

In areas where mechanical spreading and finishing is impractical, place and finish the asphalt concrete mix with alternate equipment to produce a uniform surface closely matching the surface obtained when using a mechanical paver.

Offset the longitudinal joint of one layer at least 6 inches (150 millimeters) from the joint in the layer immediately below. Make the longitudinal joint in the top layer along the striped centerline of two-lane roadways or at the lane lines of roadways with more than two lanes.

401.14 Compacting. Furnish at least three rollers, with at least one being a pneumatic-tire roller. Furnish one roller each for breakdown, intermediate, and finish rolling. Size the rollers to achieve the required results. Operate rollers according to the recommendation of the manufacturer. Do not use diesel fuel as a release agent with rollers used to compact asphalt concrete mix.

Monitor the compaction process with nuclear density gauges calibrated to the control strip core density test results and compact according to Subsection 401.17(c).

Take nuclear gauge density readings and cut and test core samples according to Table 401-8.

Compact the asphalt concrete mix with alternate equipment to obtain the required compaction along forms, curbs, headers, walls, and other places inaccessible to rollers.

401.15 Joints, Trimming Edges, and Cleanup. Complete pavement construction of adjacent traffic lanes to the same elevation within 24 hours. If elevation differences exceeding 3 inches (75 millimeters) between adjacent lanes are left overnight, sign with "*Uneven Lanes*" warning signs and provide a 1V:3H fillet.

Make transverse joints vertical to the depth of the new pavement at connections to existing pavements and previously placed lifts. Form transverse joints by cutting back the previous run to expose the full-depth course.

Apply an asphalt tack coat to the edge of both transverse and longitudinal joints according to Section 412.

Place the asphalt concrete mix as continuously as possible. Do not pass rollers over an unprotected edge of freshly laid asphalt concrete mix.

Dispose of material trimmed from the edges and other discarded asphalt concrete mix according to Subsection 211.02(a)(2).

401.16 Pavement Roughness. Measure the profile of the pavement surface according to the designated pavement roughness type. In addition, construct pavement surfaces to meet the requirements of Subsection 401.16(e).

(a) Profile measurement. The CO will use profile measurements to determine the Mean Roughness Index (MRI) values for the traveled way using the current version of Profile Viewer and Analysis (ProVAL) software. The CO will also determine areas of localized roughness. The MRI and areas of localized roughness will be used to determine payment for the designated pavement roughness type and pavement areas requiring surface corrections.

Conform to the following:

(1) Equipment. Provide an ASTM E950, Class 1 inertial profiling system conforming to AASHTO M 328 and certified according to AASHTO R 56. Provide copies of the system certifications at least 21 days before profiling begins. Display a current decal on the equipment indicating the expiration date of the certifications.

The CO may perform verification testing, equipment validation, or both as follows:

(a) Verification testing. Verification testing will consist of the CO profiling a section of pavement and comparing the results against the Contractor's results for the same section of pavement. Comparison runs will be made within 21 days of each other. The Contractor's results will be considered verified if the CO's International Ride Index (IRI) for each wheel path differs from the Contractor's IRI for the same wheel path by no more than 10 percent of their mean. Do not use equipment that fails verification.

(b) Equipment validation. Equipment validation will consist of determining a cross correlation value on at least one section of pavement having a minimum length of 528 feet (161 meters). The Contractor's profiler and the CO's profiler will be cross correlated on the same day. Coordinate and schedule the equipment validation date at least 14 days before the validation date. The CO will determine the location of the cross correlation segments. The Contractor's equipment will be considered validated if the cross correlation value is greater than or equal to 0.90. Do not use equipment that fails validation.

(2) Personnel. Provide the following:

(a) A profile system operator certified according to AASHTO R 56. Submit copies of the operator's certifications at least 21 days before profiling begins.

(b) Flaggers, pilot car operations, or other temporary traffic control according to Section 635 as required.

(3) Measuring. The CO will identify the beginning and ending points of the profile measurements. Measure the pavement profile in both wheel paths using a sensor path spacing of 65 - 71 inches (1650 - 1800 millimeters) and centered in the traveled way of the lane. Operate the inertial profiler according to AASHTO R 57 and the manufacturer's recommendations. Do not apply filters when collecting profile data. Filtering will be applied during profile analysis in ProVAL. Collect profile data (elevation and distance) at a maximum interval of 2 inches (50 millimeters). Provide a lead-in distance of at least 150 feet (45 meters) after reaching the testing speed. Use the profiler's automatic start/stop activation when collecting data.

The CO will identify excluded areas. Cattle guards, bridges not being overlaid, and turning lanes, passing lanes, side roads, and ramps less than 1,000 feet (300 meters) in length will be excluded from profile measurement, the calculation of MRI, and the determination of localized roughness. Use event markers to mark the beginning and ending location of areas to be excluded from profile measurement. Measure excluded areas with a straightedge according to Subsection 401.16(e).

Coordinate profiling operations with the CO. Export each profile (elevation, distance data, header, and marker information) in pavement profile format (ppf) to a CD or DVD and submit after profiling. Do not submit non-continuous data files.

Use the following naming convention for electronic file submissions:

(a) For Type I and Type II pavement roughness:

[Project Name (or abbreviation)] _ [beginning station_to_ending station] _ [Initial or Final],

Beaver_Cr_Rd_25+50_to_387+35_Initial.ppf.

(b) For Type III pavement roughness:

[Project Name (or abbreviation)] _ [beginning station_to_ending station],

Beaver_Cr_Rd_25+50_to_387+35.ppf.

(4) Evaluation. The CO will review and analyze profile measurements. The MRI will be calculated from profile measurements using ProVAL.

Using ProVAL, a high pass filter length of 300 feet (90 meters) and a low pass filter of 10 inches (250 millimeters) will be applied to the profiles. Individual MRI values are determined by averaging the IRI value from each wheel path. Fixed interval MRI values are reported as an average of the individual MRI values over the fixed interval length. An overall MRI value will be determined by averaging the individual MRI values, excluding segments less than 25 feet (7.62 meters) for Type I and Type II pavement roughness or 528 feet (161 meters) for Type III pavement roughness.

Areas of localized roughness will be identified by using ProVAL's continuous MRI function with a segment length of 25 feet (7.62 meters). This will yield an average MRI value and a length for each area of localized roughness which exceeds the localized roughness threshold value of every possible 25-foot (7.62-meter) segment. Areas for which the continuous report exceeds the threshold MRI value for the specified roughness type will be considered a defective area requiring correction. When corrections are not allowed, a reduction in payment will be applied according to Subsection 401.16(f). No deduction will be made for areas of localized roughness identified within 12.5 feet (3.81 meters) of the beginning or end of a profile section or within 12.5 feet (3.81 meters) of excluded areas. Measure these areas with a straightedge according to Subsection 401.16(e).

Correct areas of localized roughness according to Subsection 401.16(g).

(b) Type I pavement roughness. Measure the profile of the initial pavement surface before construction activities disturb the existing pavement surface. The initial pavement surface is defined as the existing pavement surface before construction activities begin. The localized roughness threshold computed to the nearest whole number for Type I pavement roughness is equal to the following:

$$\text{Localized Roughness Threshold} = \text{Initial Overall MRI} + 1.881(S_{25})$$

where:

Initial Overall MRI = MRI obtained before construction activities begin.

S_{25} = sample standard deviation of the 25 foot (7.62 meters) fixed interval MRI values.

Do not proceed with work that will disturb the initial pavement surface until the CO's analysis is complete.

Measure the profile of the final pavement surface before placing a surface treatment and within 21 days of completing roadway paving. The original overall surface MRI will be used in conjunction with the final overall MRI to determine an overall percent improvement for the entire traveled way.

The overall percent improvement in MRI will be determined to one decimal place for the traveled way according to the following formula:

$$\% \text{ Improvement} = [(\text{Initial Overall MRI} - \text{Final Overall MRI}) / \text{Initial Overall MRI}] \times 100$$

Table 401-3 will be used to determine the final pay factor (PF_{rough}) for the traveled way to two decimal places. When the percent improvement is less than 25.0 percent and the final overall MRI value is less than or equal to 70.0 inches per mile (1.105 meters per kilometer), Type III-A from Table 401-5 will be used to determine the final PF_{rough} .

Correct areas of localized roughness according to Subsection 401.16(g). If a pavement has an overall negative percent improvement, place a minimum 1-inch (25-millimeter) overlay over the entire paved surface.

Table 401-3
Type I Pavement Roughness Pay Factors

Type I-A	Type I-B	Pay Factor
Percent Improvement (%)	Percent Improvement (%)	(PF_{rough})
Greater than 50.0	Greater than 45.0	PF = 1.05
47.6 – 50.0	44.0 – 45.0	PF = 1.04
45.1 – 47.5	43.0 – 43.9	PF = 1.03
43.6 – 45.0	41.6 – 42.9	PF = 1.02
42.1 – 43.5	40.1 – 41.5	PF = 1.01
25.0 – 42.0	20.0 – 40.0	PF = 1.00
24.0 – 24.9	19.0 – 19.9	PF = 0.99
23.0 – 23.9	18.0 – 18.9	PF = 0.98
22.0 – 22.9	17.0 – 17.9	PF = 0.97
21.0 – 21.9	16.0 – 16.9	PF = 0.96
20.0 – 20.9	15.0 – 15.9	PF = 0.95
19.0 – 19.9	14.0 – 14.9	PF = 0.94
18.0 – 18.9	13.0 – 13.9	PF = 0.93
17.0 – 17.9	12.0 – 12.9	PF = 0.92
16.0 – 16.9	11.0 – 11.9	PF = 0.91
15.0 – 15.9	10.0 – 10.9	PF = 0.90
14.0 – 14.9	9.0 – 9.9	PF = 0.89
13.0 – 13.9	8.0 – 8.9	PF = 0.88
12.0 – 12.9	7.0 – 7.9	PF = 0.87
11.0 – 11.9	6.0 – 6.9	PF = 0.86
10.0 – 10.9	5.0 – 5.9	PF = 0.85
5.0 – 9.9	4.0 – 4.9	PF = 0.80
0.0 – 4.9	0.0 – 3.9	PF = 0.70
Negative % Improvement	Negative % Improvement	Correct & overlay

(c) Type II pavement roughness. Measure the profile of the initial pavement surface before construction activities disturb the pavement surface. The initial pavement surface is defined as the original existing pavement surface before construction activities begin. The localized roughness threshold computed to the nearest whole number for Type II pavement roughness is equal to the following:

$$\text{Localized Roughness Threshold} = \text{Initial Overall MRI} + 1.282(S_{25})$$

where:

Initial Overall MRI = MRI obtained before construction activities begin.

(S_{25}) = sample standard deviation of the 25-foot (7.62-meter) fixed interval MRI values.

Do not proceed with work that will disturb the initial pavement surface until the CO's analysis is complete.

Measure the profile of the final pavement surface before placing a surface treatment and within 21 days of completing roadway paving. The original overall surface MRI will be used in conjunction with the final overall MRI to determine an overall percent improvement for the entire traveled way.

The overall percent improvement in MRI will be determined to one decimal place for the traveled way according to the following formula:

$$\% \text{ Improvement} = [(\text{Initial Overall MRI} - \text{Final Overall MRI}) / \text{Initial Overall MRI}] \times 100$$

Table 401-4 will be used to determine the final PF_{rough} for the traveled way to two decimal places. When the percent improvement is less than 49.0 percent and the final overall MRI value is less than or equal to 70.0 inches per mile (1.105 meters per kilometer), Type III-A from Table 401-5 will be used to determine the final PF_{rough} .

Correct areas of localized roughness according to Subsection 401.16(g). If a pavement has less than a 10.0 percent improvement, place a minimum 1-inch (25-millimeter) overlay over the entire paved surface.

Table 401-4
Type II Pavement Roughness Pay Factors

Type II-A	Type II-B	
Percent Improvement (%)	Percent Improvement (%)	Pay Factor (PF_{rough})
Greater than 60.0	Greater than 50.0	PF = 1.05
58.6 – 60.0	49.0 – 50.0	PF = 1.04
57.6 – 58.5	48.0 – 48.9	PF = 1.03
56.6 – 57.5	47.0 – 47.9	PF = 1.02
55.1 – 56.5	45.0 – 46.9	PF = 1.01
49.0 – 55.0	35.0 – 44.9	PF = 1.00
48.0 – 48.9	34.0 – 34.9	PF = 0.99
47.0 – 47.9	33.0 – 33.9	PF = 0.98
46.0 – 46.9	32.0 – 32.9	PF = 0.97
45.0 – 45.9	31.0 – 31.9	PF = 0.96
44.0 – 44.9	30.0 – 30.9	PF = 0.95
43.0 – 43.9	29.0 – 29.9	PF = 0.94
42.0 – 42.9	28.0 – 28.9	PF = 0.93
41.0 – 41.9	27.0 – 27.9	PF = 0.92
40.0 – 40.9	26.0 – 26.9	PF = 0.91
38.0 – 39.9	25.0 – 25.9	PF = 0.90
36.0 – 37.9	24.0 – 24.9	PF = 0.89
35.0 – 35.9	23.0 – 23.9	PF = 0.88
34.0 – 34.9	22.0 – 22.9	PF = 0.87
33.0 – 33.9	21.0 – 21.9	PF = 0.86
31.0 – 32.9	20.0 – 20.9	PF = 0.85
25.0 – 30.9	16.0 – 19.9	PF = 0.80
10.0 – 24.9	7.5 – 15.9	PF = 0.70
Less than 10.0	Less than 7.5	Correct & overlay

(d) Type III pavement roughness. Measure the profile of the final pavement surface before placing a surface treatment and within 21 days of completing roadway paving. Pay factors from Table 401-5 will be used in conjunction with the long continuous histogram printout from ProVAL's Smoothness Assurance Analysis function and by utilizing a long continuous 528-foot (161-meter) segment length for analysis. The final PF_{rough} is equal to the sum of the products of the individual pay factors indicated in Table 401-5 multiplied by the ratio of individual lane miles (lane kilometers) to the overall project lane miles (lane kilometers) and by ProVAL's corresponding histogram percentages, divided by 100. The final PF_{rough} will be determined to three decimal places.

If the final overall MRI for the entire traveled way is greater than the values shown in Table 401-5, correct the traveled way according to Subsection 401.16(g).

**Table 401-5
Type III Pavement Roughness Pay Factors**

Mean Roughness Index (MRI) Type III-A in/mi (m/km)	Mean Roughness Index (MRI) Type III-B in/mi (m/km)	Pay Factor (PF_{rough})
Localized roughness threshold 140 in/mi (2.210 m/km)	Localized roughness threshold 140 in/mi (2.210 m/km)	
If MRI of entire roadway is greater than 125 in/mi (1.973 m/km)	If MRI of entire roadway is greater than 135 in/mi (2.131 m/km)	REJECT
Greater than 95.0 (1.50)	Greater than 110.0 (1.74)	0.700
95.0 – 90.0 (1.50 – 1.42)	110.0 – 105.0 (1.74 – 1.66)	0.800
90.0 – 85.0 (1.42 – 1.34)	105.0 – 100.0 (1.66 – 1.58)	0.850
85.0 – 80.0 (1.34 – 1.26)	100.0 – 95.0 (1.58 – 1.50)	0.900
80.0 – 75.0 (1.26 – 1.18)	95.0 – 90.0 (1.50 – 1.42)	0.960
75.0 – 70.0 (1.18 – 1.10)	90.0 – 85.0 (1.42 – 1.34)	0.980
70.0 – 65.0 (1.10 – 1.02)	85.0 – 80.0 (1.34 – 1.26)	1.000
65.0 – 60.0 (1.02 – 0.94)	80.0 – 75.0 (1.26 – 1.18)	1.010
60.0 – 55.0 (0.94 – 0.86)	75.0 – 70.0 (1.18 – 1.10)	1.020
55.0 – 50.0 (0.86 – 0.78)	70.0 – 65.0 (1.10 – 1.02)	1.025
50.0 – 45.0 (0.78 – 0.70)	65.0 – 60.0 (1.02 – 0.94)	1.030
45.0 – 40.0 (0.70 – 0.62)	60.0 – 55.0 (0.94 – 0.86)	1.035
40.0 – 35.0 (0.62 – 0.54)	55.0 – 50.0 (0.86 – 0.78)	1.040
35.0 – 30.0 (0.54 – 0.46)	50.0 – 45.0 (0.78 – 0.70)	1.045
Less than 30.0 (0.46)	Less than 45.0 (0.70)	1.050

(e) Type IV straightedge measurement. Use a 10 foot (3.0 meters) metal straightedge to measure at right angles and parallel to the centerline. Defective areas are deviations between the surface and the bottom of the straightedge in excess of ¼ inches (6 millimeters) measured between two contacts of the straightedge or deviations in excess of ¼ inches (6 millimeters) measured at the end of the straightedge. Correct defective areas according to Subsection 401.16(g).

(f) Localized roughness and straightedge measurement pay reduction. Each area of localized roughness exceeding the threshold MRI specified for the designated pavement roughness type will receive a reduction in payment according to Table 401-6.

Each defective area as determined by a 10-foot (3.0-meter) metal straightedge will receive a reduction in payment according to Table 401-6.

**Table 401-6
Localized Roughness and Straightedge Measurement Pay Reductions**

Type I	Type II & IV	Localized Roughness Limit MRI	Type III	
Deduction per Occurrence	Deduction per Occurrence		Localized Roughness Limit MRI, in/mi (m/km)	Deduction per Occurrence
\$200	\$300	Computed MRI value per Subsection	140.0 – 169.9 (2.208 – 2.680)	\$300
		401.16(b) for Type I	170.0 – 179.9 (2.681 – 2.838)	\$450
		401.16(c) for Type II	180.0 – 189.9 (2.839 – 2.995)	\$600
		401.16(d) for Type III	190.0 – 199.9 (2.996 – 3.154)	\$750
			200.0 – 209.9 (3.155 – 3.311)	\$900
			210.0 – 219.9 (3.312 – 3.469)	\$1,200
			220.0 – 229.9 (3.470 – 3.626)	\$1,500
			230.0 – 239.9 (3.627 – 3.784)	\$2,000
		≥ 240.0 (3.785)	\$4,000	

(g) Defective area correction. Obtain approval before starting corrective work. Allow 7 days for review and approval of correction method proposal.

Correct defective areas by one of the following methods:

(1) Milling. Replace the defective area by milling at least one-half the pavement depth and repaving with the approved asphalt concrete mix. Mill the defective area according to Section 413.

(2) Saw cutting. Replace the defective area by saw cutting and removing the defective area and repaving with the approved asphalt concrete mix. Saw cut and remove the defective area according to Section 203.

(3) Grinding. Use a diamond blade machine to grind off the defective surface area. Provide the manufacturer and model of the equipment to be used. Identify the beginning and ending station of each grind location, the grinding depth, and lateral extent of grinding. Optimize the endpoints of the areas where a grinder is to be applied using ProVAL's Smoothness Assurance function in conjunction with the grinding simulation function. Submit the type of seal to be placed after grinding is completed for approval. Place seals according to Section 409 or 410. Limit the grinding depth to 12.5 percent of the design pavement thickness. If grinding in excess of this depth, provide a minimum 1-inch (25-millimeter) overlay.

(4) Other. Submit a proposal for approval for other correction methods not listed above.

After corrections are made, re-measure the pavement profile according to Subsection 401.16(a). Data from the re-measurement will be analyzed to determine the MRI or percent improvement, areas of localized roughness, and the final PF_{rough} . If correction and re-measurement of the surface is required, the maximum allowable pay factor under Subsection 401.19 is 1.00.

If corrections are not allowed, no adjustment will be made to the final PF_{rough} or localized roughness pay deductions.

401.17 Acceptance. See Table 401-8 for sampling, testing, and acceptance requirements.

Aggregate quality properties will be evaluated under Subsections 106.02 and 106.04.

Mineral filler, antistripping additives, and WMA additives will be evaluated under Subsections 106.02 and 106.03.

Asphalt content, VMA, and core density will be evaluated under Subsection 106.05. Pavement roughness will be evaluated under Subsection 106.04. Asphalt binder will be evaluated under Subsections 106.03 and 106.04. Evaluations will consider the following:

(a) Asphalt content. The upper and lower specification limits are the approved JMF target value plus or minus 0.4 percent;

(b) VMA. The lower specification limit is the value shown in Table 401-1. After the JMF has been verified according to Subsections 401.03 and 401.12, use the Contractor's combined coarse and fine bulk specific gravity of aggregate G_{sb} values to calculate VMA on field produced asphalt concrete mix samples;

(c) Density (core). The lower specification limit is 91.0 percent of the maximum specific gravity (density) determined according to AASHTO T 166 and AASHTO T 209.

The percent compaction will be determined using the average maximum specific gravity (AASHTO T 209) from all samples tested each day;

(d) Pavement roughness. The evaluation for payment will be made after defective areas are addressed. See Subsection 401.16(g); and

(e) Asphalt binder. The pay factor is determined from Table 401-7.

Construction of the HMA or WMA pavement course will be evaluated under Subsections 106.02 and 106.04.

Measurement

401.18 Measure the Section 401 pay items listed in the bid schedule according to Subsection 109.02.

Payment

401.19 The accepted quantities will be paid at the contract price per unit of measurement for the Section 401 pay items listed in the bid schedule, except the asphalt concrete pavement contract price will be adjusted according to Subsections 106.05, 401.16, and Table 401-7. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.