be economically blended to meet the grading requirements of the gradations shown, the gradations may be modified to fit the characteristics of such local aggregates. The modified gradation must produce a paving mixture that satisfies the mix design requirements. 434
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 4. The aggregate gradations shown are based on aggregates of uniform specific gravity, and the percentages passing the various sieves will be subject to appropriate correction by the Engineer when aggregates of varying specific gravities are used. See The Asphalt Institute Manual Series No. 2 (MS-2), Appendix A. 442
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AGGREGATE - BITUMINOUS PAVEMENTS

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Sieve	Percentage by Weight Passing Sieves				454
Size	1 1/4" max	1" max	3/4" max	1/2" max	455
1 1/4 in. (30.0 mm)	100	---	---	---	458
1 in. (24.0 mm)	86-98	100	---	---	459
3/4 in. (19.0 mm)	68-93	76-100	100	---	460
1/2 in. (12.5 mm)	57-81	66-86	79-99	100	461
3/8" (9.5 mm)	49-69	57-77	68-88	79-99	462
No. 4 (4.75 mm)	34-54	40-60	48-68	58-78	463
No. 8 (2.36 mm)	22-42	26-46	33-53	39-59	464
No. 16 (1.18 mm)	13-33	17-37	20-40	26-46	465
No. 30 (0.600 mm)	8-24	11-27	14-30	19-35	466
No. 50 (0.300 mm)	6-18	7-19	9-21	12-24	467
No. 100 (0.150 mm)	4-12	6-16	6-16	7-17	468
No. 200 (0.075 mm)	3-6	3-6	3-6	3-6	469
-----					470
Bitumen percent:					471
Stone or gravel	4.5-7.0	4.5-7.0	5.0-7.5	5.5-8.0	472
Slag	5.0-7.5	5.0-9.0	6.5-9.5	7.0-10.5	473
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The job mix tolerances shown in Table 4 shall be applied to the job mix formula to establish a job control grading band. The full tolerances still will apply if application of the job mix tolerances results in a job control grading band outside the master grading band.

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TABLE 4. JOB MIX FORMULA TOLERANCES
(Based on a Single Test)

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Material	Tolerance	
	Plus or Minus	
Aggregate passing No. 4 sieve or larger	7 percent	490-494
Aggregate passing Nos. 8 and 16 sieves	6 percent	495-496
Aggregate passing Nos. 30 and 50 sieves	5 percent	497-498
Aggregate passing Nos. 100 and 200 sieves	3 percent	499-500
Bitumen	0.45 percent	501-502
Temperature of mix	20 deg. F (11 deg. C)	503-505

The aggregate gradation may be adjusted within the limits of Table 3 as directed, without adjustments in the contract unit prices. 508-510

Deviation from the final approved design for bitumen content and gradation of aggregates shall not be greater than the tolerances permitted and shall be based on daily plant extraction. 512-514
Extraction tests for bitumen content and aggregate gradation will be made at least twice daily. The mixture will be tested for bitumen content in accordance with ASTM D2172 and for aggregate gradation in accordance with AASHTO T30. 515-518

The completed mixture shall be sampled at the plant to retain job control. One sample shall be taken from each subplot on a random basis, in accordance with procedures contained in ASTM D3665. A lot shall consist of [**] tons and shall be divided into 4 sublots. Testing shall be in accordance with the Marshall method procedures contained in Chapter III of the Asphalt Institute Manual Series No. 2 (MS-2), current edition, except the temperature of the mix prior to compaction shall be 250 degrees F ± 5 degrees F (121 degrees C ± 2 degrees C). If any two consecutive Marshall test results of any property do not conform to the requirements shown in Tables 1 and 2, the Contractor shall take immediate corrective action. In no instance shall the percent air voids exceed ± 1 percent of the job mix formula value. 520-534

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The Engineer may halt production if the Marshall test criteria are not met and not allow it to resume until the problem is corrected. 536
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If the index of retained strength of the specimens of composite mixture, as determined by ASTM D1075, is less than 75, the aggregates shall be rejected or the asphalt shall be treated with an antistripping agent. The amount of antistripping agent added to the asphalt shall be sufficient to produce an index of retained strength of not less than 75. 539
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1. For airport pavements designed to accommodate aircraft gross weights of 12,500 pounds (5 662 kg) or less, this section may be modified to permit the use of state highway department specifications for high-quality, hot-mix bituminous pavements that have a satisfactory performance record under equivalent loadings and exposure, including design criteria, gradations, and density requirements. The Engineer may wish to specify stability, percent air voids, and density values when not required by state specifications. 551
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2. Mixes designed with stabilities greater than 2,500 pounds (1 125 kg) may result in mixtures difficult to compact to the required density. 565
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3. The lot size shall be consistent with that specified in paragraph 4.12(a). 568
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3.3 TEST SECTION. Prior to full production, the Contractor shall prepare a quantity of bituminous mixture according to the job mix formula. The amount of mixture should be sufficient to construct a test section [**_____] long and [**_____] wide placed in two sections and shall be of the same depth specified for the construction of the course which it represents. The underlying grade or pavement structure upon which the test section is to be constructed shall be the same as the remainder of the course represented by the test section. The equipment used in construction of the test section shall be the same type and weight to be used on the remainder of the course represented by the test section. 576
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If the test section should prove to be unsatisfactory, the necessary adjustments to the mix design, plant operation, and/or rolling procedures shall be made. Additional test sections, as required, shall be constructed and evaluated for conformance to the specifications. When test sections do not conform to specification requirements, the pavement shall be removed and replaced at the Contractor's expense. A marginal quality test 592
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section that has been placed in an area of little or no traffic may be left in place. If a second test section also does not meet specification requirements both sections shall be removed at the Contractor's expense. Full production shall not begin without the Engineer's approval. Test sections will be paid for in accordance with paragraph 6.1.

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1. The test section should be a minimum of 50 feet (15m) long and 20 feet (6m) wide. The test section affords the Contractor and the Engineer an opportunity to determine the quality of the mixture in place, as well as performance of the plant and laydown equipment. Wherever possible, the test section should be placed in an area where it will receive little or no traffic so that marginal quality trial runs can be safely left in place.

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2. Job mix control testing is performed at the start of plant production and in conjunction with the calibration of the plant for the job mix formula. It should be recognized that the aggregates produced by the plant may not satisfy the gradation requirements or produce a mix that meets the design requirements of the specification. In those instances, it will be necessary to re-evaluate and redesign the mix using plant-produced aggregates. Specimens should be prepared and the optimum bitumen content determined in the same manner as for the original design tests.

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3. Until the plant is producing the desired mix consistently, a large number of tests may be necessary. Once the plant has been placed in continuous operation the number of tests shall be reduced to the number specified in Paragraph 3.2.

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3.4 TESTING LABORATORY. The testing laboratory used to develop the job mix formula and to perform the tests required by this specification shall meet the requirements of ASTM D 3666. A certification that the laboratory meets these requirements shall be submitted to the Engineer. An approved testing laboratory will not be required for quality control tests made by the Contractor.

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4. CONSTRUCTION METHODS

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4.1 WEATHER LIMITATIONS. The bituminous mixture shall not be placed upon a wet surface or when the surface temperature of the underlying course is less than specified in Table 5. The temperature requirements may be waived, but only at the discretion of the Engineer.

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TABLE 5. BASE TEMPERATURE LIMITATIONS

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Mat Thickness	Base Temperature (Minimum)		
	F	C	
3 in. (7.5 cm) or greater	40	4	659
Greater than 1 in. (2.5 cm) but less than 3 in. (7.5 cm)	45	7	660
1 in. (2.5 cm) or less	50	10	661

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4.2 BITUMINOUS MIXING PLANT. Plants used for the preparation of bituminous mixtures shall conform to the requirements of ASTM D995 with the following changes:

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(a) Requirements for All Plants.

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(1) Truck scales. The bituminous mixture shall be weighed on approved scales furnished by the Contractor, or on public scales at the Contractor's expense. Such scales shall be inspected and sealed as often as the Engineer deems necessary to assure their accuracy. Scales shall conform to the requirements of Section 90.

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(2) Testing laboratory. The Contractor or producer shall provide laboratory facilities for control and acceptance testing functions during periods of mix production, sampling, and testing and whenever materials subject to the provisions of these specifications are being supplied or tested. The laboratory shall provide adequate equipment, space, and utilities as required for the performance of the specified tests.

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(3) Inspection of plant. The Engineer, or his authorized representative, shall have access, at all times, to all parts of the plant for checking adequacy of equipment; inspecting operation of the plant; verifying weights, proportions, and character of materials; and checking the temperatures maintained in the preparation of the mixtures.

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(4) Storage bins and surge bins. Paragraph 3.9 of ASTM D995 is deleted. Instead, the following applies. Use of surge bins or storage bins for temporary storage of hot bituminous mixtures will be permitted as follows:

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(a) The bituminous mixture may be stored in surge bins for period of time not to exceed 3 hours,

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(b) The bituminous mixture may be stored in insulated storage bins for a period of time not to exceed 24 hours, provided an inert gas atmosphere is maintained in the bin during the storage period.

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The bins shall be such that mix drawn from them meets the same requirements as mix loaded directly into trucks.

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If the Engineer determines that there is an excessive amount of heat loss, segregation or oxidation of the mixture due to temporary storage, no overnight storage will be allowed.

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4.3 HAULING EQUIPMENT. Trucks used for hauling bituminous mixtures shall have tight, clean, and smooth metal beds. To prevent the mixture from adhering to them, the truck beds shall be lightly coated with a minimum amount of paraffin oil, lime solution, or other approved material. Each truck shall have a suitable cover to protect the mixture from adverse weather. When necessary, to ensure that the mixture will be delivered to the site at the specified temperature, truck beds shall be insulated and covers shall be securely fastened.

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4.4 BITUMINOUS PAVERS. Bituminous pavers shall be self-contained, power-propelled units with an activated screed or strike-off assembly, heated if necessary, and shall be capable of spreading and finishing courses of bituminous plant mix material which will meet the specified thickness, smoothness, and grade. Pavers used for shoulders and similar construction shall be capable of spreading and finishing courses of bituminous plant mix material in widths shown on the plans.

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The paver shall have a receiving hopper of sufficient capacity to permit a uniform spreading operation. The hopper shall be equipped with a distribution system to place the mixture uniformly in front of the screed. The screed or strike-off assembly shall effectively produce a finished surface of the required evenness and texture without tearing, shoving, or gouging the mixture.

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The paver shall be capable of operating at forward speeds consistent with satisfactory laying of the mixture.

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If an automatic grade control device is used, the paver shall be equipped with a control system capable of automatically maintaining the specified screed elevation. The control system shall be automatically actuated from either a reference line or surface through a system of mechanical sensors or sensor-directed mechanisms or devices which will maintain the paver screed at a predetermined transverse slope and at the proper elevation to obtain the required surface. The transverse slope controller

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shall be capable of maintaining the screed at the desired slope within plus or minus 0.1 percent.

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The controls shall be capable of working in conjunction with any of the following attachments:

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(a) Ski-type device of not less than 30 feet (9.14 m) in length or as directed by the Engineer.

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(b) Taut stringline (wire) set to grade.

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(c) Short ski or shoe.

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For pavements serving aircraft over 60,000 pounds (27 000 kg) gross weight, it is recommended that the specifications require the use of automatic grade controls.

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4.5 ROLLERS. Rollers of the vibratory, steel wheel, or pneumatic-tired type may be used. They shall be in good condition, capable of operating at slow speeds to avoid displacement of the bituminous mixture. The number, type, and weight of rollers shall be sufficient to compact the mixture to the required density while it is still in a workable condition. The use of equipment which causes excessive crushing of the aggregate will not be permitted.

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4.6 PREPARATION OF BITUMINOUS MATERIAL. The bituminous material shall be heated in a manner that will avoid local overheating and provide a continuous supply of the bituminous material to the mixer at a uniform temperature. The temperature of the bituminous material delivered to the mixer shall be sufficient to provide a suitable viscosity for adequate coating of the aggregate particles but shall not exceed 325 degrees F (160 degrees C).

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4.7 PREPARATION OF MINERAL AGGREGATE. The aggregate for the mixture shall be dried and heated to the temperature designated by the job formula within the job tolerance specified. The maximum temperature and rate of heating shall be such that no permanent damage occurs to the aggregates. Particular care shall be taken that aggregates high in calcium or magnesium content are not damaged by overheating. The temperature shall not be lower than is required to obtain complete coating and uniform distribution on the aggregate particles and to provide a mixture of satisfactory workability.

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4.8 PREPARATION OF BITUMINOUS MIXTURE. The aggregates and the bituminous material shall be weighed or metered and introduced into the mixer in the amount specified by the job mix formula. 831
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The combined materials shall be mixed until the aggregate obtains a uniform coating of bitumen and is thoroughly distributed throughout the mixture. Wet mixing time shall be the shortest time that will produce a satisfactory mixture. It shall be established by the Contractor, based on the procedure for determining the percentage of coated particles described in ASTM D2489, and approved by the Engineer for each individual plant and for each type of aggregate used. The minimum mixing time shall be 25 seconds. The mixing time will be set to achieve 95 percent of coated particles. For continuous mix plants, the minimum mixing time shall be determined by dividing the weight of its contents at operating level by the weight of the mixture delivered per second by the mixer. The moisture content of the mix shall not exceed 1.0 percent. 834
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For batch plants, wet mixing time begins with the introduction of bituminous material into the mixer and ends with the opening of the mixer discharge gate. Distribution of aggregate and bituminous material as they enter the pugmill, speed of mixer shafts, and arrangement and pitch of paddles are factors governing efficiency of mixing. Prolonged exposure to air and heat in the pugmill harden the asphalt film on the aggregate. Mixing time, therefore, should be the shortest time required to obtain uniform distribution of aggregate sizes and thorough coating of aggregate particles with bituminous material. 852
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4.9 TRANSPORTING, SPREADING, AND FINISHING. The mixture shall be transported from the mixing plant to the point of use in vehicles conforming to the requirements of Section 401-4.3. Deliveries shall be scheduled so that spreading and rolling of all mixture prepared for one day's run can be completed during daylight, unless adequate artificial lighting is provided. Hauling over freshly placed material shall not be permitted until the material has been compacted, as specified, and allowed to cool to atmospheric temperature. 871
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Immediately before placing the bituminous mixture, the underlying course shall be cleared of all debris with power blowers, power brooms, or hand brooms as directed. 882
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The mix shall be placed at a temperature of not less than 250 degrees F (107 degrees C) when asphalt cement is used, and not less than 150 degrees F (65 degrees C) when tar is used. 887
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Upon arrival, the mixture shall be spread to the full width by an approved bituminous paver. It shall be struck off in a uniform layer of such depth that, when the work is completed, it shall have the required thickness and conform to the grade and contour indicated. The speed of the paver shall be regulated to eliminate pulling and tearing of the bituminous mat. Unless otherwise directed, placement of the mixture shall begin along the centerline of a crowned section or on the high side of areas with a one-way slope. The mixture shall be placed in consecutive adjacent strips having a minimum width of [**_____] except where edge lanes require less width to complete the area. The longitudinal joint in one layer shall offset that in the layer immediately below by at least 1 foot (30cm); however, the joint in the top layer shall be at the centerline of the pavement. Transverse joints in one layer shall be offset by at least 2 feet (60cm) from transverse joints in the previous layer. Transverse joints in adjacent lanes shall be offset a minimum of 10 feet (3m).

On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impractical, the mixture may be spread, raked, and luted by hand tools.

 The Engineer should specify the widest paving lane practicable in an effort to hold the number of longitudinal joints to a minimum.

4.10 COMPACTION OF MIXTURE. After spreading, the mixture shall be thoroughly and uniformly compacted by rolling. The surface shall be rolled when the mixture has attained sufficient stability so that the rolling does not cause undue displacement, cracking or shoving. The sequence of rolling operations and the type of rollers used shall be at the discretion of the Contractor.

The speed of the roller shall, at all times, be sufficiently slow to avoid displacement of the hot mixture. Any displacement occurring as a result of reversing the direction of the roller, or from any other cause, shall be corrected at once.

Sufficient rollers shall be furnished to handle the output of the plant. Rolling shall continue until all roller marks are eliminated, the surface is of uniform texture and true to grade and cross section, and the required field density is obtained.

To prevent adhesion of the mixture to the roller, the wheels shall be kept properly moistened, but excessive water will not be permitted.

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In areas not accessible to the roller, the mixture shall be thoroughly compacted with hot hand tampers. 960
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Any mixture that becomes loose and broken, mixed with dirt, or in any way defective shall be removed and replaced with fresh hot mixture and immediately compacted to conform to the surrounding area. This work shall be done at the Contractor's expense. Skin patching shall not be allowed. 964
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4.11 JOINTS. The formation of all joints shall be made in such a manner as to ensure a continuous bond between old and new sections of the course. All joints shall have the same texture, density, and smoothness as other sections of the course. 970
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The roller shall not pass over the unprotected end of the freshly laid mixture except when necessary to form a transverse joint. When necessary to form a transverse joint, it shall be made by means of placing a bulkhead or by tapering the course, in which case the edge shall be cut back to its full depth and width on a straight line to expose a vertical face. In both methods all contact surfaces shall be given a tack coat of bituminous material before placing any fresh mixture against the joint. 976
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Longitudinal joints which are irregular, damaged, or otherwise defective shall be cut back to expose a clean, sound surface for the full depth of the course. All contact surfaces shall be given a tack coat of bituminous material prior to placing any fresh mixture against the joint. 987
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4.12 ACCEPTANCE SAMPLING AND TESTING OF BITUMINOUS MIXTURE (DENSITY). Pavement density will be determined by comparing the density of cores taken from the compacted pavement to the density of laboratory-compacted specimens. 992
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(a) Lot Sizes. The pavement will be accepted for density on a lot basis. A lot will consist of: 997
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(1) one day's production where it is not expected to exceed 2,000 tons (1 814 000 kg) 1000
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(2) a half day's production where a days production is expected to consist of between 2,000 and 4,000 tons (1 814 000 and 3 628 000 kg) 1002
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(3) similar subdivisions for quantities greater than 4,000 tons 1005
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(b) Laboratory Density. Bituminous mixture for laboratory-compacted specimens shall be sampled on a lot basis from trucks delivering material to the job site. The lot size shall be the 1008
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same as indicated in paragraph 4.12(a) and shall be divided into four equal sublots. One sample shall be taken from each subplot on a random basis, in accordance with procedures contained in ASTM D3665. One laboratory compacted specimen shall be prepared from each subplot.

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The specimens shall be compacted in accordance with ASTM D1559, Section 3.5, except that the temperature immediately prior to compaction shall be 250 degrees F \pm 5 degrees (120 degrees C \pm 3 degrees). The sample of bituminous mixture can be placed in an oven for not more than 30 minutes to maintain the heat, but it shall not be reheated if it cools below 250 degrees F (120 degrees C) before use. The density of each specimen shall be determined in accordance with ASTM D2726 or D1188, whichever is applicable.

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(c) Core Density. Cores for determining the density of the compacted pavement shall be taken on a lot basis. The lot size shall be the same as indicated in paragraph 4.12(a) and shall be divided into four equal sublots. One core shall be taken from each subplot on a random basis in accordance with procedures contained in Appendix C of The Asphalt Institute's Specification Series No. 1, latest edition. The cores shall be taken in accordance with the requirements of paragraph 4.14. The density of each core shall be determined in accordance with ASTM D 2726 or D 1188, whichever is applicable.

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(d) Pavement Density. The target density (percent compaction) of each lot of in-place pavement shall be 98 percent of the average density of the laboratory-prepared specimens. The pavement density shall be determined by dividing the core density of each subplot by the average density of the laboratory-prepared specimens.

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(e) Acceptance Criteria. Acceptance of each lot of bituminous [surface] [base] course shall be based on the percentage of material within specification limits (PWL). The PWL is determined using standard statistical techniques and involves the number of tests in each lot (n) and the Quality Index (Q). The Quality Index is calculated from the following formula:

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$$Q = \frac{X-L}{R} \quad \begin{array}{l} 1051 \\ 1052 \end{array}$$

where: Q = Quality Index	1054
X = average of pavement densities	1055
(percent compaction)	1056
L = lower specification limit	1057
(96.7 percent)	1058
R = range - difference between the	1059
highest and lowest pavement densities	1060
(percent compaction)	1061

The PWL shall be determined from Table 6, using the number of tests (n) and the Quality Index (Q). | 1065
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Each lot of bituminous mix shall be accepted for density when the PWL equals or exceeds 90 percent. Each lot not meeting the 90 percent PWL requirement will be accepted at an adjusted contract unit price in accordance with Table 7. | 1067
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ITEM P-401 PLANT MIX BITUMINOUS PAVEMENTS

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TABLE 6. TABLE FOR ESTIMATING PERCENT OF LOT WITHIN TOLERANCE LIMITS

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Percent Within Limits	Positive Values of Q				
	n=3	n=4	n=5	n=6	
99	.5895	.6574	.6642	.6611	1075
98	.5879	.6440	.6387	.6264	1077
97	.5863	.6307	.6166	.5983	1078
96	.5847	.6173	.5966	.5744	1079
95	.5830	.6039	.5777	.5530	1080
94	.5814	.5905	.5600	.5330	1082
93	.5797	.5771	.5431	.5143	1083
92	.5762	.5638	.5267	.4968	1084
91	.5219	.5504	.5108	.4800	1085
90	.5677	.5370	.4955	.4640	1086
89	.5621	.5236	.4808	.4485	1088
88	.5564	.5101	.4657	.4337	1089
87	.5499	.4967	.4514	.4191	1090
86	.5432	.4833	.4373	.4050	1091
85	.5355	.4699	.4234	.3913	1092
84	.5275	.4565	.4097	.3778	1094
83	.5189	.4431	.3962	.3647	1095
82	.5098	.4297	.3829	.3517	1096
81	.5001	.4162	.3697	.3391	1097
80	.4889	.4028	.3567	.3266	1098
79	.4791	.3894	.3438	.3144	1100
78	.4679	.3760	.3311	.3023	1101
77	.4560	.3526	.3184	.2902	1102
76	.4439	.3492	.3059	.2785	1103
75	.4311	.3358	.2935	.2669	1104
74	.4179	.3223	.2811	.2554	1106
73	.4041	.3088	.2689	.2440	1107
72	.3901	.2954	.2567	.2327	1108
71	.3754	.2820	.2446	.2215	1109
70	.3604	.2685	.2325	.2104	1110

ITEM P-401 PLANT MIX BITUMINOUS PAVEMENTS

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Percent Within Limits	Positive Values of Q				
	n=3	n=4	n=5	n=6	
69	.3450	.2551	.2206	.1995	1125
68	.3293	.2417	.2086	.1884	1126
67	.3131	.2283	.1968	.1777	1127
66	.2965	.2149	.1835	.1668	1128
65	.2798	.2015	.1732	.1562	1129
64	.2625	.1881	.1614	.1455	1131
63	.2451	.1747	.1497	.1349	1132
62	.2274	.1611	.1382	.1243	1133
61	.2093	.1477	.1265	.1139	1134
60	.1911	.1343	.1149	.1034	1135
55	.0970	.0672	.0573	.0515	1137
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All negative values of Q will result in a PWL below 65 percent. 1142

TABLE 7 PRICE ADJUSTMENT SCHEDULE

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Percentage of Material Above the Specification Limit (PWL)	Percent of Contract Unit Price to be Paid	
90-100	100	1151
80-90	0.5 PWL + 55.0	1152
65-80	2.0 PWL - 65.0	1153
Below 65	1/	1154

1/ The lot shall be removed and replaced. However, the Engineer may decide to accept the deficient lot. In that case, if the Engineer and Contractor agree in writing, that lot shall not be removed, and it will be paid for at 50 percent of the contract price. 1161
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A lot is the quantity of material to be controlled and may 1170
represent a specified tonnage or a specified number of 1171
truckloads. The lot size, to be determined by the Engineer, 1173
should, for the most part, depend on the operational 1175
capacity of the plan, but shall in no case exceed 2,000 tons 1176
(1 814 360 kg). The Engineer will specify the lot size in 1177
the specifications. 1177
***** 1178.2

4.13 SURFACE TESTS. Tests for conformity with the specified 1184
crown and grade shall be made by the Contractor immediately after 1185
initial compaction. Any variation shall be corrected by the 1186
removal or addition of materials and by continuous rolling. 1187

The finished surface shall not vary more than [** _____] for the 1191
surface course when tested with a 16-foot (4.8m) straightedge 1192
applied parallel with, or at right angles to, the centerline. 1195
***** 1199.1
Specify 1/4 inch (6.35 mm) for surface course and 3/8 inch 1200
(9.51 mm) for base course. 1201
***** 1202.2

After the completion of final rolling, the smoothness of the 1208
course shall be tested by the Engineer; humps or depressions 1209
exceeding the specified tolerances shall be immediately corrected 1210
by removing the defective work and replacing with new material, 1211
as directed by the Engineer. This shall be done at the 1213
Contractor's expense. 1213

The finished surfaces of bituminous courses shall not vary from 1215
the gradeline, elevations, and cross sections shown on the 1218
contract drawings by more than 1/2 inch (12.70 mm). The 1220
Contractor shall correct pavement areas varying in excess of this 1220
amount by paving and replacing the defective work. Skin patching 1222
will not be permitted. 1222

4.14 SAMPLING PAVEMENT. Core samples for determination of the 1225
density of completed pavements shall be obtained by the 1226
Contractor at no extra cost. The size, number, and locations of 1229
the samples will be as directed by the Engineer. Samples shall 1230
be neatly cut with a saw, core drill, or other approved 1232
equipment. The Contractor shall furnish all tools, labor, and 1235
materials for cutting samples and replacing pavement. 1235

All tests necessary to determine conformance with requirements 1237
specified in this item will be performed by the Engineer without 1238
cost to the Contractor. 1238

ITEM P-401 PLANT MIX BITUMINOUS PAVEMENTS

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5. METHOD OF MEASUREMENT

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5.1 Plant mix bituminous concrete pavement shall be measured by the number of tons (kg) of bituminous mixture used in the accepted work. Recorded batch weights or truck scale weights will be used to determine the basis for the tonnage.

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6. BASIS OF PAYMENT

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6.1 Payment for an accepted bituminous concrete pavement shall be made at the full or adjusted contract unit price per ton (kg). The price shall be full compensation for furnishing all materials, for all preparation, mixing, and placing of these materials, and for all labor, equipment, tools, and incidentals necessary to complete the item.

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(a) Basis of Adjusted Payment. Table 7 shall be used to determine the adjusted contract price for a lot of material when the results of the pavement density tests for that lot indicate that the percentage of material above the specification limit is less than 90 percent.

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(b) Payment. Payment will be made under:

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Item P-401-6.1 Bituminous [Surface] [Base] Course -
per ton (kg).

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7. TESTING REQUIREMENTS

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ASTM C29 Unit Weight of Aggregate

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ASTM C88 Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate

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ASTM C131 Resistance to Abrasion of Small Size Coarse Aggregate by Use of the Los Angeles Machine

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ASTM C136 Sieve or Screen Analysis of Fine and Coarse Aggregates

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ASTM C183 Sampling Hydraulic Cement

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ASTM D75 Sampling Aggregates

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ASTM D423 Liquid Limit of Soils

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<u>ASTM D424</u>	<u>P</u> lastic Limit and Plasticity Index of Soils	1298
<u>ASTM D995</u>	<u>R</u> equirements for Mixing Plants for Hot-Mixed, <u>H</u> ot-Laid Bituminous Paving Mixtures	1301 1302
<u>ASTM D1075</u>	<u>E</u> ffect of Water on Cohesion of Compacted Bituminous Mixtures	1305 1305
<u>ASTM D1188</u>	<u>B</u> ulk Specific Gravity of Compacted Bituminous Mixtures Using <u>P</u> araffin-Coated Specimens	1308 1309
<u>ASTM D1559</u>	<u>R</u> esistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus	1312 1312
<u>ASTM D2172</u>	<u>Q</u> uantitative Extraction of Bitumen from Bituminous Paving Mixtures	1315 1315
<u>ASTM D2489</u>	<u>D</u> egree of Particle Coating of Bituminous- Aggregate Mixtures	1318 1318
<u>ASTM D2726</u>	<u>B</u> ulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated <u>S</u> urface-Dry Specimens	1321 1322 1322
<u>ASTM D3665</u>	<u>R</u> andom Sampling of Paving Materials	1325
<u>ASTM D3666</u>	<u>I</u> nspection and Testing Agencies for Bituminous Paving Materials	1328 1328
<u>AASHTO T30</u>	<u>M</u> echanical Analysis of Extracted Aggregate	1331
<u>The Asphalt Institute's Series (SS-1)</u>	<u>M</u> odel Construction Specifications for Asphalt Concrete and Other Plant-Type Mixes	1334 1337 1339
<u>The Asphalt Institute's Manual No. 2 (MS-2)</u>	<u>M</u> ix Design Methods for Asphalt Concrete	1342 1344 1346 1348
<u>8. MATERIAL REQUIREMENTS</u>		1350
<u>ASTM D242</u>	<u>M</u> ineral Filler for Bituminous Paving Mixtures	1353
<u>ASTM D490</u>	<u>T</u> ar	1356
<u>ASTM D946</u>	<u>A</u> sphalt Cement for Use in Pavement Construction	1359 1359

ITEM P-401 PLANT MIX BITUMINOUS PAVEMENTS

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ASTM D3381Viscosity-Graded Asphalt Cement for Use in
Pavement Construction

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AASHTO M226Viscosity Graded Asphalt Cement

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+ + END OF ITEM P-401 + +

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