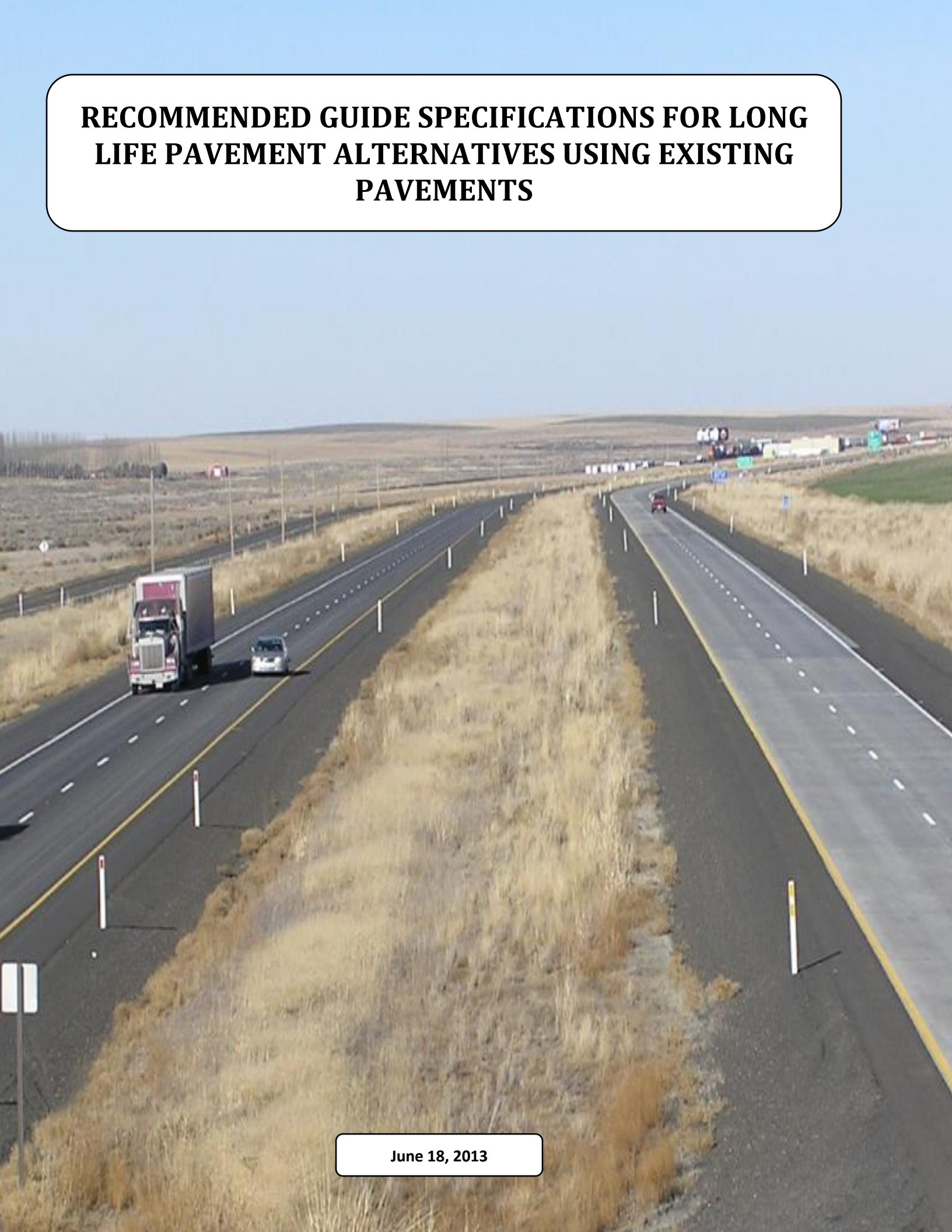
RECOMMENDED GUIDE SPECIFICATIONS FOR LONG LIFE PAVEMENT ALTERNATIVES USING EXISTING PAVEMENTS



June 18, 2013

Table of Contents

RECOMMENDED GUIDE SPECIFICATIONS FOR LONG LIFE PAVEMENT ALTERNATIVES USING EXISTING PAVEMENTS

Introduction

The guide specifications developed by the SHRP2 R23 team are presented in this document. They are organized into three sections which are: (1) guide specifications for pavement components that are not contained within the AASHTO Guide Specifications, (2) elements that can be added to or otherwise modify existing AASHTO Guide Specifications, and (3) summaries for relevant State DOT and AASHTO specifications that were used to produce the "elements" in item 2.

The study team used AASHTO Guide Specifications as a starting point, in part, due to the fact that there are a wide variety of pavement-oriented specifications developed and maintained by AASHTO committees. Further, AASHTO Guide Specifications reflect national practice, which is a necessary part of this study. The approach was to review existing State DOT and AASHTO Guide Specifications and select sensible components (or elements), and place those in lists (see "Elements for AASHTO Guide Specifications").

There were four guide specifications not contained in the AASHTO Guide Specifications that were felt necessary for this study. These are: Stone Matrix Asphalt (SMA), Open Graded Friction Course (OGFC), Rubblization of PCC, and Saw, Crack and Seat. Guide specifications were prepared and are contained in this document (see "Specifications not contained in the AASHTO Guide Specifications").

SPECIFICATIONS NOT CONTAINED IN THE AASHTO GUIDE SPECIFICATIONS

SHRP2 R23 Guide Specification
Stone Matrix Asphalt (SMA)

<table>
<tr><th>Paragraph</th><th>Content</th></tr>
<tr><td>Description</td><td>The work covered by this specification shall consist of constructing a hot mix asphalt layer of fiber stabilized stone matrix asphalt pavement on a prepared surface in accordance with these specifications and in conformity with the lines, grades, typical cross section.</td></tr>
<tr><td>Materials</td><td>
1. Coarse Aggregates
a. Coarse Aggregate: Coarse aggregate shall be aggregate retained on the No. 4 sieve. Virgin aggregate shall be 100% crushed material.
b. Coarse Aggregate Flat and Elongated Particles. The maximum amount of flat and elongated particles in coarse aggregate for SMA is shown in the table below:
<table>
<tr><th>Test Method and Description</th><th>% of Flat and Elongated Particles in Coarse Aggregate</th></tr>
<tr><td>Flat and Elongated % by Count 3:1 (max to min) ASTM D4791 Section 8.4</td><td>20%</td></tr>
<tr><td>Flat and Elongated % by Count 5:1 (max to min) ASTM D4791 Section 8.4</td><td>5%</td></tr>
</table>
c. Coarse Aggregate Soundness for SMA: The percent degradation of the source aggregate by the sodium sulfate soundness test (AASHTO T104) after five cycles of testing shall not exceed 10%.
d. Deleterious Materials and Absorption in Coarse Aggregate: The amount of deleterious substances and absorption in the coarse aggregate shall not exceed the limits in the following table:
<table>
<tr><th>Test Method and Description</th><th>Percent</th></tr>
<tr><td>Clay Lump and Friable Particles (AASHTO T112)</td><td>0.25%</td></tr>
<tr><td>Absorption (applied to the material passing the 0.75 in. sieve and retained on the No.4 sieve)(AASHTO T85)</td><td>2.0%</td></tr>
</table>
e. Los Angeles Abrasion Criteria for Coarse Aggregate: The percent loss of the coarse aggregate by the LA Abrasion test (AASHTO T96) shall not exceed 40%.
2. Fine Aggregates
a. Fine aggregate shall be 100% crushed materials and conform to the following table:
b. Fine aggregate shall have a maximum of 1.0% clay lumps and friable particles as determined by AASHTO T112. It shall consist of hard, though grains free of deleterious substances.
<table>
<tr><th>Test Method and Description</th><th>Minimum</th><th>Maximum</th></tr>
<tr><td>Uncompacted Voids % (AASHTO T304)</td><td>45%</td><td>100%</td></tr>
<tr><td>Sand Equivalent % (AASHTO T176)</td><td>50%</td><td>100%</td></tr>
<tr><td>Liquid Limit % (AASHTO T89)</td><td>0%</td><td>25%</td></tr>
<tr><td>Plasticity Index (AASHTO T90)</td><td colspan="2">Non-plastic</td></tr>
</table>
3. Mineral Filler for SMA: Mineral filler shall meet the requirements of AASHTO M17. These minerals shall consist of finely divided mineral matter such as crusher fines, road dust, slag dust, hydrated lime, hydraulic cement, or fly ash (Class F) meeting the requirements of AASHTO M17. Any lime based product shall meet the requirements
</td></tr>
</table>

<table>
<tr><th>Paragraph</th><th>Content</th></tr>
<tr><td>Materials (continued)</td><td>
of AASHTO M303.
4. Recycled Asphalt Pavement (RAP) and Reclaimed Asphalt Shingles (RAS): RAP and RAS are not allowed in SMA mixes unless local practice has shown that performance is not impacted negatively.
5. Blend of Aggregates: The combined aggregates shall conform to the percent passing by volume requirements given in the following table:
<table>
<tr><th rowspan="2">Sieve Size</th><th colspan="2">0.5 in.</th><th colspan="2">0.375 in.</th></tr>
<tr><th>Lower Limit</th><th>Upper Limit</th><th>Lower Limit</th><th>Upper Limit</th></tr>
<tr><td>0.75 in.</td><td>100</td><td>100</td><td></td><td></td></tr>
<tr><td>0.5 in.</td><td>90</td><td>100</td><td>100</td><td>100</td></tr>
<tr><td>0.375 in.</td><td>26</td><td>78</td><td>90</td><td>100</td></tr>
<tr><td>No. 4</td><td>20</td><td>28</td><td>26</td><td>60</td></tr>
<tr><td>No. 8</td><td>16</td><td>24</td><td>20</td><td>28</td></tr>
<tr><td>No. 16</td><td>13</td><td>21</td><td>13</td><td>21</td></tr>
<tr><td>No. 30</td><td>12</td><td>18</td><td>12</td><td>18</td></tr>
<tr><td>No. 50</td><td>12</td><td>15</td><td>12</td><td>15</td></tr>
<tr><td>No. 200</td><td>8</td><td>10</td><td>8</td><td>10</td></tr>
<tr><td colspan="5">Typical asphalt content ranges between 6.0 and 7.5% by weight of total mix.</td></tr>
</table>
6. Asphalt Binder
a. Asphalt Binder for SMA: The liquid asphalt binder shall be polymer modified and meet local PG binder temperature requirements.
b. Binder Draindown: When fiber is used, the dosage rate shall be a minimum of 0.3% for both cellulose and mineral fibers by weight of total mix and shall produce a maximum liquid asphalt binder draindown of 0.3% or less when tested in accordance with AASHTO T305.
7. Mix Design: ASMA mixes shall be designed by an approved mix design process. If the Superpave Gyratory Compactor is used, a compactive effort of 50 gyrations shall be used. SMA mixes can also be designed using a 50 blow Marshall design. The SMA shall have a minimum VMA of 17 and air voids (V_a) of 4.0%. Voids in the coarse aggregate (VCA) should be used to ensure stone-on-stone skeleton is achieved. The SMA mix shall be designed with a minimum tensile strength ratio (TSR) of 70% according to AASHTO T283 with the test conducted at an air void level of 6.0%. The mix should be checked for rutting potential by the Asphalt Pavement Analyzer or the Hamburg Wheel Tracking Device and locally determined rut criteria.
</td></tr>
<tr><td>Construction</td><td>
1. Hot Mix Plant Requirements: SMA shall not be stored at elevated temperatures for more than three hours. SMA shall not be heated above 350°F without approval of the Engineer.
2. Weather and Temperature Limitations: The mixture shall be laid only upon an approved underlying course, which is dry, and only when weather conditions are suitable. SMA shall not be placed when the surface or air temperature is below 40ºF. Spreading operations shall be stopped when the air temperature is below 45 ºF and falling.
3. Surface Preparation: A tack coat shall be applied to ensure uniform and complete adherence of the overlay.
4. Compaction: The mixture, when delivered to the paver, shall have a temperature of not less than 290°F.Due to the nature of stone matrix asphalt mixture, the surface
</td></tr>
</table>

Paragraph	Content
Construction (continued)	shall be rolled immediately. Rolling shall be accomplished with steel wheel rollers. Pneumatic tire rollers shall not be used on stone matrix asphalt. Rollers shall move at a uniform speed, not to exceed 3 miles per hour, with the drive roller nearest the paver. Rolling shall be continued until all roller marks are eliminated and the required density has been obtained, but not after the mat has cooled to 240 °F. The Contractor shall monitor density during the compaction process by use of nuclear density gauges to ensure that the required density is being obtained. If vibratory compaction causes aggregate breakdown or forces liquid asphalt binder to the surface, the vibratory mode shall be turned off and the roller shall operate in static mode only. To prevent adhesion of the mixture to the rollers, it shall be necessary to keep the wheels properly moistened.
Method of Measurement and Basis of Payment	The accepted quantities of SMA wearing layer in tons will be measured. The SMA mix shall be evaluated for asphalt binder content, laboratory compacted air voids, and in-place density; pay factors will be applied. In-place density will be assessed as a percentage of theoretical maximum density (TMD) (AASHTO T209). The target density for SMA mix is 94% of TMD.

REFERENCES

ALDOT (2008), "Stone Matrix Asphalt (SMA) (Fiber Stabilized Asphalt Concrete), Section 423, Standard Specifications, Alabama Department of Transportation.

Brown, R. and Cooley, L. (1999), "Designing Stone Matrix Asphalt Mixtures for Rut-Resistant Pavements," Report 425, Project 9-8, National Cooperative Highway Research Program, Transportation Research Board.

Prowell, B., Watson, D., Hurley, G., and Brown, R. (2010), "Evaluation of Stone Matrix Asphalt (SMA) for Airfield Pavements," Paper, 2010 FAA Worldwide Airport Technology Transfer Conference, Atlantic City, NJ, April 2010.

SHRP2 R23 Guide Specification
Open Graded Friction Course

<table>
<tr><th>Paragraph</th><th>Content</th></tr>
<tr><td>Description</td><td>The work covered by this specification shall consist of constructing a hot mixed, hot laid polymer modified open graded friction course wearing layer placed on an existing pavement.</td></tr>
<tr><td>Materials</td><td>
1. Aggregates: The aggregate shall be limited to 100% crushed, virgin aggregates.
a. The aggregate shall be combined into a total blend that will produce an acceptable job mix within the gradation limits shown below in the following table. The blend shall be made from at least two stockpiles of different gradations. At least 10% of the blend shall be taken from each stockpile.
<table>
<tr><th>Sieve Size</th><th>Percent Passing by Weight</th></tr>
<tr><td>0.75 in.</td><td>100</td></tr>
<tr><td>0.5 in.</td><td>85 – 100</td></tr>
<tr><td>0.375 in.</td><td>55 – 65</td></tr>
<tr><td>No. 4</td><td>10 – 25</td></tr>
<tr><td>No. 8</td><td>5 – 10</td></tr>
<tr><td>No. 200</td><td>2 - 4</td></tr>
</table>
b. No RAP or RAS will be allowed.
2. Asphalt Binder: The liquid binder shall be a polymer modified PG graded and meet local PG grading requirements. The proportion of liquid asphalt binder to total sample by weight shall be 4.7 % to 9.0 %. The exact proportion shall be fixed by the job mix formula. A fiber stabilizer shall be incorporated into the mix to reduce draindown.
3. Mix Design: The Open Graded Friction Course shall be designed with a minimum air void content of 12%.
</td></tr>
<tr><td>Construction</td><td>
1. Compaction Equipment: Steel wheel tandem (7 ton {6 metric ton} minimum size) rollers shall be furnished in sufficient numbers based on the quantity of material being placed to provide effective compaction coverage within the workable time period of the mix as designated by the Engineer. Rubber-tire rollers shall not be used.
2. Weather and Temperature Limitations: The mixture shall be laid only upon an approved underlying course, which is dry, and only when weather conditions are suitable. SMA shall not be placed when the surface or air temperature is below 40ºF. Spreading operations shall be stopped when the air temperature is below 45 ºF and falling.
3. Rolling: Rolling shall be as approved by the Engineer. No density tests are required.
</td></tr>
<tr><td>Method of Measurement and Basis of Payment</td><td>Open graded friction course described by this specification shall be paid for by the ton.</td></tr>
</table>

REFERENCES

ALDOT (2008), “Polymer Modified Open Graded Friction Course, Section 420, Standard Specifications, Alabama Department of Transportation.

SHRP2 R23 Guide Specification
Rubblization of Existing Concrete Pavement

Paragraph	Content
Description	Rubblize and compact existing concrete pavement.
Equipment	Provide either a Type I or Type II rubblizer, unless otherwise shown on the plans, and necessary rollers for compacting the rubblized pavement. **1.** Type I Rubblizer: A self-contained, self-propelled, resonant frequency breaker, capable of producing low-amplitude, 2000 lb blows, at a rate not less than 44 Hz. **2.** Type II Rubblizer: A self-contained, self-propelled, multiple-head breaker, with each hammer independently adjustable, and capable of rubblizing a width of up to 13 ft. in one pass. **3.** Roller-Vibratory: Drum (Type C), with a static weight ≥ 10 tons. **4.** Roller-Medium Pneumatic **5.** Roller-Z Grid Vibratory: When rubblizing with Type II equipment, provide a steel wheel, self-propelled vibratory roller, with a minimum weight of 10 tons, and a Z-pattern cladding bolted transversely to the surface of the drum.
Construction	**1. Preparatory Work:** Prior to initiating rubblization, the following work must be complete: a. If required, construct pavement drainage systems at least two weeks prior to rubblization. b. Any existing material overlaying the concrete pavement must be removed. c. Adjustments or additions to the pavement adjacent to the existing concrete must be complete to the elevation of the concrete pavement to be rubblized. d. Before rubblizing a section, cut full-depth saw cut joints at any locations shown on the plans to protect facilities that will remain in place. **2. Rubblization and Compaction:** Operate equipment in a manner that will not damage the base, underground utilities, drainage structures, and other facilities on the project; in the event that damage to such features occurs, the Contractor shall be fully responsible for their repair. a. Use a Type I or Type II rubblizer to completely debond any reinforcing steel and rubblize the existing concrete pavement. Other types of rubblizing equipment will only be used if shown on the plans or approved in writing. Above the reinforcing steel or upper one-half of the pavement (if unreinforced), the equipment shall produce at least 75 percent of broken pieces less than 3 inches in greatest dimension. At the surface of the rubblized layer, all pieces shall be less than 2~~6~~ inches in greatest dimension. Below the reinforcing steel or in the lower half of the pavement, at least 75% of the broken pieces will be less than 9 inches in greatest dimension with the maximum particle size ~~shall be~~ 12~~9~~ inches in greatest dimension. Any large concrete pieces that do not meet the size requirements previously specified shall be treated as follows: i. If the affected area is less than 10 ft^2 the area may be patched with aggregate. ii. Areas greater than 10 ft^2 that do not meet the specified particle size shall be repaired with hot-mix asphalt, unless otherwise approved by the Engineer. b. Reinforcing steel exposed and projecting from the surface after rubblization or compaction shall be cut off below the surface and removed.

Paragraph	Content
Construction (continued)	3. **Type I Rubblization:** Begin at a free edge or previously broken edge and work transversely toward the other edge. In the event the rubblizer causes excessive deformation of the pavement, the Engineer may require high flotation tires with tire pressures less than 60 psi. Any displaced areas shall be considered non-conforming and treated as described above. Compact by seating rubblized pavement with the following rolling pattern: One pass from a vibratory roller, followed by at least one pass with the pneumatic roller, followed by at least two more passes with the vibratory roller. The rolling pattern may be changed as directed. 4. **Type II Rubblization:** Unless otherwise directed, rubblize the entire lane width in one pass. Provide a screen to protect vehicles from flying particles as directed. Compact by seating the pavement with the following rolling pattern: A minimum of four passes with the Z-grid vibratory roller, followed by four passes with a vibratory roller, then at least two passes from a pneumatic roller. The rolling pattern may be changed as directed. 5. **Verification of Rubblization Process:** Before full production begins, the Engineer will select approximately 200 linear ft. of one lane width to verify the rubblization operation. The contractor shall rubblize the test section, using the section to adjust equipment. From within this test section, the Engineer and Contractor shall agree upon a test pit location. At the test pit, excavate a 4 ft. square test pit. The Engineer shall test the material to verify that the specified particle size distribution has been achieved through the entire depth of pavement. Additional test pits may be required during the project to confirm ongoing compliance with the particle size specification. Test pit areas shall be patched as directed either with aggregate or hot-mix asphalt. If the rubblized material from the test pit does not meet specifications, another test strip shall be conducted and tested. Should this pit also fail, rubblization operations shall be suspended until the Contractor demonstrates to the satisfaction of the Engineer that specifications can be met, at which time the Engineer shall allow the Contractor to conduct another test strip. 6. **Trafficking:** Public traffic shall not be allowed on the rubblized pavement, except at Engineer-approved access points, and the Contractor shall avoid unnecessary trafficking of the rubblized pavement with construction equipment. 7. **Placement of Surfacing:** The Contractor shall coordinate construction activities so that the first overlay course is placed within 48 hours after completion of rubblization. If rain occurs after rubblization but before paving, paving shall not take place until the rubblized layer is dry and stable to the satisfaction of the Engineer.
Method of Measurement	Rubblization shall be measured by the square yard of original concrete pavement. The limits of measurement will be as shown on plans.

Paragraph	Content
Payment	The work performed and materials furnished in accordance with this specification and measured as provided under "Measurement" will be paid for at the unit bid price for "Rubblization of Existing Concrete Pavement." This price is full compensation for rubblizing and compacting existing concrete pavement, saw-cutting required locations, cutting and removing exposed reinforcing steel, repairing unstable or non-conforming locations, conducting required test pits, and equipment, labor, tools, and incidentals.

REFERENCES

Sebesta, S., Scullion, T., and Von Holdt, C. (2006), "Rubblization for Rehabilitation of Concrete Pavement in Texas: Preliminary Guidelines and Case Studies," Report No. FHWA/TX-06/0-4687-1, Texas Transportation Institute, February 2006.

Antigo Construction (2012), "Analysis of Rubblization Specifications of 34 State Transportation Agencies and Suggested Consensus Particle Size Requirements," August 2012.

SHRP2 R23 Guide Specification
Saw, Crack, and Seat Concrete Pavement

Paragraph	Content
Description	Saw, crack and seat existing jointed reinforced concrete pavement. Note: This specification is used in conjunction with elements for AASHTO Specification 567 Cracking and Seating later in this document on existing jointed reinforced concrete pavements
Equipment	Provide a concrete saw capable of sawing at least 5 inches deep
Construction	**1. Preparatory Work:** Prior to sawing, the following work must be complete: a. If required, construct pavement drainage systems at least two weeks prior to saw cutting and cracking and seating. b. Any existing material overlaying the concrete pavement must be removed. **2. Sawing:** Transverse saw cuts will be made at a 4 ft to 5 ft spacing along the centerline of the pavement to the depth required to cut the reinforcing steel contained in the jointed reinforced concrete pavement. **3. Cracking and Seating:** Cracking and Seating shall proceed in accordance with the guide specifications for Cracking and Seating with the additional requirement that the equipment used to crack the pavement will include a protective plate that eliminates any spalling of the saw cut during the cracking operation.
Method of Measurement	Sawing, cracking and seating shall be measured by the square yard of original concrete pavement. The limits of measurement will be as shown on plans.
Payment	The work performed and materials furnished in accordance with this specification and measured as provided under “Measurement” will be paid for at the unit bid price for “Saw, Crack, and Seat Existing Concrete Pavement.” This price is full compensation for sawing, cracking and seating existing concrete pavement, repairing unstable or non-conforming locations, required coring, and equipment, labor, tools, and incidentals.

REFERENCES

Department for Transport United Kingdom (2009), "Manual of Contract Documents for Highway Works,” Volume 1, Series 0700, Road Pavement General.

ELEMENTS FOR USE WITH AASHTO GUIDE SPECIFICATIONS

Recommended R23 Specification Elements
AASHTO Section 313 Open Graded Bituminous Base (OGBB)

AASHTO Paragraph	R23 Recommendations		Source
313.02 Materials	Asphalt	1. Use only PG graded binders in accordance with AASHTO M320.	All states reviewed
		2. Do not use PG binders higher than PG 82-xx	AASHTO M323
		3. Consider use of LTPPBind for selection of PG binder grade or verified local practice.	Study Team
	Aggregate	1. General: Use AASHTO specification sections and subsections unless local conditions require otherwise.	AASHTO 313
		2. RAP is not allowed.	Virginia 313
313.03 Construction	Proportioning	1. Use AASHTO 313 unless other local criteria are more appropriate	AASHTO 313
	Draindown	1. ≤ 0.3%	Virginia 313
	Equipment	1. Vibratory rollers will not be used.	Virginia 313
	Maximum Compacted Layer Thickness	≤ 4 in.	Missouri 302
	Compaction	Compact with 3 passes of 10 ton steel drum roller.	Michigan 303
	HMA Placement Temps	1. Weather Limitations: Use AASHTO guidance unless other local criteria are more appropriate	AASHTO 313
		2. Plant discharge temperature range: 250 to 300°F.	Missouri 302
		3. Use an approved MTV for placing all HMA surface courses	Study Team
	Traffic Restrictions	The Contractor shall not use the open-graded course as a haul road or storage area.	Virginia 313
	Hydraulic Efficiency	Use AASHTO 313 or Virginia 313 criteria.	AASHTO 313 or Virginia 313

Recommended R23 Specification Elements
AASHTO Section 315 Separator Fabric for Bases

AASHTO Paragraph	R23 Recommendations		Source
315.02 Materials	Fabric	1. Meet AASHTO M288 Class 1 or 2, or 2. Meet Washington Section 2-12 requirements.	AASHTO 315 Missouri 1011 Washington 2-12
315.03 Construction	Construction	1. Apply construction requirements from AASHTO 315 unless local conditions are more appropriate, or 2. Use Washington Section 2-12 requirements.	AASHTO 315 Washington 2-12

Recommended R23 Specification Elements
AASHTO Section 401 Hot Mix Asphalt (HMA) Pavements

AASHTO Paragraph	R23 Recommendations		Source
401.02 Materials	Asphalt	Use only PG graded binders in accordance with AASHTO M320.	All states reviewed
		Do not use PG binders higher than PG 82-xx	AASHTO M323
		Consider use of LTPPBind for selection of PG binder grade or verified local practice.	Study Team
		Consider a change in the high temperature binder grade if the mix RAP content > 20%.	AASHTO M323
	Aggregate	General: Use AASHTO specification sections and subsections unless local conditions require otherwise.	AASHTO 401
		Crush or break RAP so that 100% passes a 2-in. sieve.	TxDOT 340, Virginia 211
	Warm Mix Asphalt	The Contractor may use warm mix asphalt (WMA) processes in the production of HMA. The Contractor shall submit for approval the process that is proposed and how it will be used in the manufacture of HMA.	Washington 5-04
401.03 Construction	Mix Design	Consider use of fine mix gradation which can be defined as ½ in. NMAS: > 40 to 47% passing No. 8 sieve AASHTO M323 has a difference definition for coarse and fine-graded mixtures.	Mn/DOT 2360, Study Team, and NCHRP 531
		Avoid use of 19 mm NMAS mixes unless local performance is acceptable	Study Team
		TSR should be > 80% of AASHTO T283	Missouri 403 and Others
		If RAP content > 30%, mix design must incorporate RAP material in the mix design gradation.	Study Team
		Use AASHTO mix guidelines in AASHTO M323 with a Va = 4.0%.	AASHTO and Virginia 211
		Consider use of the Hamburg Wheel Tester to assess mix rutting potential. Use TxDOT criteria unless other, local criteria are available.	TxDOT 340

AASHTO Paragraph	R23 Recommendations		Source
401.03 Construction (continued)	HMA Placement Temps	Use AASHTO guidance unless other local criteria are more appropriate	AASHTO 401
		Do not place crusted HMA into the paver	Michigan 502
		Use an approved MTV for placing all HMA surface courses	Study Team
		Establish minimum HMA placing temperatures (before entering the paver) or use TxDOT 340	TxDOT 340
		When the temperature of the mat immediately behind the screed falls below 200°F, stop paving and place a transverse construction joint. If the temperature of the mat falls below 190°F before any rolling, remove and replace the mat. [An exception would be a Warm Mix]	Michigan 502
		Segregation: Consider use and associated measurement options of density profile approach used by TxDOT.	TxDOT 341
	Tack	An asphalt tack coat shall be applied to existing asphalt and concrete surfaces, and to the surface of each course or lift constructed.	Minnesota 2360
	Joints	Stagger joints according to AASHTO	AASHTO 401
		The minimum density of all traveled way pavement within 6 inches of a longitudinal joint, including the pavement on the traveled way side of the shoulder joint, shall not be less than 2.0 percent below the specified density when unconfined.	Missouri 403
	Lift Thickness	t/NMAS should conform to NCAT recommendations. • For fine-graded HMA: t/NMAS ≥ 3.0 • For coarse-graded HMA: t/NMA ≥ 4.0 • For SMA mixes: t/NMA ≥ 4.0	NCHRP 531
	Compaction	Achieve a minimum compaction of 92% of TMD. The average target % of TMD should range between 93 and 94% for dense graded mixes.	AASHTO 401 NCAT

AASHTO Paragraph	R23 Recommendations		Source
401.03 Construction (continued)	Rollers and Traffic	Rollers and traffic shall not stand on or operate on the uncompacted or newly rolled pavement with a surface temperature > 140°F.	Minnesota 2360 Missouri 403
	Smoothness	Use a 10-ft. straightedge. Allowable deviations are: Base course mixtures: 3/8 to ¾-in. Leveling and top course mixtures: 1/8 to ¼-in.	Michigan 502

Recommended R23 Specification Elements
AASHTO Section 404 Tack Coat

AASHTO Paragraph	R23 Recommendations		Source
404.02 Materials	Binder	Use either an asphalt cement (AASHTO M320) or emulsified asphalt (AASHTO M140 or M208) in accordance with local practice	AASHTO 404 Texas 340 Virginia 310
404.03 Construction	Weather Limitations	Apply tack coat during dry weather only.	AASHTO 404 Michigan 501
	Surface Preparation	Patch, clean, and remove irregularities from all surfaces to receive tack coat. Remove loose materials.	AASHTO 404 Minnesota 2357 Missouri 407
	Application Surfaces	1. Apply the bond coat to each layer of HMA and to the vertical edge of the adjacent pavement before placing subsequent layers. 2. Apply a thin, uniform tack coat to all contact surfaces of curbs, structures, and all joints.	Michigan 501 Texas 340
	Application Rate	1. Apply undiluted tack at a rate ranging from 0.05 to 0.10 gal/SY. 2. Many State DOTs allow dilution with water up to 50%.	Range generally falls within most state limits
	Application Temperatures	Use manufacturer recommendations	Study Team

Recommended R23 Specification Elements
AASHTO Section 409 Cold Milling Asphalt Pavement

AASHTO Paragraph	R23 Recommendations		Source
409.02 Materials	Not Applicable		
409.03 Construction	Milling Equipment	Equipment must consistently remove the HMA surface, in one or more passes, to the required grade and cross section producing a uniformly textured surface. Machines must be equipped with all of the following: • Automatically controlled and activated cutting drums • Grade reference and transverse slope control capabilities • An approved grade referencing attachment, not less than 30 feet in length. An alternate grade referencing attachment may be used if approved by the Engineer prior to use.	Michigan 502
	Milling Operations	The pavement surface shall be milled to the depth, width, grade, and cross slope as shown in the Plans or as otherwise directed by the Engineer. Machine speeds shall be varied to produce the desired surface texture grid pattern. Milling shall be performed without excessive tearing or gouging of the underlying material.	Minnesota 2232
	Milling Operations and Traffic	The pavement surface shall be milled to the depth, width, grade, and cross slope as shown in the Plans or as otherwise directed by the Engineer. Machine speeds shall be varied to produce the desired surface texture grid pattern. Milling shall be performed without excessive tearing or gouging of the underlying material.	Minnesota 2232

Recommended R23 Specification Elements
AASHTO Section 411 In-Place Cold Recycled Asphalt Pavement

AASHTO Paragraph	R23 Recommendations		Source
411.02 Materials	Not Applicable		
411.03 Construction	Use AASHTO 411		

Recommended R23 Specification Elements
AASHTO Section 501 Portland Cement Concrete Pavements

AASHTO Paragraph	R23 Recommendations		Source
501.02 Materials	Basic PCC Mix Design Requirements	• Minimum compressive strength = 3,000 psi to 3,500 psi at 7 day cure. • Flexural strength: minimum between 550 and 650 psi at 7 day cure. • Maximum water/cement ratio: range between 0.35 to 0.45 • Cement content: range from to 560 to 598 lb/CY • Nominal Maximum Aggregate Size = 1.0 in. • Slump: 0 to 3 in. • Air content = 5.0 to 6.5%	AASHTO 501 Mn/DOT 2301 Missouri 501 Virginia 217
	Supplementary Cementitious Materials	Supplementary cementitious materials may be used to replace a maximum of 35 to 50% of the portland cement.	AASHTO 501 Missouri 501 Washington 5-05
	Dowel Bars	Use corrosion resistant dowel bars. Details available via WSDOT Section 5-05	Washington 5-05
501.03 Construction	Mix and Placing Limitations	• Protect the concrete from freezing until the concrete has attained a compressive strength of at least 1,000 psi. • Stop mixing and concreting operations if shaded ambient air temperature away from artificial heat is 40°F or less. Resume operations only when the ambient air temperature is 40°F and rising. • Place mixed concrete only when its temperature is between 50°F and 90°F.	AASHTO 501 Michigan 602 Texas 360
	Curing	• Curing systems: Membrane-forming compounds: The compound shall be applied under constant pressure at the rate of 100 to 150 square feet per gallon (or according to manufacturer's recommendation) by mechanical sprayers mounted on movable bridges. On textured surfaces, the rate shall be as close to 100 square feet as possible. • Protection in cold weather: The Contractor shall prevent protect the concrete from freezing during the first 72 hours immediately following concrete placement.	Virginia 316

AASHTO Paragraph	R23 Recommendations		Source
501.03 Construction (continued)	Curing (continued)	• Curing in hot or windy conditions: Care shall be taken in hot, dry, or windy weather to protect the concrete from shrinkage cracking by applying the curing medium at the earliest possible time after finishing operations and after the sheen has disappeared from the surface of the pavement.	
	Surface Texture or Final Finish	Two options—select one: 1. Transverse tining: Texture the final surface to form an even groove pattern perpendicular to the centerline. Provide a surface with individual grooves 1/16 in. to 1/8 in. wide and 1/8 in. to 3/16 in. deep spaced on 3/8-in. to 3/4-in. centers. Use metal tines. 2. Longitudinal tining: The pavement shall be given an initial and a final texturing. Initial texturing shall be performed with a burlap drag or broom device that will produce striations parallel with centerline. Final texturing shall be performed with a spring steel tine device that will produce grooves parallel with the centerline. The spring steel tine device shall be operated within 5-inches, but not closer than 3-inches, of pavement edges. Burlap drags, brooms and tine devices shall be installed on self-propelled equipment having external alignment control. Spring steel tines of the final texturing device shall be rectangular in cross section, $^{3}/_{32}$ to $^{1}/_{8}$ inch wide, on ¾ inch centers, and of sufficient length, thickness and resilience to form grooves approximately $^{3}/_{16}$ inch deep in the fresh concrete surface. Final texture shall be uniform in appearance with substantially all of the grooves having a depth between $^{1}/_{16}$ inch and $^{5}/_{16}$ inch. 3. Additional texturing methods: Methods that include astro-turf drag, diamond grinding and diamond grooving can be considered in accordance with local practice.”	AASHTO 501 Michigan 602 Washington 5-05 and Amendment dated 8-2-10
	Minimum strength requirements for opening to traffic	• Min flexural strength ranges from 350 psi for thick slabs (≥ 9.5 in.) to 500 psi for thin slabs (6 in.). • Min compressive strength ≥ 2,500 psi	Mn/DOT 2301 Texas 360 Washington 5-05

Recommended R23 Specification Elements
AASHTO Section 552 Subsealing and Stabilization

AASHTO Paragraph	R23 Recommendations		Source
552.02 Materials	Grout	Use AASHTO Section 552	AASHTO 552
552.03 Construction	Grout Plant	Use AASHTO Section 552	AASHTO 552

Recommended R23 Specification Elements
AASHTO Section 557 Partial Depth Patching

AASHTO Paragraph	R23 Recommendations		Source
557.02 Materials	Concrete Mix for Patches	Use requirements in AASHTO Section 557	AASHTO 557
557.03 Construction	Patch Preparation	1. **Use of Jackhammers**: If jackhammers are used for removing pavement, they shall not weigh more than 30-pounds, and chipping hammers shall not weigh more than 15-pounds. All power driven hand tools used for the removal of pavement shall be operated at angles less than 45-degrees as measured from the surface of the pavement to the tool. 2. **Patch Limits**: The patch limits shall extend beyond the spalled area a minimum of 3.0-inches. Repair areas shall be kept square or rectangular. Repair areas that are within 12.0-inches of another repair area shall be combined. 3. **Patches and Joints**: WSDOT calls for specific requirements when spall repairs involve all joint types.	Washington 5-01.3(5)
	Placing Concrete	Place concrete the same day that the existing pavement is removed. Immediately before the concrete placement, wet the faces of the existing pavement and the surface of the aggregate base with water.	Michigan 603
	Opening to Traffic	The repair areas may be opened to traffic when the new concrete has attained a flexural strength of 300 psi and all joints have been sawed.	Michigan 603

Recommended R23 Specification Elements
AASHTO Section 558 Full Depth Patching

AASHTO Paragraph	R23 Recommendations		Source
558.02 Materials	Concrete Mix for Patches	1. Use requirements in AASHTO Section 557 2. For shorter opening times, refer to criteria in Michigan 603 or Texas 361	AASHTO 558 Michigan 603 Texas 361
558.03 Construction	Repair Area	Make repair areas rectangular, at least 6 ft. long and at least 1/2 a full lane in width unless otherwise shown on the plans.	Texas 361
	Repair Process Steps	• Saw-cut full depth through the concrete around the perimeter of the repair area before removal. • Remove or repair loose or damaged base material, and replace or repair it with approved base material to the original top of base grade. Place a polyethylene sheet at least 4 mils thick as a bond breaker at the interface of the base and new pavement. Allow concrete used as base material to attain sufficient strength to prevent displacement when placing pavement concrete. • Broom finish the concrete surface unless otherwise shown on the plans.	Texas 361
	Joints	There shall be no new joints closer than 3.0-feet to an existing transverse joint or crack.	Washington 5-01.3(4)

Recommended R23 Specification Elements
AASHTO Section 560 Diamond Grinding Concrete Pavement

AASHTO Paragraph	R23 Recommendations		Source
560.02 Materials		No materials requirements.	
560.03 Construction	Equipment	The grinding equipment shall use diamond tipped saw blades mounted on a power driven, self-propelled machine that is specifically designed to smooth and texture PCC pavement. The equipment shall grind the pavement to the specified texture and smoothness tolerances. The equipment shall not damage the underlying surface of the pavement, cause excessive ravels, aggregate fractures, spalls, or otherwise disturb the transverse or longitudinal joint.	AASHTO 560 Texas 360
	Faulted Pavement	Faulted areas at transverse cracks and joints in excess of 1⁄16 inch after initial grinding must be reground until faulting is less than 1⁄16 inch.	Michigan 603
	Texture	Grind to a parallel corduroy type texture consisting of grooves 1⁄16 to 1⁄8 inch wide, 1⁄16 inch deep and 1⁄16 to 1⁄8 inch on center. Grind to a finished uniform texture. Make the transverse slope of the pavement uniform with no depressions or misalignment of slope greater than 1⁄8 inch when checked with a 10-foot straightedge.	Michigan 603

Recommended R23 Specification Elements
AASHTO Section 561 Milling Pavement

AASHTO Paragraph	R23 Recommendations		Source
561.02 Materials		No materials requirements.	
561.03 Construction	Equipment	• Pavement milling shall be accomplished with a power operated, self-propelled cold milling machine capable of removing concrete and bituminous surface material as necessary to produce the required profile, cross slope, and surface texture uniformly across the pavement surface. The machine shall also be equipped with means to control dust and other particulate matter created by the cutting action. • The machine shall be equipped to accurately and automatically establish profile grades along each edge of the machine, within plus or minus 1/8 inch, by referencing from the existing pavement by means of a ski or matching shoe, or from an independent grade control. The machine shall be controlled by an automatic system for controlling grade, elevation, and cross slope at a given rate.	Minnesota 2232
	Milling Operation	• Mill the surface in a longitudinal direction. For the initial pass, use as a reference the curb, longitudinal edge of pavement, or a string attached to the pavement surface. Furnish a milling machine with a steering guide or reference that allows the operator to follow the guidance reference within 2 in. When milling next to previously milled pavement, use the edge of the milled trench as the longitudinal reference for succeeding passes. • Provide a milled surface with a uniform texture free of excessive gouges, ridges, and grooves. • Provide an end transition on a 4:1 slope to the existing pavement surface at each end of the milling work each day. End the milling passes as close to each other as practical. Do not leave longitudinal joints more than 2 in. deep exposed during nonworking hours.	AASHTO 561

Recommended R23 Specification Elements
AASHTO Section 563 Portland Cement Concrete Unbonded Overlays

AASHTO Paragraph	R23 Recommendations		Source
563.02 Materials	Basic PCC Mix Design Requirements	• Minimum compressive strength = 3,000 psi to 3,500 psi at 7 day cure. • Flexural strength: minimum between 550 and 650 psi at 7 day cure. • Maximum water/cement ratio: range between 0.35 to 0.45 • Cement content: range from to 560 to 598 lb/CY • Nominal Maximum Aggregate Size = 1.0 in. • Slump: 0 to 4 in. • Air content = 5.0 to 6.5%	AASHTO 501 and 563 Mn/DOT 2301 Missouri 501 Virginia 217
	Supplementary Cementitious Materials	Supplementary cementitious materials may be used to replace a maximum of 40 to 50% of the portland cement.	AASHTO 501 Missouri 501
	Interlayer	• The interlayer material shall be a minimum of 1 in. thick new bituminous material.	Missouri 506.20
563.03 Construction	Mix and Placing Limitations	• Protect the concrete from freezing until the concrete has attained a compressive strength of at least 1,000 psi. • Stop mixing and concreting operations if shaded ambient air temperature away from artificial heat is 40°F or less. Resume operations only when the ambient air temperature is 40°F and rising. • Place mixed concrete only when its temperature is between 50°F and 85°F.	AASHTO 501 Michigan 602 Texas 360
	Surface Preparation	All holes greater than 2 inches wide and one inch deep in the surface of the traffic lanes, excluding shoulders, shall be filled with patching material and shall be compacted to a flat, tight surface	Missouri 506.20
	Surface Texture	Same as recommendations for AASHTO 501	

AASHTO Paragraph	R23 Recommendations		Source
563.03 Construction (continued)	Bituminous Interlayer	The surface temperature of a bituminous interlayer shall not exceed 90°F prior to the overlay placement. The temperature may be controlled with any means approved by the Engineer, including, but not limited to white curing compound and water misting.	Missouri 506.20
	Curing	• Cure the concrete for at least 3 days immediately after the finishing operation. • Curing systems: Membrane-forming compounds: The compound shall be applied under constant pressure at the rate of 100 to 150 square feet per gallon by (or according to manufacturer's recommendation) mechanical sprayers mounted on movable bridges. On textured surfaces, the rate shall be as close to 100 square feet as possible. • Protection in cold weather: The Contractor shall protect the concrete from freezing during the first 72 hours immediately following concrete placement. • Curing in hot or windy conditions: Care shall be taken in hot, dry, or windy weather to protect the concrete from shrinkage cracking by applying the curing medium at the earliest possible time after finishing operations and after the sheen has disappeared from the surface of the pavement.	AASHTO 561 Virginia 316
	Minimum strength requirements for opening to traffic	• Min flexural strength opening ranges from 350 psi for thick slabs (≥ 9.5 in.) to 500 psi for thin slabs (6 in.). [Mostly Mn/DOT 2301} • The unbounded concrete overlay may be opened for light-weight traffic when the concrete has attained a minimum compressive strength of 2500 psi. The concrete pavement shall not be opened to all types of traffic until the concrete has attained a minimum compressive strength of 3000 psi. [Missouri 506.20]	Mn/DOT 2301 Missouri 506.20 Texas 360

Recommended R23 Specification Elements
AASHTO Section 567 Cracking and Seating

AASHTO Paragraph	R23 Recommendations		Source
567.02 Materials		No materials related specifications.	AASHTO 567
567.03 Construction	General Construction	Use AASHTO Section 567	AASHTO 567
	Cracking Operations	AASHTO 567 recommends a cracking pattern that result in PCC pieces of 1.2 to 1.8 ft^2 in area. Other state experience, such as Caltrans, suggests that a much larger cracking pattern can work well for JPCP such as 6 ft by 5 ft (for a 12 ft wide lane with 15 ft contraction joint spacing results in a lane cracked in half and approximately at the third points). Confirmed by United Kingdom which calls for cracking every 0.75 to 2 m.	Study Team UK Dept. of Transport Specifications (Section 716)
		Given the variability of the specifications available, the study team recommends the minimum distance from a contraction joint to initiate cracking be 3 ft. This should ensure that the cracked areas be dimensioned with a 2 to 1 ratio or less. This assumes the slab is longitudinally cracked down the middle.	Study Team
	Seating Operations	AASHTO 567 recommends seating using a 10 ton steel wheel vibratory roller, with sufficient passes to seat the slabs. The UK Dept of Transport, Section 716 calls for a minimum of six passes with a 20 tonne pneumatic tire roller. Past reports by NCHRP and NAPA have recommended use of a 35 to 50 ton pneumatic tire roller.	UK Dept. for Transport Specifications (Section 716)

AASHTO AND STATE DOT SPECIFICATION SUMMARIES

AASHTO Specification Designation 313 "Description"
Open Graded Bituminous Base (OGBB)

Agency/Organization	Specification Section
	Description
AASHTO (Section 313)	"Construct a permeable base course of aggregate and bituminous material mixed in a central plant and spread and compacted on a prepared foundation."
Michigan DOT (Section 303)	"Construct an open-graded drainage course (OGDC) on an approved surface." NOT BITUMINOUS STABILIZED.
Minnesota DOT	Not available.
Missouri DOT (Section 302)	"This work shall consist of furnishing and placing a stabilized permeable base material. The mixture shall be placed, spread and compacted as shown on the plans or as directed by the engineer." Stabilized permeable base shall be either asphalt binder stabilized or Portland cement stabilized at the option of the contractor. Asphalt stabilized base is described.
Texas DOT (Item 247)	Not available.
Virginia DOT (Section 313)	"This work shall consist of furnishing and placing a course of asphalt-stabilized open-graded material on a prepared subbase or subgrade in accordance with the required tolerances in these specifications and in conformity with the lines and grades shown on the plans or established by the Engineer."
Washington DOT	Not available.

AASHTO Specification Designation 313 "Materials"
Open Graded Bituminous Base (OGBB)

<table>
<tr><th rowspan="2">Agency/Organization</th><th>Specification Section</th></tr>
<tr><th>Materials</th></tr>
<tr><td>AASHTO (Section 313)</td><td>
1. Asphalt Cement/Binder: Meet AASHTO M20 for pen graded, AASHTO M320 for PG graded, or AASHTO M226 for viscosity graded.
2. Aggregates: Major tests and properties
<table>
<tr><td>LA Abrasion, % wear, maximum</td><td>40%</td></tr>
<tr><td>Mechanically fractured faces (of material retained on No. 4 (4.75-mm) sieve), % minimum</td><td>75% with 2 or more fractured faces</td></tr>
<tr><td>Flat or elongated pieces on combined and retained on No. 4 (4.75-mm) sieve, % maximum</td><td>15%</td></tr>
</table>
<table>
<tr><th rowspan="2">Sieve Size</th><th colspan="2">Percent Passing</th></tr>
<tr><th>Min</th><th>Max</th></tr>
<tr><td>1.5-in.</td><td>100</td><td>100</td></tr>
<tr><td>1.0-in.</td><td>95</td><td>100</td></tr>
<tr><td>½-in.</td><td>25</td><td>60</td></tr>
<tr><td>No. 4</td><td>0</td><td>10</td></tr>
<tr><td>No. 10</td><td>0</td><td>5</td></tr>
<tr><td>No. 200</td><td>0</td><td>3</td></tr>
</table>
</td></tr>
<tr><td>Michigan DOT (Section 303)</td><td>Materials—refer to Section 902.</td></tr>
<tr><td>Minnesota DOT</td><td>Not available.</td></tr>
<tr><td>Missouri DOT (Section 302)</td><td>
1. Asphalt Cement/Binder: Mixtures shall be composed of the base aggregate and 2.5 percent asphalt binder by weight (mass) of the total mixture. PG 64-22, PG 70-22 or PG 76-22 asphalt binder shall be used.
2. Aggregates: Major tests and properties—refer to Section 1009
</td></tr>
<tr><td>Texas DOT (Item 247)</td><td>Not available.</td></tr>
<tr><td>Virginia DOT (Section 313)</td><td>
1. Asphalt Cement/Binder: Shall be PG 70–22. Asphalt content 4.3% ± 0.3%
2. Aggregates: Major tests and properties
<table>
<tr><th rowspan="2">Sieve Size</th><th colspan="2">Percent Passing</th></tr>
<tr><th>Min</th><th>Max</th></tr>
<tr><td>1-in.</td><td>100</td><td>100</td></tr>
<tr><td>¾-in.</td><td>88</td><td>100</td></tr>
<tr><td>½-in.</td><td>70</td><td>90</td></tr>
<tr><td>No. 8</td><td>0</td><td>15</td></tr>
<tr><td>No. 200</td><td>0.5</td><td>4.5</td></tr>
</table>
3. Hydrated lime shall be added at 0.5% by weight of total dry aggregate.
4. RAP is not allowed.
5. Coarse aggregate shall conform to Grade A Section 203
6. Fine aggregate shall conform to Section 202
</td></tr>
<tr><td>Washington DOT</td><td>Not available.</td></tr>
</table>

AASHTO Specification Designation 313 "Construction"
Open Graded Bituminous Base (OGBB)

<table>
<tr><th>Agency/Organization</th><th>Specification Section
Construction</th></tr>
<tr><td>AASHTO
(Section 313)</td><td>Major construction related items
<table>
<tr><td>Proportioning</td><td>PG 64-22, percentage by weight (mass) of 2.5 ± 0.3 of the mix</td></tr>
<tr><td>Equipment</td><td>Standard paving equipment as for HMA (AASHTO Section 401)</td></tr>
<tr><td>Prime Coat</td><td>If required, apply Prime Coat as per AASHTO Section 405</td></tr>
<tr><td>Surface Tolerance</td><td>Shall not exceed 0.5-in. deviation longitudinal or transverse by use of Method 1 (10 ft. straightedge).</td></tr>
<tr><td>Weather Limitations</td><td>If layer thickness less than 3-in., minimum air temp = 40°F and surface temp = 45°F. If greater than 3-in., minimum air temp = 30°F and surface temp = 35°F.</td></tr>
<tr><td>Traffic Restrictions and Curing Period</td><td>No vehicles or construction equipment on the OGBB until cooled to ambient temperature.</td></tr>
<tr><td>Hydraulic Efficiency</td><td>Apply 0.26 gal (1 L) of water to surface. Must be totally absorbed into base within 15 seconds.</td></tr>
</table></td></tr>
<tr><td>Michigan DOT
(Section 303)</td><td>Major construction related items
<table>
<tr><td>Equipment</td><td>Compact with 3 passes of 10 ton (minimum) steel drum roller.</td></tr>
<tr><td>Surface Tolerance</td><td>Shall not exceed 0.75-in. deviation.</td></tr>
<tr><td>Traffic Restrictions and Curing Period</td><td>Limit vehicles and construction equipment on the layer.</td></tr>
</table></td></tr>
<tr><td>Minnesota DOT</td><td>Not available.</td></tr>
<tr><td>Missouri DOT
(Section 302)</td><td>Major construction related items
<table>
<tr><td>Equipment</td><td>Compact with 3 passes of 5 to 10 ton steel drum roller.</td></tr>
<tr><td>Plant discharge temperature</td><td>250 to 300°F</td></tr>
<tr><td>Maximum compacted layer thickness</td><td>≤ 4 in.</td></tr>
</table></td></tr>
<tr><td>Texas DOT (Item 247)</td><td>Not available.</td></tr>
</table>

<table>
<tr><th>Agency/Organization</th><th>Specification Section</th></tr>
<tr><td></td><td>Construction</td></tr>
<tr><td>Virginia DOT
(Section 313)</td><td>Major construction related items
<table>
<tr><td>Drai□down</td><td>≤ 0.3%</td></tr>
<tr><td>Equipm□nt</td><td>Vibratory rollers shall not be used. Asphalt-stabilized open-graded material shall be placed in one layer by approved equipment conforming. Compaction shall begin when the internal mat temperature is approximately 150 to 200°F. A static, steel, two-wheel roller shall compact the material in one to three passes in an established pattern. An 8- to 10-ton roller is recommended for such use. The mat shall be compacted sufficiently to support the placement of the next layer but not to the point that it is not free draining or that the aggregate is crushed.</td></tr>
<tr><td>Mix temperature</td><td>Mixtures shall be between 250 to 280°F</td></tr>
<tr><td>Surface Tolerance</td><td>The finished surface of the stabilized open-graded material shall be uniform and shall not vary at any point more than 0.5 inch above or below the grade shown on the plans.</td></tr>
<tr><td>Weather Limitations</td><td>Atmospheric temp > 40°F and the surface temp ≥ 35°F</td></tr>
<tr><td>Traffic Restrictions</td><td>The Contractor shall not use the open-graded course as a haul road or storage area. Construction tr□ffic will not be permitted on the open-graded course except for equipment required to place the next layer.</td></tr>
<tr><td>Hydraulic Efficie□cy</td><td>Stabilized open-graded material shall be designed to have an in-place coefficient of permeability of at least 1,000 feet per day when tested in accordance with VTM-84.</td></tr>
</table></td></tr>
<tr><td>Washington DOT</td><td>Not available.</td></tr>
</table>

REFERENCES

AASHTO (2008), “Guide Specifications for Highway Construction,” American Association of State Highway and Transportation Officials.
Michigan DOT (2003), “Standard Specifications for Construction,” Michigan Department of Transportation.
Mn/DOT (2005), “Mn/DOT Standard Specifications for Construction,” Minnesota Department of Transportation.
MoDOT (2004), “Missouri Standard Specifications for Highway Construction,” Missouri Department of Transportation.
TxDOT (2004), “Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges,” Texas Department of Transportation.
Virginia DOT (2007), “Road and Bridge Specifications,” Virginia Department of Transportation.
WSDOT (2010), “Standard Specifications for Road, Bridge, and Municipal Construction, M41-10, Washington State Department of Transportation.

AASHTO Specification Designation 315 "Description"
Separator Fabric for Bases

Agency/Organization	Specification Section
	Description
AASHTO (Section 315)	"Furnish and install geotextiles for subgrade separation." "Separation geotextile shall be used as a separation material to prevent mixing of dissimilar material, and to control migration of backfill material through joints in structural elements."
Michigan DOT	Not available.
Minnesota DOT	Not available.
Missouri DOT (Section 1011)	"This specification covers geotextile for use in subsurface drainage, sediment control and erosion control, or as a permeable separator."
Texas DOT	Not available.
Virginia DOT	Not available.
Washington DOT (Section 2-12)	"The Contractor shall furnish and place construction geosynthetic in accordance with the details shown in the Plans."

AASHTO Specification Designation 315 "Materials"
Separator Fabric for Bases

<table>
<tr><th rowspan="2">Agency/Organization</th><th>Specification Section</th></tr>
<tr><th>Materials</th></tr>
<tr><td>AASHTO (Section 315)</td><td>1. Separator fabric: Meet AASHTO M288 for separation.</td></tr>
<tr><td>Michigan DOT</td><td>Not available.</td></tr>
<tr><td>Minnesota DOT</td><td>Not available.</td></tr>
<tr><td>Missouri DOT
(Section 1011)</td><td>2. The material shall be either AASHTO M288 Class 1 or Class 2. [Note: Geotextile Classes 1 and 2 relate to grab, sewn seam, tear, and puncture strengths as well as permittivity.]
3. The minimum permittivity shall be 1.0 sec-1</td></tr>
<tr><td>Texas DOT</td><td>Not available.</td></tr>
<tr><td>Virginia DOT</td><td>4. Not available.</td></tr>
<tr><td>Washington DOT
(Section 2-12)</td><td>5. Geosynthetic roll identification, storage, and handling shall be in conformance to ASTM D 4873.
6. During periods of shipment and storage, the geosynthetic shall be stored off the ground.
7. The geosynthetic shall be covered at all times during shipment and storage such that it is fully protected from ultraviolet radiation including sunlight, site construction damage, precipitation, chemicals that are strong acids or strong bases, flames including welding sparks, temperatures in excess of 160 F, and any other environmental condition that may damage the physical property values of the geosynthetic.
8. Geosynthetics for separation shall conform to:
<table>
<tr><th rowspan="2">Geotextile Property</th><th rowspan="2">ASTM Test</th><th colspan="2">Geotextile Property Requirements</th></tr>
<tr><th>Woven</th><th>Nonwoven</th></tr>
<tr><td>AOS</td><td>D4751</td><td colspan="2">No. 30 max</td></tr>
<tr><td>Water Permittivity</td><td>D4491</td><td colspan="2">0.02 sec-1 min.</td></tr>
<tr><td>Grab Tensile Strength</td><td>D4632</td><td>250 lb min.</td><td>160 lb min.</td></tr>
<tr><td>Grab Failure Strain</td><td>D4632</td><td>< 50%</td><td>≥ 50%</td></tr>
<tr><td>Seam Breaking Strength</td><td>D4632</td><td>220 lb min.</td><td>140 lb min.</td></tr>
<tr><td>Puncture Resistance</td><td>D6241</td><td>495 lb min.</td><td>310 lb min.</td></tr>
<tr><td>Tear Strength</td><td>D4533</td><td>80 lb min.</td><td>50 lb min.</td></tr>
<tr><td>UV Radiation Stability</td><td>D4355</td><td colspan="2">50% strength retained minimum after 500 hours in xenon arc device.</td></tr>
</table>
</td></tr>
</table>

AASHTO Specification Designation 315 "Construction"
Separator Fabric for Bases

<table>
<tr><th rowspan="2">Agency/Organization</th><th colspan="2">Specification Section</th></tr>
<tr><th colspan="2">Construction</th></tr>
<tr><td>AASHTO
(Section 315)</td><td colspan="2">Major construction related items<table>
<tr><td>Protecting and Storing Geotextiles</td><td>Wrap geotextile in a protective covering to prevent damage during shipping and handling.</td></tr>
<tr><td>Preparing the Surface</td><td>Prepare the surface to receive the geotextile to a smooth condition, free of obstructions and debris that may damage the fabric during installation.</td></tr>
<tr><td>Placing Geotextiles</td><td>Place the fabric in the manner and at the locations shown on the plans.</td></tr>
<tr><td>Constructing Seams</td><td>To join separate geotextile sheets, either provide a minimum 18-in. overlap or provide sewn seams. If overlapped, place the fabric so that the preceding roll overlaps the following roll in the direction the base material is being spread. If sewn, ensure the seam strength is at least 70 percent of the required tensile strength of the unaged fabric.</td></tr>
<tr><td>Applying Cover Material</td><td>Cover the fabric with the base material within two weeks of its placement. Apply cover material by back dumping in a manner that prevents slippage of the fabric. Apply a minimum cover of 3 in. Bituminous mix material may be laid by a tracked laydown machine.</td></tr>
</table></td></tr>
<tr><td>Michigan DOT</td><td colspan="2">Not available.</td></tr>
<tr><td>Minnesota DOT</td><td colspan="2">Not available.</td></tr>
<tr><td>Missouri DOT
(Section 1011)</td><td colspan="2">No major construction related items listed in Section 1011.</td></tr>
<tr><td>Texas DOT</td><td colspan="2">Not available.</td></tr>
<tr><td>Virginia DOT</td><td colspan="2">Not available.</td></tr>
</table>

Agency/Organization	Specification Section
	Construction
Washington DOT (Section 2-12)	1. The area to be covered by the geosynthetic shall be graded to a smooth, uniform condition free from ruts, potholes, and protruding objects such as rocks or sticks. 2. The geosynthetic shall be spread immediately ahead of the covering operation. The geosynthetic shall not be left exposed to sunlight during installation for a total of more than 14-calendar days. The geosynthetic shall be laid smooth without excessive wrinkles. 3. Under no circumstances shall the geosynthetic be dragged through mud or over sharp objects which could damage the geosynthetic. 4. The cover material shall be placed on the geosynthetic such that the minimum initial lift thickness required will be between the equipment tires or tracks and the geosynthetic at all times. 5. Construction vehicles shall be limited in size and weight, to reduce rutting in the initial lift above the geosynthetic, to not greater than 3-inches deep to prevent overstressing the geosynthetic. Turning of vehicles on the first lift above the geosynthetic will not be permitted. 6. The geotextile shall either be overlapped a minimum of 2-feet at all longitudinal and transverse joints, or the geotextile joints shall be sewn together. The initial lift thickness shall be 6-inches or more.

REFERENCES

AASHTO (2008), "Guide Specifications for Highway Construction," American Association of State Highway and Transportation Officials.

Michigan DOT (2003), "Standard Specifications for Construction," Michigan Department of Transportation.

Mn/DOT (2005), "Mn/DOT Standard Specifications for Construction," Minnesota Department of Transportation.

MoDOT (2004), "Missouri Standard Specifications for Highway Construction," Missouri Department of Transportation.

TxDOT (2004), "Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges," Texas Department of Transportation.

Virginia DOT (2007), "Road and Bridge Specifications," Virginia Department of Transportation.

WSDOT (2010), "Standard Specifications for Road, Bridge, and Municipal Construction, M41-10, Washington State Department of Transportation.

AASHTO Specification Designation 401 "Description"
Hot Mix Asphalt Pavements

Agency/Organization	Specification Section Description
AASHTO (Section 401)	"Construct one or more courses of hot mix asphalt (HMA) mixtures on a prepared foundation."
Michigan DOT (Section 501)	"Plant mixed hot mix asphalt (HMA) consists of asphalt binder, aggregates, mineral filler, and other additives."
Minnesota DOT (Section 2360)	"This work consists of the construction of one or more pavement courses of hot plant mixed asphalt-aggregate mixture on the approved prepared foundation, base course or existing surface…"
Missouri DOT (Section 403)	"…work shall consist of providing a bituminous mixture to be placed in one or more courses on a prepared base or underlying course…"
Texas DOT (Items 340 and 341)	"Construct a pavement layer composed of a compacted, dense-graded mixture of aggregate and asphalt binder mixed hot in a mixing plant."
Virginia DOT (Sections 211 and 315)	"This work shall consist of constructing one or more courses of asphalt concrete on a prepared foundation in accordance with the requirements of these specifications and within the specified tolerances for the lines, grades, thicknesses, and cross sections shown on the plans or as established by the Engineer."
Washington DOT (Section 5-04)	"This Work shall consist of providing and placing 1 or more layers of plant-mixed hot mix asphalt (HMA) on a prepared foundation or base in accordance with these Specifications and the lines, grades, thicknesses, and typical cross-sections shown in the Plans. The manufacture of HMA may include warm mix asphalt (WMA) processes in accordance with these Specifications. WMA processes include organic additives, chemical additives, and foaming."

AASHTO Specification Designation 401 "Materials"
Hot Mix Asphalt Pavements

<table>
<tr><th rowspan="2">Agency/Organization</th><th>Specification Section</th></tr>
<tr><th>Materials</th></tr>
<tr><td>AASHTO
(Section 401)</td><td>
1. Asphalt Cement/Binder: Meet AASHTO M20 for pen graded, AASHTO M320 for PG graded, or AASHTO M226 for viscosity graded.
2. Aggregates: Major tests and properties
a. Coarse Aggregate. Meet ASTM D 692 and AASHTO M 323. Provide aggregate of crushed stone, crushed slag, crushed gravel, or natural gravel.
b. Fine Aggregate. Meet AASHTO M 29 and AASHTO M 323. Provide aggregate of natural sand, manufactured sand, stone screenings, slag screenings, or a combination of these materials.
c. Mineral Filler. Meet AASHTO M 17.
d. Lime for Asphalt Mixtures. Meet AASHTO M 303.

Maximum PG Binders: Binders stiffer than PG 82-xx should be avoided. (AASHTO M323)

Binder selection guidelines for RAP mixtures (AASHTO M323)
<table>
<tr><th>Recommended Virgin Binder Grade</th><th>RAP Percentage</th></tr>
<tr><td>No change</td><td>< 15%</td></tr>
<tr><td>One grade softer</td><td>15-25%</td></tr>
<tr><td>Follow recommendations from blending charts</td><td>≥ 25%</td></tr>
</table>
Nominal Maximum Aggregate Size: Combined aggregate shall have a NMAS of 4.75 to 19.0 mm for surface courses and no larger than 37.5 mm for HMA subsurface courses. [AASHTO M323]

Gradation Classification: Combined aggregate gradation classified as "coarse-graded" when it passes below the Primary Control Sieve (PCS). All other gradations above the PCS are "fine-graded." (AASHTO M323)
<table>
<tr><td>NMAS (mm)</td><td>37.5</td><td>25.0</td><td>19.0</td><td>12.5</td><td>9.5</td></tr>
<tr><td>PCS (mm)</td><td>9.5</td><td>4.75</td><td>4.75</td><td>2.36</td><td>2.36</td></tr>
<tr><td>PCS Control Point % Passing</td><td>47%</td><td>40%</td><td>47%</td><td>39%</td><td>47%</td></tr>
</table>
Minimum Sand Equivalent (AASHTO M323)
<table>
<tr><th>Design ESALs</th><th>Minimum Sand Equivalent (%)</th></tr>
<tr><td>< 0.3</td><td>40%</td></tr>
<tr><td>0.3 to < 3</td><td>40%</td></tr>
<tr><td>3 to < 10</td><td>45%</td></tr>
<tr><td>10 to < 30</td><td>45%</td></tr>
<tr><td>≥ 30</td><td>50%</td></tr>
</table>
</td></tr>
<tr><td>Michigan DOT
(Section 501)</td><td>Materials—refer to Section 902.</td></tr>
</table>

<table>
<tr><th>Agency/Organization</th><th>Specification Section
Materials</th></tr>
<tr><td>Minnesota DOT
(Section 2360)</td><td>Major materials related items
<table>
<tr><td>Design Air Void Content</td><td>
<table>
<tr><td>Location from surface</td><td>≤ 4-in.</td><td>>4-in.</td></tr>
<tr><td>Design Air Voids (Va)</td><td>4.0%</td><td>3.0%</td></tr>
</table>
</td></tr>
<tr><td>PG Binder Selection with RAP</td><td>
<table>
<tr><td></td><td>Specified PG</td><td colspan="2">PG to be used with RAP</td></tr>
<tr><td></td><td></td><td>≤ 20% RAP</td><td>> 20% RAP</td></tr>
<tr><td>Overlay</td><td>64-22</td><td>64-22</td><td>64-28</td></tr>
<tr><td></td><td>All others</td><td>No adjust.</td><td>No adjust.</td></tr>
<tr><td>New Const.</td><td>52-34</td><td>52-34</td><td>Not allow</td></tr>
<tr><td></td><td>58-28</td><td>58-28</td><td>58-28</td></tr>
<tr><td></td><td>58-34</td><td>58-34</td><td>Not allow</td></tr>
<tr><td></td><td>64-28</td><td>64-28</td><td>64-28</td></tr>
<tr><td></td><td>64-34</td><td>64-34</td><td>Not allow</td></tr>
<tr><td></td><td>All others</td><td>No adjust.</td><td>Not allow</td></tr>
</table>
</td></tr>
<tr><td>VMA as a function of Fine and Coarse Gradations</td><td>
<table>
<tr><th>NMAS (in.)</th><th>Fine Mix % Pass No. 8</th><th>Min VMA</th><th>Coarse Mix % Pass No. 8</th><th>Min VMA</th></tr>
<tr><td>3/8</td><td>--</td><td>15.0</td><td>--</td><td>--</td></tr>
<tr><td>½</td><td>> 47</td><td>15.0</td><td>≤ 47</td><td>14.5</td></tr>
<tr><td>¾</td><td>></td><td>14.0</td><td>≤ 39</td><td>13.5</td></tr>
<tr><td>1</td><td>> 35</td><td>13.0</td><td>≤ 35</td><td>12.5</td></tr>
</table>
</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><th>Agency/Organization</th><th>Specification Section
Materials</th></tr>
<tr><td>Missouri DOT
(Section 403)</td><td>Major materials related items
<table>
<tr><td>VMA</td><td>
<table>
<tr><th>NMAS</th><th>Minimum VMA (%)</th></tr>
<tr><td>9.5 mm</td><td>15.0</td></tr>
<tr><td>12.5mm</td><td>14.0</td></tr>
<tr><td>19.0 mm</td><td>13.0</td></tr>
<tr><td>25.0 mm</td><td>12.0</td></tr>
</table>
</td></tr>
<tr><td>RAP</td><td>Recycled Asphalt Pavement (RAP) may be used in any mixture, except SMA mixtures. Mixtures may be used with more than 30 percent virgin binder replacement provided testing according to AASHTO M 323 is included with the job mix formula that ensures the combined binder meets the grade specified in the contract. All RAP material, except as noted below, shall be tested in accordance with AASHTO TP 58, Method of Resistance of Coarse Aggregate Degradation by Abrasion in the Micro-Deval Apparatus.</td></tr>
<tr><td>Moisture Susceptibility</td><td>For all mixtures except SMA, the mixture shall have a tensile strength ratio (TSR) greater than 80 percent when compacted to 95 mm with 7 ± 0.5 percent air voids and tested in accordance with AASHTO T 283. SMA mixtures shall have a TSR greater than 80 percent when compacted to 95 mm with 6 ± 0.5 percent air voids and tested in accordance with AASHTO T 283.</td></tr>
</table></td></tr>
<tr><td>Texas DOT
(Item 340 and 341—Dense Graded Hot Mix Asphalt (Method) and (QC/QA)</td><td>
<table>
<tr><td>Sand Equivalent</td><td>For combined aggregate, the minimum SE shall be 45%.</td></tr>
<tr><td>RAP</td><td>RAP is salvaged, milled, pulverized, broken, or crushed asphalt pavement. Crush or break RAP so that 100% of the particles pass the 2-in. sieve.

When RAP is allowed by plan note, use no more than 30% RAP in Type A or B mixtures [Coarse and Fine Base mixes] unless otherwise shown on the plans. For all other mixtures, use no more than 20% RAP unless otherwise shown on the plans.</td></tr>
<tr><td>VMA</td><td>
<table>
<tr><th>Aggregate Desc.</th><th>Approx. NMAS</th><th>Design VMA, min %</th><th>Plant Produced VMA, min %</th></tr>
<tr><td>Coarse Base (A)</td><td>37.5 mm</td><td>12.0</td><td>11.0</td></tr>
<tr><td>Fine Base (B)</td><td>25.0</td><td>13.0</td><td>12.0</td></tr>
</table>
</td></tr>
</table></td></tr>
</table>

Agency/Organization	Specification Section
	Materials

		mm		
	Coarse Surface (C)	19.0 mm	14.0	13.0
	Fine Surface (D)	12.5 mm	15.0	14.0
	Fine Surface (E)	9.5 mm	16.0	15.0

Hamburg Wheel Test Requirements

PG High Temp Grade	Minimum Number of Passes @ 0.5" Rut Depth, Tested @ 122°F
PG 64 or lower	10,000
PG 70	15,000
PG 76 or higher	20,000

<table>
<tr><th>Agency/Organization</th><th colspan="2">Specification Section</th></tr>
<tr><th></th><th colspan="2">Materials</th></tr>
<tr><td>Virginia DOT (Sections 211 and 315)</td><td colspan="2">
<table>
<tr><td>Mix Tensile Strength Ratio (Section 211)</td><td>The mixture shall produce a tensile strength ratio (TSR) not less than 0.80 for the design and production tests. The TSR shall be determined in accordance with AASHTO T283…</td></tr>
<tr><td>Mixes and PG Binders (Section 211)</td><td>
<table>
<tr><th>Mix</th><th>ESALs (millions)</th><th>PG Binder</th></tr>
<tr><td>9.0 mm</td><td>0 – 3</td><td>64-22</td></tr>
<tr><td></td><td>3 – 10</td><td>70-22</td></tr>
<tr><td></td><td>> 10</td><td>76-22</td></tr>
<tr><td>9.5 mm</td><td>0 – 3</td><td>64-22</td></tr>
<tr><td></td><td>3 – 10</td><td>70-22</td></tr>
<tr><td></td><td>> 10</td><td>76-22</td></tr>
<tr><td>12.5 mm</td><td>0 – 3</td><td>64-22</td></tr>
<tr><td></td><td>3 – 10</td><td>70-22</td></tr>
<tr><td></td><td>> 10</td><td>76-22</td></tr>
<tr><td>19,0</td><td><10</td><td>64-22</td></tr>
<tr><td></td><td>≥ 10</td><td>70-22</td></tr>
<tr><td>25.0</td><td>≥ 10</td><td>70-22</td></tr>
</table>
</td></tr>
<tr><td>RA (Section 211)</td><td>RAP shall be processed in such a manner as to ensure that the maximum top size introduced into the mix shall be 2 inches.</td></tr>
<tr><td>PG Grades and RAP (Section 211)</td><td>
<table>
<tr><th rowspan="2">Mix Type by NMAS</th><th colspan="2">% RAP in Mix</th></tr>
<tr><th>0 – 20%</th><th>> 20%</th></tr>
<tr><td>9.0, 9.5 and 12.5 mm (9.0 and 9.5 mm mixes are considered as NMAS = 9.5 mm)</td><td>64-22
70-22
76-22</td><td>58-28
64-28
70-28</td></tr>
<tr><td>19 mm</td><td>64-22
70-22</td><td>58-28
64-28</td></tr>
<tr><td>25 mm</td><td>64-22
70-22</td><td>64-22
70-22</td></tr>
</table>
Other conditions and exceptions apply. Refer to VDOT 211 for additional details.
</td></tr>
<tr><td>Design Air Voids, Va (Section 211)</td><td>Asphalt content should be selected at 4.0% air voids.</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><th>Agency/Organization</th><th>Specification Section</th></tr>
<tr><td></td><td>Materials</td></tr>
<tr><td>Washington DOT
(Sections 5-04
and 9-03)</td><td>Major materials related items
<table>
<tr><td>RAP</td><td>The Contractor may choose to utilize recycled asphalt pavement (RAP) in the production of HMA. If utilized, the amount of RAP shall not exceed 20-percent of the total weight of the HMA. The RAP may be from pavements removed under the Contract, if any, or pavement material from an existing stockpile.</td></tr>
<tr><td>Warm Mix Asphalt</td><td>The Contractor may use warm mix asphalt (WMA) processes in the production of HMA. The Contractor shall submit to the Engineer for approval the process that is proposed and how it will be used in the manufacture of HMA.</td></tr>
<tr><td>Gradation</td><td>
<table>
<tr><th colspan="5">Aggregate Gradation Control Points</th></tr>
<tr><th>Sieve
%
Passing</th><th>3/8 in.</th><th>½ in.</th><th>¾ in.</th><th>1 in.</th></tr>
<tr><td>1.5 in.</td><td></td><td></td><td></td><td>100</td></tr>
<tr><td>1.0 in.</td><td></td><td></td><td>100</td><td>90-100</td></tr>
<tr><td>0.75 in.</td><td></td><td>100</td><td>90-100</td><td>90 max</td></tr>
<tr><td>0.5 in.</td><td>100</td><td>90-100</td><td>90 max</td><td></td></tr>
<tr><td>0.375
in.</td><td>90-100</td><td>90 max</td><td></td><td></td></tr>
<tr><td>No. 4</td><td>90 max</td><td></td><td></td><td></td></tr>
<tr><td>No. 8</td><td>32-67</td><td>28-58</td><td>23-49</td><td>19-45</td></tr>
<tr><td>No. 200</td><td>2.0-7.0</td><td>2.0-7.0</td><td>2.0-7.0</td><td>1.0-7.0</td></tr>
</table>
</td></tr>
</table>
</td></tr>
</table>

AASHTO Specification Designation 401 "Construction"
Hot Mix Asphalt Pavements

<table>
<tr><th>Agency/Organization</th><th colspan="2">Specification Section</th></tr>
<tr><th></th><th colspan="2">Construction</th></tr>
<tr><td>AASHTO
(Section 401)</td><td colspan="2">Major construction related items
<table>
<tr><td>Spreading and Placing</td><td>Offset longitudinal joints 6 to 12 in. from the joint in the layer immediately below. Create the longitudinal joint in the top layer along the centerline of two-lane highways or at the lane lines of roadways with more than two lanes.</td></tr>
<tr><td>HMA Placement Temperature Limitations</td><td>
<table>
<tr><th>Paving Course</th><th>Thickness (in.)</th><th>Min Air Temp (°F)</th><th>Surface Temp (°F)</th></tr>
<tr><td>Surface</td><td>All</td><td>50</td><td>55</td></tr>
<tr><td>Subsurface</td><td>< 3</td><td>40</td><td>45</td></tr>
<tr><td>Subsurface</td><td>≥ 3</td><td>30</td><td>35</td></tr>
</table>
</td></tr>
<tr><td>Compaction</td><td>Achieve the minimum [92] percent of theoretical maximum density. Discontinue paving if unable to achieve the specified density before the mixture cools to 175°F.</td></tr>
<tr><td>Joint□s</td><td>Apply a tack coat on transverse and longitudinal joint contact surfaces immediately before paving. Stagger longitudinal and transverse joints on succeeding lifts approximately 6 in. Construct all longitudinal joints within 12 in. of the lane lines.</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><th>Agency/Organization</th><th>Specification Section
Construction</th></tr>
<tr><td>Michigan DOT
(Section 502)</td><td>Major construction related items
<table>
<tr><td>Transportation of Mixtures</td><td>Do not place crusted HMA in the paver.</td></tr>
<tr><td>Laydown Temperatures</td><td>Reject all loads having a temperature below 250°F or above 350°F at time of discharge from the hauling unit. A tolerance of ± 20°F from the specified target placement temperature is acceptable (see table below)
<table>
<tr><th rowspan="3">Temperature of Surface Overlaid (°F)</th><th colspan="3">Application of HMA Material (lb/SY)</th></tr>
<tr><th>< 120</th><th>120-200</th><th>> 200</th></tr>
<tr><th colspan="3">Target Placement Temperatures (°F)</th></tr>
<tr><td>35-39</td><td></td><td></td><td>330</td></tr>
<tr><td>40-49</td><td></td><td>330</td><td>315</td></tr>
<tr><td>50-59</td><td>330</td><td>315</td><td>300</td></tr>
<tr><td>60-69</td><td>315</td><td>300</td><td>285</td></tr>
<tr><td>70-79</td><td>300</td><td>285</td><td>270</td></tr>
<tr><td>80-89</td><td>285</td><td>270</td><td>270</td></tr>
<tr><td>≥ 90</td><td>270</td><td>270</td><td>270</td></tr>
</table></td></tr>
<tr><td>Paving Temperatures</td><td>When the temperature of the mat immediately behind the screed falls below 200°F, stop paving and place a transverse construction joint. If the temperature of the mat falls below 190°F before any rolling, remove and replace the mat.</td></tr>
<tr><td>Longitudinal Joints</td><td>Construct either vertical or tapered longitudinal joints.</td></tr>
<tr><td>Smoothness</td><td>Use a 10-ft. straightedge. Allowable deviations are:
• Base course mixtures: 3/8 to ¾-in.
• Leveling and top course mixtures: 1/8 to ¼-in.</td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Agency/Organization</th><th>Specification Section
Construction</th></tr>
<tr><td>Minnesota DOT
(Section 2360)</td><td>Major construction related items
<table>
<tr><td>Tack Coat</td><td>An asphalt tack coat shall be applied to existing asphalt and concrete surfaces, and to the surface of each course or lift constructed.</td></tr>
<tr><td>Compaction</td><td>Rollers shall not stand on the uncompacted or newly rolled pavement with a surface temperature > 140°F.</td></tr>
<tr><td>Minimum lift thicknesses</td><td>
<table>
<tr><th>Aggregate Size</th><th>Thickness (in.)</th></tr>
<tr><td>3/8-in.</td><td>¾-in.</td></tr>
<tr><td>½ and ¾-in.</td><td>1.5-in.</td></tr>
<tr><td>1-in.</td><td>2.5-in.</td></tr>
</table>
</td></tr>
<tr><td>Compaction Pay Schedule</td><td>
<table>
<tr><th>% Gmm
Depth from surface
≤ 4-in.</th><th>% Gmm
Depth from surface
> □-in.</th><th>%
Payment</th></tr>
<tr><td>≥ 93.6</td><td>≥ 94.6</td><td>104</td></tr>
<tr><td>93.1 - 93.5</td><td>94.1 - 94.5</td><td>102</td></tr>
<tr><td>92.0 - 93.0</td><td>93.0 - 94.0</td><td>100</td></tr>
<tr><td>91.0 - 91.9</td><td>92.0- 92.9</td><td>98</td></tr>
<tr><td>90.5 - 90.9</td><td>91.5 - 91.9</td><td>95</td></tr>
<tr><td>90.0 - 90.4</td><td>91.0 - 91.4</td><td>91</td></tr>
<tr><td>89.5 - 89.9</td><td>90.5 - 90.9</td><td>85</td></tr>
<tr><td>89.0 - 89.4</td><td>90.0 - 90.4</td><td>70</td></tr>
<tr><td>Less than 89.0</td><td>Less than 90.0</td><td>Other</td></tr>
</table>
Average % Gmm for a lot.
</td></tr>
</table>
</td></tr>
<tr><td>Missouri DOT
(Section 403)</td><td>Major construction related items
<table>
<tr><td>Joints</td><td>Longitudinal joints shall be formed by the use of an edging plate fixed on both sides of the finishing machine. The minimum density of all traveled way pavement within 6 inches of a longitudinal joint, including the pavement on the traveled way side of the shoulder joint, shall not be less than 2.0 percent below the specified density when unconfined.</td></tr>
<tr><td>Traffic</td><td>The contractor shall keep traffic off the asphaltic concrete until the surface of the asphaltic concrete is ≤ 140°F.</td></tr>
<tr><td>Rollers/Rolling HMA</td><td>Rollers shall not be used in the vibratory mode when the mixture temperature is below 225°F. When warm mix technology is used, rollers shall not be used in the vibratory mode when the mixture temperature is below 200°F.</td></tr>
<tr><td>HMA Density</td><td>The final, in-place density of the mixture shall be 94.5 ± 2.5 percent of the theoretical maximum specific gravity for all mixtures except SMA. SMA mixtures shall have a minimum density of 94.0 percent of the theoretical maximum specific gravity.</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><th>Agency/Organization</th><th colspan="2">Specification Section
Construction</th></tr>
<tr><td>Texas DOT
(Items 340 and 341)</td><td colspan="2">
<table>
<tr><td>Weather Conditions (Items 340 and 341)</td><td>Place mixture when the roadway surface temperature is ≥ 60°F unless otherwise approved. Measure the roadway surface temperature with a handheld infrared thermometer.</td></tr>
<tr><td>Minimum Placement Temp (Suggested) (Item 340)</td><td>
<table>
<tr><th>High Temp PG Grade</th><th>Minimum Placement Temperature (Before Entering Paver)</th></tr>
<tr><td>PG 64 or lower</td><td>260°F</td></tr>
<tr><td>PG 70</td><td>270°F</td></tr>
<tr><td>PG 76</td><td>280°F</td></tr>
<tr><td>PG 82 or higher</td><td>290°F</td></tr>
</table>
</td></tr>
<tr><td>Maximum Production Temperature (Item 341)</td><td>TxDOT will not pay for or allow placement of any mixture produced at more than 350°F.</td></tr>
<tr><td>Air Void Control (Item 340)</td><td>Compact dense-graded hot-mix asphalt to contain from 5% to 9% in-place air voids. Do not increase the asphalt content of the mixture to reduce pavement air voids.</td></tr>
<tr><td>Segregation (Density Profile) (Item 341)</td><td>Unless otherwise approved, perform a density profile every time the screed stops, on areas that are identified by either the Contractor or the Engineer as having thermal segregation, and on any visibly segregated areas. If the temperature differential is greater than 25°F, the area will be deemed as having thermal segregation. Take corrective action to eliminate areas that have thermal segregation. Unless otherwise directed, suspend operations if the maximum temperature differential exceeds 50°F. Criteria are:
<table>
<tr><th>Mixture Type</th><th>Max Allowable Density Range (Highest to Lowest)</th><th>Max Allowable Density Range (Average to Lowest)</th></tr>
<tr><td>Types A and B</td><td>8.0 pcf</td><td>5.0 pcf</td></tr>
<tr><td>Types C, D and E</td><td>6.0 pcf</td><td>3.0 pcf</td></tr>
</table>
Tex-244-F “Thermal Profile of Hot Mix Asphalt” requires the use of one of three temperature measurement systems:
1. Non-contact infrared thermometer
2. Thermal camera behind the paver
3. Paver mounted infrared bar (Pave-IR system)
The temperature measurements are applied to 150 ft. longitudinally measure portion of the mat behind the paver.</td></tr>
<tr><td>Longitudinal Joint Density (Item 341)</td><td>While establishing the rolling pattern, perform joint density evaluations and verify that the joint density is no more than 3.0 pcf below the density taken at or near the center of the mat. Adjust the rolling pattern if needed to achieve the desired joint density. Perform additional joint density evaluations at least once per sublot unless otherwise directed.</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><th>Agency/Organization</th><th>Specification Section
Construction</th></tr>
<tr><td>Virginia DOT
(Section 315)</td><td>
<table>
<tr><td>HMA Placement and t/NMAS</td><td>Asphalt concrete SUPERPAVE pavement courses shall be placed in layers ≤ 4.0 times the nominal maximum size aggregate in the asphalt mixture. The minimum thickness for a pavement course shall be ≥ 2.5 times the nominal maximum size aggregate in the asphalt mixture.</td></tr>
<tr><td>Longitudinal Joints</td><td>The longitudinal joint in one layer shall offset that in the layer immediately below by approximately 6 inches. However, the joint in the wearing surface shall be at the centerline of the pavement…</td></tr>
<tr><td>Transverse Joints</td><td>Transverse joints shall be formed by cutting back on the previous run to expose the full depth of the course. A coat of asphalt shall be applied to contact surfaces of transverse joints just before additional mixture is placed against the previously rolled material.</td></tr>
<tr><td>Surface Tolerance</td><td>The surface will be tested by using a 10-foot straightedge. The variation of the surface from the testing edge of the straightedge between any two contacts with the surface shall be not more than 1/4 inch.</td></tr>
<tr><td>Density Requirements and Payment</td><td>
<table>
<tr><th>Mix Type</th><th>Minimum Control Strip Density as a function of % of TMD</th></tr>
<tr><td>9.5 to 12.5 mm</td><td>92.2 to 92.5%</td></tr>
<tr><td>19.0 mm</td><td>92.0 to 92.2%</td></tr>
<tr><td>25.0 mm</td><td>91.5%</td></tr>
</table>
The control strip density is a function of design ESAL levels which are not shown.
<table>
<tr><th>% of Target Control Strip Density</th><th>% of Payment</th></tr>
<tr><td>> 102</td><td>95</td></tr>
<tr><td>98 to 102</td><td>100</td></tr>
<tr><td>97 to < 98</td><td>95</td></tr>
<tr><td>96 to < 97</td><td>90</td></tr>
<tr><td>< 96</td><td>75</td></tr>
</table>
</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><th>Agency/Organization</th><th>Specification Section
Construction</th></tr>
<tr><td>Washington DOT
(Section 5-04)</td><td>
<table>
<tr><td>MTV</td><td>1. Direct transfer of HMA from the hauling equipment to the paving machine will not be allowed in the top 0.30-feet of the pavement section of hot mix asphalt (HMA) used in traffic lanes with a depth of 0.08-feet or greater. A material transfer device or vehicle (MTD/V) shall be used to deliver the HMA from the hauling equipment to the paving machine.
2. HMA placed in irregularly shaped and minor areas such as road approaches, tapers, and turn lanes are excluded from this requirement.
3. The MTD/V shall mix the HMA after delivery by the hauling equipment and prior to laydown by the paving machine. Mixing of the HMA shall be sufficient to obtain a uniform temperature throughout the mixture.
4. If a windrow elevator is used, the length of the windrow may be limited in urban areas or through intersections, at the discretion of the Project Engineer.</td></tr>
<tr><td>Cyclic Density</td><td>1. The Project Engineer may also evaluate the HMA for low cyclic density of the pavement in accordance with WSDOT procedures. Low cyclic density areas are defined as spots or streaks in the pavement that are less than 90.0-percent of the reference maximum density.
2. A $500 price adjustment will be assessed for any 500-foot section with two or more density readings below 90.0-percent of the reference maximum density.</td></tr>
<tr><td>Long. Joint Density</td><td>1. The Project Engineer will evaluate the HMA wearing surface for low density at the longitudinal joint in accordance with WSDOT procedures. Low density is defined as less than 90.0-percent of the reference maximum density.
2. If one density reading, at either longitudinal joint, is below 90.0-percent of the reference maximum density, a $200 price adjustment will be assessed for that sublot.</td></tr>
</table>
</td></tr>
<tr><td>NCAT
(Brown, et al, 2004)</td><td>Recommendations included:
1. For fine-graded HMA: lift thickness/Nominal Maximum Aggregate Size (or t/NMAS) ≥ 3.0
2. For coarse-graded HMA: t/NMA ≥ 4.0
3. For SMA mixes: t/NMA ≥ 4.0</td></tr>
<tr><td></td><td>Coarse and fine-graded mixes as defined by NAPA
<table>
<tr><th>Mixture NMAS</th><th>Coarse-Graded</th><th>Fine-Graded</th></tr>
<tr><td>25.0 mm</td><td>< 40% Passing 4.75 sieve</td><td>> 40% Passing 4.75 sieve</td></tr>
<tr><td>19.0 mm</td><td>< 35% Passing 2.36 sieve</td><td>> 35% Passing 2.36 sieve</td></tr>
<tr><td>12.5 mm</td><td>< 40% Passing 2.36 sieve</td><td>> 40% Passing 2.36 sieve</td></tr>
<tr><td>9.5 mm</td><td>< 45% Passing 2.36 sieve</td><td>> 45% Passing 2.36 sieve</td></tr>
</table>
Source for table: National Asphalt Pavement Association, Information Series 128, “HMA
Pavement Mix Type Selection Guide.” Control sieves and % passing are similar to AASHTO 401 but are not identical.</td></tr>
</table>

REFERENCES

AASHTO (2008), “Guide Specifications for Highway Construction,” American Association of State Highway and Transportation Officials.

Brown, R., Hainin, R., Cooley, A., and Hurley G. (2004), “Relationship of Air Voids, Lift Thickness, and Permeability in Hot Mix Asphalt Pavements,” Report 531, National Cooperative Highway Research Program, Transportation Research Board.

Michigan DOT (2003), “Standard Specifications for Construction,” Michigan Department of Transportation.

Mn/DOT (2005), “Mn/DOT Standard Specifications for Construction,” Minnesota Department of Transportation.

MoDOT (2004), “Missouri Standard Specifications for Highway Construction,” Missouri Department of Transportation.

TxDOT (2004), “Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges,” Texas Department of Transportation.

Virginia DOT (2007), “Road and Bridge Specifications,” Virginia Department of Transportation.

WSDOT (2010), “Standard Specifications for Road, Bridge, and Municipal Construction, M41-10, Washington State Department of Transportation.

AASHTO Specification Designation 404 "Description"
Tack Coat

Agency/Organization	Specification Section
	Description
AASHTO (Section 404)	"Apply an asphalt binder tack coat to a prepared existing surface."
Michigan DOT (Section 501)	"Apply the bond coat uniformly to the clean, dry, surface with a pressure distributor."
Minnesota DOT (Section 2357)	"This work shall consist of treating an existing bituminous or concrete surface with bituminous material preparatory to placing a bituminous course or seal coat thereon."
Missouri DOT (Section 407)	"This work shall consist of preparing and treating an existing bituminous or concrete surface with bituminous material, and blotter material if required, in accordance with these specifications, as shown on the plans or as directed by the engineer."
Texas DOT (Item 340)	The tack specification was largely contained within Item 340 "Dense-Graded Hot Mix Asphalt."
Virginia DOT (Section 310)	"This work shall consist of preparing and treating an existing asphalt or concrete surface with asphalt in accordance with the requirements of these specifications and in conformity with the lines shown on the plans or as established by the Engineer."
Washington DOT (Section 5-04)	Tack coat requirements are contained in Section 5-04 "Hot Mix Asphalt."

AASHTO Specification Designation 404 "Materials"
Tack Coat

<table>
<tr><th>Agency/Organization</th><th>Specification Section
Materials</th></tr>
<tr><td>AASHTO
(Section 404)</td><td>1. AASHTO references to Section 702 which lists:
a. Asphalt cements/binders: AASHTO M20, M320, or M226.
b. Cutback asphalt: AASHTO M81 for rapid cure and AASHTO M82 for medium cure.
c. Emulsified asphalt: AASHTO M140 or M208.
2. Temperature application ranges—see table
<table>
<tr><th>Type and Grade of Material</th><th>Spray Temperature (°F)</th></tr>
<tr><td>RC 70</td><td>80 – 150</td></tr>
<tr><td>RC 250</td><td>100 – 175</td></tr>
<tr><td>RC 800</td><td>160 – 225</td></tr>
<tr><td>RC 3000</td><td>200 – 275</td></tr>
<tr><td>MC 30</td><td>50 – 120</td></tr>
<tr><td>MC 70</td><td>80 – 150</td></tr>
<tr><td>MC 250</td><td>100 – 200</td></tr>
<tr><td>MC 800</td><td>185 – 260</td></tr>
<tr><td>MC 3000</td><td>225 – 275</td></tr>
<tr><td>All Emulsions</td><td>50 – 160</td></tr>
<tr><td>Asphalt Cements (all grades)</td><td>400 max</td></tr>
</table></td></tr>
<tr><td>Michigan DOT</td><td>Additional details are provided in MDOT Sections 506 and 507 but the applications are slurry seals and micro-surfacing, respectively.</td></tr>
<tr><td>Minnesota DOT
(Section 2357)</td><td>Tack coats are typically limited to use of emulsified asphalts except during freezing weather:
Anionic..... SS-1, SS-1H, MS-2, RS-1, RS-2
Cationic..... CSS-1, CSS-1H, CRS-1, CRS-2</td></tr>
<tr><td>Missouri DOT
(Section 407)</td><td>Emulsified asphalts are used and can include SS-1, SS-1H, CSS-1 or CSS-1H).</td></tr>
<tr><td>Texas DOT (Item 340)</td><td>1. Use CSS-1H, SS-1H, or a PG binder with a minimum high-temperature grade of PG 58 for tack coat binder in accordance with Item 300.
2. Do not dilute emulsified asphalts at the terminal, in the field, or at any other location before use.</td></tr>
<tr><td>Virginia DOT
(Section 310)</td><td>1. Asphalt for tack coat shall be CRS-1, CRS-2, CRS-1h, or CSS-1h.
2. CMS-2 may be used during the winter months. CMS-2 is not allowed to be diluted
3. Asphalt for tack coat may be diluted with 50 percent water provided that resulting material produces a uniform application of the tack.</td></tr>
<tr><td>Washington DOT</td><td>1. Unless otherwise approved by the Engineer, the tack coat shall be CSS-1, CSS-1h, or STE-1 emulsified asphalt.
2. The CSS-1 and CSS-1h emulsified asphalt may be diluted with water at a rate not to exceed 1-part water to 1-part emulsified asphalt.
3. The tack coat shall not exceed the maximum temperature recommended by the emulsified asphalt manufacturer.</td></tr>
</table>

AASHTO Specification Designation 404 "Construction"
Tack Coat

<table>
<tr><th>Agency/Organization</th><th>Specification Section</th></tr>
<tr><td></td><td>Construction</td></tr>
<tr><td>AASHTO (Section 404)</td><td>Major construction related items
<table>
<tr><td>Weather Limitations</td><td>Apply tack coat during dry weather only.</td></tr>
<tr><td>Equipment</td><td>Distributors. Use a distributor capable of uniformly dispensing asphalt to the required section at a pressure from [0.05 to 2.0 ± 0.02 gal/yd2]. Maintain uniform asphalt temperature. Equip distributors with a tachometer, pressure gauges, volume-measuring devices or a calibrated tank, tank thermometer, power unit for the pump, and full circulation spray bars adjustable laterally and vertically.</td></tr>
<tr><td>Prepare Existing Surface</td><td>Patch, clean, and remove irregularities from all surfaces to receive tack coat. Remove loose materials.</td></tr>
<tr><td>Applying Asphalt</td><td>Use a calibrated pressure distributor to apply a uniform tack coat. Tack irregular or inaccessible areas using hand-hose application methods. Apply at a rate of [0.033 to 0.15 gal/yd2]. Obtain approval before diluting emulsified asphalt.</td></tr>
</table></td></tr>
<tr><td>Michigan DOT
(Section 501)</td><td>Major construction related items
<table>
<tr><td>Application</td><td>Apply the bond coat to each layer of HMA and to the vertical edge of the adjacent pavement before placing subsequent layers.</td></tr>
<tr><td>Weather and Seasonal Limitations</td><td>Do not place HMA or apply bond coat when precipitation is imminent or when moisture on the existing surface will prevent satisfactory curing.</td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Agency/Organization</th><th>Specification Section</th></tr>
<tr><td></td><td>Construction</td></tr>
<tr><td>Minnesota DOT
(Section 2357)</td><td>Major construction related items
<table>
<tr><td>Road Surface Preparation</td><td>At the time of applying bituminous material, the road surface shall be dry and clean, and all necessary repairs or reconditioning work shall have been completed. All objectionable foreign matter on the road surface shall be removed and disposed of by the Contractor as the Engineer approves. Preparatory to placing an abutting bituminous course, the contact surfaces of all fixed structures and the edge of the in-place mixture in all courses at transverse joints and in the wearing course at longitudinal joints shall be given a uniform coating of liquid asphalt or emulsified asphalt, applied by methods that will ensure uniform</td></tr>
<tr><td>Application Rates</td><td>The bituminous material shall be applied at a uniform rate not to exceed:
(1) 0.05 gallon per square yard for cutback asphalt and undiluted asphalt emulsion (as supplied from the refinery).
(2) 0.20 gallon per square yard for diluted asphalt emulsion (with water added in the field).</td></tr>
<tr><td>Application Temperatures</td><td>Emulsified Asphalts (1) SS-1, SS-1H, MS-2, CSS-1, CSS-1H: 70 to 160ºF, (2) RS-1: 70 to 140ºF, and (3) SS-2, CRS-1, CRS-2: 120 to 185ºF</td></tr>
<tr><td>Dilution with Water</td><td>Grades SS-1, SS-1H, CSS-1, and CSS-1H: water may be added up to 50 percent by volume to improve the material application and distribution characteristics. However, the added water will be excluded from the pay quantities.</td></tr>
</table></td></tr>
<tr><td>Missouri DOT
(Section 407)</td><td>Major construction related items
<table>
<tr><td>Preparation of Surface</td><td>The existing surface shall be free of all dust, loose material, grease or other foreign material at the time the tack is applied.</td></tr>
<tr><td>Application Rates</td><td>Asphalt emulsion shall be applied uniformly with a pressure distributor at the rate specified in the contract or as revised by the engineer to be within a minimum of 0.02 gallon per square yard and a maximum of 0.10 gallon per square yard.</td></tr>
<tr><td>Dilution with Water</td><td>Water may be added to the asphalt emulsion in such a proportion that the resulting mixture will contain no more than 50 percent of added water. The contractor shall notify the engineer of the exact quantity of added water. The application of the resulting mixture shall be such that the original emulsion will be spread at the specified rate.</td></tr>
</table></td></tr>
</table>

<table>
<tr><th rowspan="2">Agency/Organization</th><th>Specification Section</th></tr>
<tr><th>Construction</th></tr>
<tr><td>Texas DOT (Item 340)</td><td>Major construction related items
<table>
<tr><td>Preparation of Surface</td><td>Clean the surface before placing the tack coat.</td></tr>
<tr><td>Application Rates</td><td>Unless otherwise approved, apply tack coat uniformly at the rate directed by the Engineer. The Engineer will set the rate between 0.04 and 0.10 gal. of residual asphalt per square yard of surface area.</td></tr>
<tr><td>Tacked Surfaces</td><td>Apply a thin, uniform tack coat to all contact surfaces of curbs, structures, and all joints.</td></tr>
<tr><td>Adhesion Properties</td><td>The Engineer may use Tex-243-F to verify that the tack coat has adequate adhesive properties.</td></tr>
</table></td></tr>
<tr><td>Virginia DOT
(Section 310)</td><td>Major construction related items
<table>
<tr><td>Preparation of Surface</td><td>The existing surface shall be patched, cleaned, and rendered free from irregularities to the extent necessary to provide a reasonably smooth and uniform surface.</td></tr>
<tr><td>Tacked Surfaces</td><td>The edges of existing pavements that are to be adjacent to new pavement shall be cleaned to permit adhesion of asphalt.</td></tr>
<tr><td>Application Rates</td><td>Undiluted asphalt shall be applied at the rate of 0.05 to 0.10 gallons per square yard. Diluted asphalt shall be applied at the rate of 0.10 to 0.15 gallons per square yard.</td></tr>
</table></td></tr>
<tr><td>Washington DOT
(Section 5-04)</td><td>1. A tack coat of asphalt shall be applied to all paved surfaces on which any course of HMA is to be placed or abutted.
2. Tack coat shall be uniformly applied to cover the existing pavement with a thin film of residual asphalt free of streaks and bare spots. A heavy application of tack coat shall be applied to all joints.
3. For Roadways open to traffic, the application of tack coat shall be limited to surfaces that will be paved during the same working shift.
4. The spreading equipment shall be equipped with a thermometer to indicate the temperature of the tack coat material.
5. Equipment shall not operate on tacked surfaces until the tack has broken and cured. If the Contractor’s operation damages the tack coat it shall be repaired prior to placement of the HMA.</td></tr>
</table>

REFERENCES

AASHTO (2008), “Guide Specifications for Highway Construction,” American Association of State Highway and Transportation Officials.
Michigan DOT (2003), “Standard Specifications for Construction,” Michigan Department of Transportation.
Mn/DOT (2005), “Mn/DOT Standard Specifications for Construction,” Minnesota Department of Transportation.
MoDOT (2004), “Missouri Standard Specifications for Highway Construction,” Missouri Department of Transportation.
TxDOT (2004), “Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges,” Texas Department of Transportation.
Virginia DOT (2007), “Road and Bridge Specifications,” Virginia Department of Transportation.
WSDOT (2010), “Standard Specifications for Road, Bridge, and Municipal Construction, M41-10, Washington State Department of Transportation.

AASHTO Specification Designation 409 "Description"
Cold Milling Asphalt Pavement

Agency/Organization	Specification Section
	Description
AASHTO (Section 409)	"Cold mill and remove existing asphalt pavement."
Michigan DOT (Section 502)	No specific description. Cold Milling specification information largely contained in MDOT Section 502 "Hot Mix Asphalt Construction Practices."
Minnesota DOT (Section 2232)	"This work shall consist of improving the profile, cross slope, and surface texture of an existing pavement surface by machine (cold) milling preparatory to placement of another course thereon.
Missouri DOT	No information found.
Texas DOT	No files available.
Virginia DOT	No files available.
Washington DOT	No specification available.

AASHTO Specification Designation 409 "Materials"
Cold Mill Asphalt Pavement

Agency/Organization	Specification Section
	Materials
AASHTO (Section 409)	AASHTO does not list any materials related specifications for Section 409.
Michigan DOT (Section 502)	MDOT does not list any materials related specifications for cold milled asphalt pavement.
Minnesota DOT (Section 2232)	MnDOT does not list any materials related specifications for cold milled asphalt pavement.
Missouri DOT	No available information found.
Texas DOT	No files available.
Virginia DOT	No files available.
Washington DOT	No specification available.

AASHTO Specification Designation 409 "Construction"
Cold Mill Asphalt Pavement

<table>
<tr><th>Agency/Organization</th><th>Specification Section
Construction</th></tr>
<tr><td>AASHTO (Section 409)</td><td>Major construction related items
<table>
<tr><td>Milling Equipment</td><td>Use self-propelled milling equipment capable of maintaining accurate cut depth and slope. Ensure the equipment can accurately and adequately establish profile grade and control cross slope. Equip the milling machine with integral material pickup and truck discharges, if specified. Ensure the milling machine has effective means for dust control.</td></tr>
<tr><td>Milling Operations</td><td>Cold mill the existing pavement to the specified profile grade and cross section. Taper the transverse joint at the end of each day's run. Unless specified otherwise, dispose of the reclaimed pavement in a manner approved by the Engineer.</td></tr>
<tr><td>Surface Tests</td><td>Meet the specified surface tolerance, as verified using a 10-ft rolling straightedge operated parallel to centerline. Ensure no variation greater than [1/4 in.]</td></tr>
</table></td></tr>
<tr><td>Michigan DOT (Section 502)</td><td>Major construction related items
<table>
<tr><td>Milling Equipment</td><td>Equipment must consistently remove the HMA surface, in one or more passes, to the required grade and cross section producing a uniformly textured surface. Machines must be equipped with all of the following:
• Automatically controlled and activated cutting drums
• Grade reference and transverse slope control capabilities
• An approved grade referencing attachment, not less than 30 feet in length. An alternate grade referencing attachment may be used if approved by the Engineer prior to use.</td></tr>
<tr><td>Milling Operations</td><td>1. Remove the HMA surface to the depth, width, grade, and cross section specified. Backfill, and compact, all depressions left by removal of material below the specified grade.
2. Immediately after cold-milling, clean the surface. Dispose of the material removed from the surface. Do not incorporate the material into the HMA.</td></tr>
</table></td></tr>
</table>

<table>
<tr><th rowspan="2">Agency/Organization</th><th colspan="2">Specification Section</th></tr>
<tr><th colspan="2">Construction</th></tr>
<tr><td>Minnesota DOT
(Section 2232)</td><td colspan="2">Major construction related items
<table>
<tr><td>Milling Equipment</td><td>Pavement milling shall be accomplished with a power operated, self-propelled cold milling machine capable of removing concrete and bituminous surface material as necessary to produce the required profile, cross slope, and surface texture uniformly across the pavement surface. The machine shall also be equipped with means to control dust and other particulate matter created by the cutting action.

The machine shall be equipped to accurately and automatically establish profile grades along each edge of the machine, within plus or minus 1/8 inch, by referencing from the existing pavement by means of a ski or matching shoe, or from an independent grade control. The machine shall be controlled by an automatic system for controlling grade, elevation, and cross slope at a given rate.</td></tr>
<tr><td>Milling Operations</td><td>The pavement surface shall be milled to the depth, width, grade, and cross slope as shown in the Plans or as otherwise directed by the Engineer. Machine speeds shall be varied to produce the desired surface texture grid pattern. Milling shall be performed without excessive tearing or gouging of the underlying material.</td></tr>
<tr><td>Milling Operations and Traffic</td><td>Milling operations shall be conducted so that the entire pavement width is milled to a flush surface at the end of each work period, whenever the pavement is open to traffic.</td></tr>
<tr><td>Milled Material</td><td>The surfacing removed in conjunction with the milling operations may be recycled for use on the project in accordance with the applicable Specifications, or disposed of.</td></tr>
</table></td></tr>
<tr><td>Missouri DOT</td><td colspan="2">No information found.</td></tr>
<tr><td>Texas DOT</td><td colspan="2">No files available.</td></tr>
<tr><td>Virginia DOT</td><td colspan="2">No files available.</td></tr>
<tr><td>Washington DOT</td><td colspan="2">No specification available.</td></tr>
</table>

REFERENCES

AASHTO (2008), “Guide Specifications for Highway Construction,” American Association of State Highway and Transportation Officials.
Michigan DOT (2003), “Standard Specifications for Construction,” Michigan Department of Transportation.
Mn/DOT (2005), “Mn/DOT Standard Specifications for Construction,” Minnesota Department of Transportation.
MoDOT (2004), “Missouri Standard Specifications for Highway Construction,” Missouri Department of Transportation.
TxDOT (2004), “Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges,” Texas Department of Transportation.
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WSDOT (2010), “Standard Specifications for Road, Bridge, and Municipal Construction, M41-10, Washington State Department of Transportation.

AASHTO Specification Designation 411 "Description"
In-Place Cold Recycled Asphalt Pavement

Agency/Organization	Specification Section
	Description
AASHTO (Section 411)	"Construct an in-place cold recycled asphalt pavement."
Michigan DOT	Not available
Minnesota DOT	Not available
Missouri DOT	No files available.
Texas DOT	No files available.
Virginia DOT	No files available.
Washington DOT	Not available.

AASHTO Specification Designation 411 "Materials"
In-Place Cold Recycled Asphalt Pavement

Agency/Organization	Specification Section
	Materials
AASHTO (Section 411)	No specific information provided unique to Section 411.
Michigan DOT	Not available
Minnesota DOT	Not available
Missouri DOT	No files available.
Texas DOT	No files available.
Virginia DOT	No files available.
Washington DOT	Not available.

AASHTO Specification Designation 411 "Construction"
In-Place Cold Recycled Asphalt Pavement

<table>
<tr><th>Agency/Organization</th><th>Specification Section
Construction</th></tr>
<tr><td>AASHTO (Section 411)</td><td>Major construction related items
<table>
<tr><td>Weather Limitations</td><td>Work when the atmospheric temperature is at least [60°F] and when there is no precipitation.</td></tr>
<tr><td>Pulverizing</td><td>Mill and pulverize existing asphalt pavement to the specified depth. Use a self-propelling pulverizing machine capable of maintaining a uniform grade and cross slope. Ensure pulverized material meets the following gradation:

<table>
<tr><th>Sieve Size</th><th>% Passing</th></tr>
<tr><td>2.0-in.</td><td>100</td></tr>
<tr><td>1.5-in.</td><td>90 – 100</td></tr>
</table>
Reject pulverized asphalt pavement contaminated with base or subgrade material.</td></tr>
<tr><td>Mixing</td><td>Combine an asphalt binder with the pulverized material at the specified rate, using one of the following methods to ensure a consistent mixture:
1. Incorporate with the liquid used to cool the cutter teeth. Ensure even application across the width of the cut and uniformly blend.
2. Incorporate into the pulverized asphalt windrow with a separate mechanical mixing device and uniformly blend.
3. Incorporate through a paving machine during combined mixing and placing operation.</td></tr>
<tr><td>Placing and Compacting</td><td>Place the surface course only when the final moisture content of the recycled mixture is less than [1.5] percent. Apply tack, prime, and fog coats to the existing subgrade or surface when specified. Blot excess asphalt with fine sand.
1. Placing by Blade. Use self-propelled, pneumatic-tired graders to spread the windrowed material to the required section and grade. Establish a test strip to verify the rolling pattern and maximum placement thickness. Meet density, cross section, and profile grade requirements.
2. Placing by Paver. Place the recycled mixture with a self-propelled asphalt paver. Spread the material in one or more lifts.

Compact as specified.</td></tr>
</table></td></tr>
</table>

Agency/Organization	Specification Section
	Construction
Michigan DOT	Not available
Minnesota DOT	Not available
Missouri DOT	No files available.
Texas DOT	No files available.
Virginia DOT	No files available.
Washington DOT	Not available.

REFERENCES

AASHTO (2008), "Guide Specifications for Highway Construction," American Association of State Highway and Transportation Officials.

Michigan DOT (2003), "Standard Specifications for Construction," Michigan Department of Transportation.

Mn/DOT (2005), "Mn/DOT Standard Specifications for Construction," Minnesota Department of Transportation.

MoDOT (2004), "Missouri Standard Specifications for Highway Construction," Missouri Department of Transportation.

TxDOT (2004), "Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges," Texas Department of Transportation.

Virginia DOT (2007), "Road and Bridge Specifications," Virginia Department of Transportation.

WSDOT (2010), "Standard Specifications for Road, Bridge, and Municipal Construction, M41-10, Washington State Department of Transportation.

AASHTO Specification Designation 501 "Description"
Portland Cement Concrete Pavements

Agency/Organization	Specification Section Description
AASHTO (Section 501)	"Construct a portland cement concrete pavement on a prepared subgrade or base course."
Michigan DOT (Sections 601 and 602)	"Construct a jointed Portland cement concrete pavement, unbonded overlay, base course, or shoulder, with or without reinforcement." Both MDOT Sections 601 (Portland Cement Concrete Pavements) and 602 (Concrete Pavement Construction) were reviewed.
Minnesota DOT (Section 2301)	"This work shall consist of constructing Portland cement concrete pavement on a prepared base."
Missouri DOT (Sections 501, 502)	"**502.** This work shall consist of constructing a Portland cement concrete base or pavement, with or without reinforcement as specified, shown on the plans or directed by the engineer." "**501.** Concrete shall consist of a mixture of cement, fine aggregate, coarse aggregate and water, combined in the proportions specified for the various classes. Admixtures may be added as specifically required or permitted." Brief mention is made of **Section 507** "Strength of Concrete Using the Maturity Method."
Texas DOT (Item 360)	"Construct hydraulic cement concrete pavement with or without curbs on the concrete pavement."
Virginia DOT (Sections 217 and 316)	**Section 316**: "This work shall consist of constructing reinforced, non-reinforced, or continuously reinforced hydraulic cement concrete pavement and approach slabs composed of hydraulic cement concrete, with or without reinforcement as specified, on a prepared subgrade or base course in accordance with the requirements of these specifications and within the specified tolerances for the lines, grades, thicknesses, and cross sections shown on the plans or as established by the Engineer."
Washington DOT (Section 5-05)	"This Work shall consist of constructing a pavement composed of Portland cement concrete on a prepared Subgrade or base in accordance with these Specifications and in conformity with the lines, grades, thicknesses, and typical cross-sections shown in the Plans or established by the Engineer."

AASHTO Specification Designation 501 "Materials"
Portland Cement Concrete Pavements

<table>
<tr><th>Agency/Organization</th><th colspan="2">Specification Section
Materials</th></tr>
<tr><td>AASHTO
(Section 501)</td><td colspan="2">Major materials related items
<table>
<tr><td>Portland Cement</td><td>Conform to AASHTO M85</td></tr>
<tr><td>Fine Aggregate</td><td>Conform to AASHTO M6</td></tr>
<tr><td>Coarse Aggregate</td><td>Conform to AASHTO M80</td></tr>
<tr><td>Load Transfer Devices</td><td>Conform to AASHTO M31</td></tr>
<tr><td>Joint Filler</td><td>Conform to AASHTO M282 Poured Joint Sealants for Pavements</td></tr>
<tr><td>Reinforcing Steel</td><td>1. Conform to AASHTO M31 or M322.
2. Furnish deformed bars for concrete structures meeting the tensile properties for the grade specified.</td></tr>
<tr><td>Curing Materials</td><td>1. Burlap Cloth: AASHTO M182
2. Sheet Materials: AASHTO M171
3. Liquid Membrane Compounds: AASHTO M148</td></tr>
<tr><td>Air-Entraining Admixtures</td><td>Conform to AASHTO M154</td></tr>
<tr><td>Chemical Admixtures</td><td>Conform to AASHTO M194 as applied to (1) water-reducing, (2) set-retarding, and (3) set-accelerating.</td></tr>
<tr><td>Fly Ash</td><td>Conform to AASHTO M295</td></tr>
<tr><td>Ground Granulated Blast Furnace Slay (GGBFS)</td><td>Conform to AASHTO M302</td></tr>
<tr><td>Water</td><td>Conform to AASHTO M157
Potable-quality water requires no testing.</td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Agency/Organization</th><th>Specification Section</th></tr>
<tr><td></td><th>Materials</th></tr>
<tr><td>Michigan DOT
(Section 601)</td><td>Major materials related items
<table>
<tr><td>Cement</td><td>Section 901</td></tr>
<tr><td>GGBFS</td><td>Section 901</td></tr>
<tr><td>Fly Ash</td><td>Section 901</td></tr>
<tr><td>Coarse Aggregate</td><td>Section 902</td></tr>
<tr><td>Fine Aggregate</td><td>Section 902</td></tr>
<tr><td>Concrete Admixtures</td><td>Section 903</td></tr>
<tr><td>Water</td><td>Section 911</td></tr>
</table>
<table>
<tr><td>Certified Batch Plants</td><td>Supply Portland cement concrete from certified portable and stationary concrete batch plant facilities meeting the requirements of the National Ready Mixed Concrete Association (NRMCA) certification program for automatic control and automatic systems.

When no fully automated NRMCA certified facility is within 25 miles
of the project limits, the Engineer may waive NRMCA certification and/
or automation requirements</td></tr>
<tr><td>Additional Water at Placement Site</td><td>Do not add more water than the approved concrete mix design will allow based on maximum water content and maximum water/cementitious material ratio.</td></tr>
<tr><td>Concrete Placing Temp</td><td>Concrete must be between 45°F and 90°F at the time it is placed.</td></tr>
<tr><td>Air Content</td><td>At the time of placement, concrete must have 6.5 ± 1.5 percent entrained air. However, concrete furnished for slipform placement and having a slump of 1.5 inches or less, may have a minimum of 4.5 percent entrained air</td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Agency/Organization</th><th>Specification Section</th></tr>
<tr><td></td><td>Materials</td></tr>
<tr><td>Minnesota DOT
(Section 2301)</td><td>Major materials related items
<table>
<tr><td>Minimum Cementitious Content</td><td>530 lb/CY with a minimum of portland cement = 400 lb/CY when using fly ash or GGBFS.</td></tr>
<tr><td>Total Alkalis in Portland Cement</td><td>0.60%</td></tr>
<tr><td>Total Alkalis in Cementitious Material</td><td>≤ 5 lb/CY</td></tr>
<tr><td>Water Cement Ratio</td><td>The target W/C ratio is 0.40 for large paving projects (>5,000 CY). Incentives and disincentives associated with lower or higher W/C ratios are shown below
<table>
<tr><th>Mean Value of W/C (termed QI)</th><th>Payment Incentive or Disincentive per CY ($/CY)</th></tr>
<tr><td>≤0.35</td><td>+ 4.00</td></tr>
<tr><td>0.36</td><td>+ 3.00</td></tr>
<tr><td>0.37</td><td>+ 2.00</td></tr>
<tr><td>0.38</td><td>+ 1.25</td></tr>
<tr><td>0.39</td><td>+ 0.50</td></tr>
<tr><td>0.40</td><td>0.00</td></tr>
<tr><td>0.41</td><td>- 0.50</td></tr>
<tr><td>0.42</td><td>- 1.25</td></tr>
<tr><td>0.43</td><td>- 2.00</td></tr>
<tr><td>0.44</td><td>- 3.00</td></tr>
<tr><td>≥ 0.45</td><td>Determined by the Concrete Engineer</td></tr>
</table></td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Agency/Organization</th><th>Specification Section
Materials</th></tr>
<tr><td>Missouri DOT
(Section 501, 507)</td><td>Major materials related items
<table>
<tr><td>Cement</td><td>Section 1019</td></tr>
<tr><td>GGBFS</td><td>Section 1017</td></tr>
<tr><td>Fly Ash</td><td>Section 1018</td></tr>
<tr><td>Coarse Aggregate</td><td>Section 1005.2</td></tr>
<tr><td>Fine Aggregate</td><td>S□ection 1005.3</td></tr>
<tr><td>Concrete □dmixtures</td><td>Section 1054</td></tr>
<tr><td>Water</td><td>Section 1070</td></tr>
</table>
<table>
<tr><td>Cement Requirement for Pavement Concrete</td><td>560 lb/CY</td></tr>
<tr><td>Minimum Compressive Strength for Pavement Concrete</td><td>4,000 psi (cure period not stated in Section 501).</td></tr>
<tr><td>Max Water/Cementitious Ratio</td><td>0.50 for air entrained concrete
0.53 for non-air entrained concrete</td></tr>
<tr><td>Air Entrainment</td><td>If air-entrained concrete is used, the designated quantity of air by volume shall be a minimum of 5.0 percent.</td></tr>
<tr><td>Supplementary Cementitious Materials</td><td>1. Supplementary cementitious materials may be used to replace a maximum of 40 percent of the Portland cement.
2. Fly Ash: Class C or Class F fly ash may be used to replace a maximum of 25 percent of the Portland cement on a pound for pound basis in all concrete.
3. GGBFS: GGBFS may be used to replace a maximum of 30 percent of the Portland cement on a pound for pound basis in all concrete.</td></tr>
<tr><td>Maturity Method</td><td>Specification in Section 507 covers the maturity method as a non-destructive means of determining in-place concrete strength for pavement or structural applications. This method requires the establishment of a relationship between compressive strength and calculated maturity indices for a specific concrete mixture prior to placement of the mixture in the field. The contractor may use the maturity method in accordance with Section 507 to estimate the compressive strength of the in-place concrete.</td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Agency/Organization</th><th>Specification Section
Materials</th></tr>
<tr><td>Texas DOT
(Item 360)</td><td>Major materials related items
<table>
<tr><td>Minimum Strength</td><td>Provide Class P concrete designed to meet a minimum average flexural strength of 570 psi or a minimum average compressive strength of 3,500 psi at 7 days or a minimum average flexural strength of 680 psi or a minimum average compressive strength of 4,400 psi at 28 days.</td></tr>
</table></td></tr>
<tr><td>Virginia DOT (Section 217)</td><td>Major materials related items
<table>
<tr><td>Basic PCC Mix Design Requirements for Pavement</td><td>1. Minimum compressive strength = 3,000 psi
2. Maximum water/cement ratio = 0.49
3. Nominal Maximum Aggregate Size = 1.0 in.
4. Slump: 0 to 3 in.
5. Air content = 6% ± 2%</td></tr>
<tr><td>Cementitious Materials</td><td>Limits for fly ash, GGBFS, and silica fume
1. Fly ash, Class F ≤ 30%
2. GGBFS ≤ 50%
3. Silica fume ≤ 10%</td></tr>
<tr><td>Ready-Mixed Concrete Time Limitation</td><td>
<table>
<tr><th rowspan="2">Equipment</th><th colspan="3">Concrete Temperature</th></tr>
<tr><th>< 80°F</th><th>80 to 90°F</th><th>> 90°F</th></tr>
<tr><td>Agitator Type Haul Equipment
• Retarded
• Unretarded</td><td>
2.5 hours
1.5 hours</td><td>
2.0 hours
1.25 hours</td><td>
1.5 hours
1.0 hour</td></tr>
<tr><td>Nonagitator Type Haul Equipment—all Concrete</td><td>1.0 hour</td><td>0.75 hour</td><td>0.5 hour</td></tr>
</table>
</td></tr>
<tr><td>Placement Temperature Limitation</td><td>When paving concrete is placed by slipform and contains a water reducer, placement temperature limits of 40 to 95°F apply.</td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Agency/Organization</th><th>Specification Section</th></tr>
<tr><td></td><td>Materials</td></tr>
<tr><td>Washington DOT
(Section 5-05)</td><td>Major materials related items
<table>
<tr><td>Cementitious Materials</td><td>Limits for fly ash, GGBFS, and silica fume
1. Fly ash, Class F ≤ 35% with max CaO content of 15%.
2. GGBFS ≤ 25%
3. Max GGBFS + fly ash ≤ 35% by weight of total cementitious materials.</td></tr>
<tr><td>Minimum Cementitious Materials</td><td>≥ 564 lb/CY</td></tr>
<tr><td>Water-Cementitious Ratio</td><td>≤ 0.44</td></tr>
</table></td></tr>
</table>

AASHTO Specification Designation 501 "Construction"
Portland Cement Concrete Pavements

<table>
<tr><th>Agency/Organization</th><th>Specification Section
Construction</th></tr>
<tr><td>AASHTO
(Section 501)</td><td>Major construction related items
<table>
<tr><td>Mix Design Options</td><td>1. Mix based on minimum strength. Must meet properties shown in table below:
<table>
<tr><th>Property</th><th>Value</th><th>AASHTO Test Method</th></tr>
<tr><td>Compressive Strength (min)</td><td>3,500 psi</td><td>T22</td></tr>
<tr><td>Flexural Strength (min)</td><td>550 psi</td><td>T97</td></tr>
<tr><td>Flexural Strength (min)</td><td>650 psi</td><td>T177</td></tr>
<tr><td>Slump</td><td>3/8 to 3 in.</td><td>T119</td></tr>
<tr><td>Cement Content
Without Air (min)
With Air (min)</td><td>
564 lb/CY
598 lb/CY</td><td></td></tr>
<tr><td>Fly Ash
Type C
Type F</td><td>
30% max[1]
25% max[1]</td><td>Note 1: % max cement replacement</td></tr>
<tr><td>GGBFS</td><td>50% max[1]</td><td>See Note 1</td></tr>
<tr><td>Water/Cementitious Ratio
Without Air (max)
With Air (max)</td><td>

0.53
0.49</td><td></td></tr>
<tr><td>Entrained Air</td><td>5 to 8%</td><td>T152, T196, or T199</td></tr>
</table>
2. Contractor proposed mix.
3. Mix based on predetermined cement content—use table above.</td></tr>
<tr><td>Mixing and Placing Limitations</td><td>1. Stop mixing and concreting operations if shaded ambient air temperature away from artificial heat is 40°F or less. Resume operations only when the ambient air temperature is 40°F and rising.
2. Place mixed concrete only when its temperature is between 50°F and 85°F.</td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Agency/Organization</th><th>Specification Section</th></tr>
<tr><td></td><td>Construction</td></tr>
<tr><td>AASHTO
(Section 501)
(continued)</td><td>
<table>
<tr><td>Longitudinal Joints</td><td>
<table>
<tr><td>Dimensions</td><td>Saw the first cut or insert the joint material to one third of the depth.</td></tr>
<tr><td>Tiebars</td><td>Place [30 in.] long No. 5 tiebars of Grade 60 steel, spaced [30 in.] center-to-center to one half of the depth of the PCCP. Ensure that tiebars are placed perpendicular to the face of the joint, centered in the slab depth, and parallel to the finished surface.</td></tr>
<tr><td>Construction</td><td>Form or saw longitudinal joints in the plastic concrete. Saw the joints within 4 to 24 hours after placing the concrete and immediately after completing the transverse joints. Allow only the saw on the pavement during sawing operations.</td></tr>
<tr><td>Sealing</td><td>Seal joints after the curing period and before opening the pavement to traffic. Use sandblasting followed by an oil-free air jet to clean the faces and joint openings before sealing. Seal joints only when they are completely dry. Do not dry joints with a heat lance. Use an approved backer rod to seal the lower portion of the joint groove to a uniform depth to prevent sealant from entering beneath the specified depth. Ensure that backer rod is compatible with the sealant type specified and install according to manufacturers’ recommendations.</td></tr>
</table>
</td></tr>
<tr><td>Contraction Joints</td><td>
<table>
<tr><td>Location and Dimensions</td><td>Form or saw joints as narrowly as possible, to at least one third of the pavement depth.</td></tr>
<tr><td>Load Transfer</td><td>Install load transfer dowel bars of specified grade and size, spaced at […] centers, and secured with a wire basket or implanted mechanically. Place dowel bars one half of the depth parallel to the surface and pavement edge to an alignment tolerance of (±1/4 in.). Vibrate concrete around all dowel bars without misaligning them.</td></tr>
<tr><td>Construction</td><td>Place formed joints while the concrete is plastic. Begin relief-cut joint sawing immediately after the concrete hardens to the stage that it can be sawed without raveling. Saw all joints between 4 and 24 hours after placing concrete but before uncontrolled shrinkage cracking develops.</td></tr>
<tr><td>Sealing</td><td>Similar to longitudinal joint construction.</td></tr>
</table>
</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><th>Agency/Organization</th><th colspan="2">Specification Section
Construction</th></tr>
<tr><td>AASHTO
(Section 501)
(continued)</td><td colspan="2">
<table>
<tr><td>Transverse Construction Joints</td><td>Install transverse construction joints at the end of each day’s placement. Form bulkheads when stopping the placement in an emergency or at the end of each day’s pour.</td></tr>
<tr><td>Surface Tolerances</td><td>AASHTO provides for two profile measurement methods
1. Straightedge: This method applies to all paving. Test the surface with a 10-ft straightedge at random locations. The Engineer will identify pavement areas that deviate more than [3/16 in.] from the straightedge as defective work.
2. Profilograph: Describes a California-type profilograph.</td></tr>
<tr><td>Curing</td><td>1. Cure the concrete for at least 3 days immediately after the finishing operation.
2. Protect the concrete for at least 10 days or until the concrete achieves a compressive strength of [2,200 psi].</td></tr>
<tr><td>Tolerance and Price Adjustments for Pavement Thickness</td><td>1. Determine pavement thickness according to AASHTO T148.
2. Price adjustments in accordance with the table below.
<table>
<tr><th>Deficiency in Thickness as Determined by Cores (in.)</th><th>Contract Price Allowed</th></tr>
<tr><td>0 to 0.20</td><td>100</td></tr>
<tr><td>0.21 to 0.30</td><td>80</td></tr>
<tr><td>0.31 to 0.40</td><td>72</td></tr>
<tr><td>0.41 to 0.50</td><td>68</td></tr>
<tr><td>0.51 to 0.75</td><td>57</td></tr>
<tr><td>0.76 to 1.00</td><td>50</td></tr>
<tr><td>> 1.00</td><td>Remove and Replace</td></tr>
</table>
</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><th>Agency/Organization</th><th>Specification Section</th></tr>
<tr><td></td><td>Construction</td></tr>
<tr><td>Michigan DOT
(Section 602)</td><td>Major construction related items

<table>
<tr><td>Surface Texture</td><td>When the pavement has set sufficiently to maintain texture, drag the surface longitudinally using one or two layers of an approved damp fabric material. Maintain fabric contact with the surface across the entire width of concrete being placed. Immediately after dragging, groove all surfaces other than concrete base courses and shoulders. Orient the grooves generally perpendicular to the centerline and form the grooves in the plastic concrete cleanly without slumping of the edges or severe tearing of the surface. Provide a surface texture consisting of 1/8 inch wide grooves spaced 1/2 inch on center and 1/8 to 1/4 inch deep.</td></tr>
<tr><td>Sealing Joints with Hot-Poured Sealants</td><td>Seal the joints immediately after the joints are cleaned. Joint surfaces must be dry when sealed. Do not place sealant when temperature is less than 50°F.</td></tr>
<tr><td>Profile</td><td>While the concrete is still plastic, test the slab surface for trueness to the required grade and cross section using a 10-foot straightedge. If high or low spots exceeding 1/8 inch in 10 feet (1/4 inch for concrete shoulders and inch for concrete base course and temporary concrete pavement) are found, suspend paving operations and correct the finishing procedures. Correct high spots in pavements that exceed these tolerances.</td></tr>
<tr><td>Weather and Temperature Limitations</td><td>1. Protect the concrete from freezing until the concrete has attained a compressive strength of at least 1,000 psi.
2. Do not place concrete if portions of the base, subbase, or subgrade layer are frozen, or if the grade exhibits poor stability from excessive moisture levels.
3. Do not place concrete when the temperature of the plastic concrete at the point of placement is above 90°F.</td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Agency/Organization</th><th>Specification Section
Construction</th></tr>
<tr><td>Minnesota DOT
(Section 2301)</td><td>Major construction related items

<table>
<tr><td>High-Early Strength Concrete</td><td>High-early concrete is defined as a concrete mixture having a cementitious content greater than 600 pounds per cubic yard. High Early mixes shall be designed to provide a maximum water/cementitious ratio of 0.40 and a minimum flexural strength of 500 psi or a minimum compressive strength of 3000 psi in 48 hours. High early mixes may have up to 100 % portland cement. High-early mixes are not eligible for incentive payments for water/cementitious ratio.</td></tr>
<tr><td>Minimum Strength Requirement for Opening Pavements to Construction and General Public Traffic</td><td>New pavement shall be closed to use by construction and general public traffic for 7 days or according to the values listed in the table below, whichever is the shorter.

<table>
<tr><th>Slab Thickness (in.)</th><th>Flexural Strength (psi)</th></tr>
<tr><td>6.0</td><td>500</td></tr>
<tr><td>6.5</td><td>500</td></tr>
<tr><td>7.0</td><td>500</td></tr>
<tr><td>7.5</td><td>480</td></tr>
<tr><td>8.0</td><td>460</td></tr>
<tr><td>8.5</td><td>440</td></tr>
<tr><td>9.0</td><td>390</td></tr>
<tr><td>9.5</td><td>350</td></tr>
<tr><td>10.0</td><td>350</td></tr>
<tr><td>≥ 10.5</td><td>350</td></tr>
</table></td></tr>
<tr><td>Placing Concrete</td><td>1. All main line pavement constructed by standard or vibratory machine placement methods shall be constructed in a single layer of concrete.
2. Water shall not be added to the surface of the concrete to aid in finishing without the approval of the Engineer. The Engineer will only give this approval to replace evaporated surface water directly behind the paver caused by a halt in forward progress from a short-term breakdown in equipment or supply of concrete.
3. Should placement of concrete be temporarily suspended, the placement operations shall be resumed in such manner that will not result in a cold joint or honeycombing. If the suspension period exceeds 90 minutes, a standard header joint shall be constructed.</td></tr>
<tr><td>Joint Construction</td><td>Initial joint sawing shall be approximately 1/8 inch wide and to the full joint depth. The initial sawing shall be accomplished as soon as the condition of the concrete will permit without raveling and before random cracking occurs. The sequence of initial sawing shall be at the Contractor's option.</td></tr>
</table></td></tr>
</table>

Agency/Organization	Specification Section	
	Construction	
Minnesota DOT (Section 2301) (continued)	Surface Finish	Mn/DOT uses a standard longitudinal carpet drag followed by transverse tining.
	Concrete Curing	The Contractor shall: (1) Cure and protect the concrete by the blanket curing method or one of the membrane curing methods. (2) Cure the entire pavement surface and edges as soon as surface conditions permit after the finishing operations. (3) Continue curing and protecting the concrete for at least 72 hours. (4) Place the curing media on the pavement edges within 30 minutes after removal of the forms when side forms are used. (5) Extend the minimum curing period to 96 hours when fly ash or Portland-pozzolan cement substitutions are used.
	Surface Smoothness	The Contractor shall test the pavement surface for surface smoothness and ride quality. Surface Smoothness and Ride Quality shall be measured with a **25 foot** California type profilograph, or a Lightweight Inertial Profiler (IP), which produces a profilogram (profile trace of the surface tested). Either type of device must be certified according to the procedure on file in the Mn/DOT Concrete Engineering Unit.
	Thickness Requirements	Where the cores show a thickness deficiency exceeding **½ inch**, but less than **1 inch**, the pavement represented by those cores will not be excluded from the pay quantities; however, a deduction will be made from the moneys due the Contractor equal to the product of the defective areas and **$20.00 per square yard**. Pavement represented by cores showing a thickness deficiency of **1 inch** or more will be excluded from all payments **plus** a deduction will be made from the moneys due the Contractor equal to the product of the defective areas and **$20.00 per square yard**. These deductions will be assessed in lieu of removing and replacing the areas of pavement which are deficient in thickness.

Agency/Organization	Specification Section	
	Construction	
Missouri DOT (Section 502)	Major construction related items	
	Weather Limitations wrt Freezing Conditions	All concrete shall be effectively protected from freezing until a minimum compressive strength of 3500 psi has been attained.
	Added Finishing Water	Moisture in any form shall not be applied to the surface of the concrete except for emergency conditions.
	Required Texture Depth	The results of ASTM E 965 shall show a texture depth of any sublot, as defined in Sec 502.10.1, to have a minimum value of 1.00 mm. Any sublot showing a texture depth of less than 1.00 mm shall require diamond grinding of the pavement represented by this sublot to attain the necessary texture. All testing of the surface texture shall be completed no later than the day following pavement placement.
	Curing	Immediately after the finishing operations have been completed and as soon as marring of the concrete will not occur, the entire surface and exposed edges of the newly placed concrete shall be covered and cured in accordance with one of the following methods. The concrete shall not be left exposed for more than 30 minutes between stages of curing or during the curing period. 1. White Pigmented Membrane: The contractor shall provide satisfactory equipment to ensure uniform mixture and coverage of curing material, without loss, on the pavement at the rate of not less than one gallon for each 200 square feet. 2. Burlap
	Straightedge	As soon as practical, the engineer will straightedge all segments of the paved surface not profilographed, including shoulders. Any variations exceeding 1/8 inch in 10 feet will be marked. Areas more than 1/8 inch high shall be removed
	Air Entrainment during Paving Operations	Tests for entrained air content shall be performed on a random basis for each 500 cubic yards of material produced. The minimum air content in front of the paver shall be 5.0 percent plus the air loss through the paver. The air loss through the paver is determined a minimum of once per half-day production by sampling the concrete ahead of the paver and behind the paver and subtracting the value obtained ahead of the paver from the value obtained behind the paver.

<table>
<tr><th>Agency/Organization</th><th>Specification Section</th></tr>
<tr><td></td><td>Construction</td></tr>
<tr><td>Texas DOT
(Item 360)</td><td>
<table>
<tr><td>Concrete Placement</td><td>1. Do not allow the pavement edge to deviate from the established paving line by more than 1/2 in. at any point. Place the concrete as near as possible to its final location, and minimize segregation and rehandling. Where hand spreading is necessary, distribute concrete using shovels. Do not use rakes or vibrators to distribute concrete.
2. Consolidate all concrete by approved mechanical vibrators operated on the front of the paving equipment. Use immersion-type vibrators that simultaneously consolidate the full width of the placement when machine finishing. Keep vibrators from dislodging reinforcement. Use hand-operated vibrators to consolidate concrete in areas not accessible to the machine mounted vibrators. Do not operate machine-mounted vibrators while the paving equipment is stationary.</td></tr>
<tr><td>Temperature Restrictions</td><td>Place concrete that is between 40°F and 95°F when measured in accordance with Tex-422-A at the time of discharge, except that concrete may be used if it was already in transit when the temperature was found to exceed the allowable maximum. Take immediate corrective action or cease concrete production when the concrete temperature exceeds 95°F.</td></tr>
<tr><td>Early Opening</td><td>Concrete pavement may be opened after curing is complete and the concrete has attained a flexural strength of 450 psi or a compressive strength of 2,800 psi. The maturity method, Tex-426-A, may be used to estimate concrete strength for early opening pavement to traffic.</td></tr>
<tr><td>Tolerance and Price Adjustments for Pavement Thickness</td><td>
<table>
<tr><th>Deficiency in Thickness as Determined by Cores (in.)</th><th>Contract Price Allowed</th></tr>
<tr><td>Not Deficient</td><td>100</td></tr>
<tr><td>> 0 to 0.20</td><td>100</td></tr>
<tr><td>> 0.20 to 0.30</td><td>80</td></tr>
<tr><td>> 0.30 to 0.40</td><td>72</td></tr>
<tr><td>> 0.40 to 0.50</td><td>68</td></tr>
<tr><td>> 0.50 to 0.75</td><td>57</td></tr>
<tr><td>> 0.75</td><td>Zero pay or removal</td></tr>
</table>
</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><th>Agency/Organization</th><th>Specification Section
Construction</th></tr>
<tr><td>Virginia DOT
(Section 316)</td><td>
<table>
<tr><td>Concrete Base Course</td><td>The construction of a hydraulic cement concrete base course shall conform to the requirements of these Specifications except for floating and final finishing of the surface. The surface shall be finished so that there will be no deviation of more than 1/4 inch between any two contact points when tested with a 10-foot straightedge placed parallel with the centerline. A heavy broomed texture shall be applied.</td></tr>
<tr><td>Curing</td><td>The following apply to curing:
1. Curing systems: Membrane-forming compounds: The compound shall be applied under constant pressure at the rate of 100 to 150 square feet per gallon by mechanical sprayers mounted on movable bridges. On textured surfaces, the rate shall be as close to 100 square feet as possible.
2. Protection in cold weather: The Contractor shall prevent the temperature at the surface of the concrete from falling below 40°F during the first 72 hours immediately following concrete placement.
3. Curing in hot or windy conditions: Care shall be taken in hot, dry, or windy weather to protect the concrete from shrinkage cracking by applying the curing medium at the earliest possible time after finishing operations and after the sheen has disappeared from the surface of the pavement.</td></tr>
<tr><td>Joint Sealers</td><td>VDOT allows three basic types of joint sealers. These are:
1. Performed
2. Hot-poured
3. Silicone</td></tr>
<tr><td>Thickness Price Adjustments</td><td>
<table>
<tr><th>Deficiency in Thickness (in.)</th><th>% of Contract Price Allowed</th></tr>
<tr><td>0 to 0.20</td><td>100</td></tr>
<tr><td>0.21 to 0.30</td><td>80</td></tr>
<tr><td>0.31 to 0.40</td><td>72</td></tr>
<tr><td>0.41 to 0.50</td><td>68</td></tr>
<tr><td>0.51 to 0.75</td><td>57</td></tr>
<tr><td>0.76 to 1.00</td><td>50</td></tr>
<tr><td>> 1.00</td><td>Either zero pay or remove and replace</td></tr>
</table>
</td></tr>
<tr><td>Opening to Traffic</td><td>Pavement shall not be opened to traffic until specimen beams have attained a modulus of rupture strength of 600 pounds per square inch when tested by the center point loading method in accordance with the requirements of ASTM C293. In the absence of such tests, pavement shall not be opened to traffic until 14 days after concrete is placed. Prior to opening to traffic, pavement shall be cleaned and joints sealed and trimmed.</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><th>Agency/Organization</th><th>Specification Section</th></tr>
<tr><td></td><td>Construction</td></tr>
<tr><td>Washington DOT
(Section 5-05)</td><td>
<table>
<tr><td>Subgrade</td><td>1. The Subgrade shall be prepared and compacted a minimum of 3-feet beyond each edge of the area which is to receive concrete pavement in order to accommodate the slip-form equipment.
2. Concrete shall not be placed on a frozen Subgrade nor during heavy rainfall.
3. The Subgrade shall be moist before the concrete is placed. When placing concrete on a treated base, the surface temperature shall not exceed 90°F.</td></tr>
<tr><td>Contraction Joints</td><td>1. All transverse and longitudinal contraction joints shall be formed with suitable power-driven concrete saws. The Contractor shall provide sufficient sawing equipment capable of completing the sawing to the required dimensions and at the required rate to control cracking. The Contractor shall provide adequate artificial lighting facilities for night sawing.
2. Joints shall not vary from the specified or indicated line by more than ¾-inch.
3. Commencement of sawing transverse contraction joints will be dependent upon the setting time of the concrete and shall be done at the earliest possible time following placement of the concrete without tearing or raveling the adjacent concrete excessively.
4. Longitudinal contraction joints shall be sawed as required to control cracking and as soon as practical after the initial control transverse contraction joints are completed.
5. Any damage to the curing material during the sawing operations shall be repaired immediately after the sawing is completed.
6. When cement concrete pavement is placed adjacent to existing cement concrete pavement, the vertical face of all existing working joints shall be covered with a bondbreaking material such as polyethylene film, roofing paper, or other material as approved by the Engineer.</td></tr>
</table>
</td></tr>
</table>

Agency/Organization	Specification Section	
	Construction	
Washington DOT (Section 5-05) (continued)	Dowel Bars	1. Corrosion resistant dowel bars shall be placed at all transverse contraction joints as shown in the Contract or in accordance with the Standard Plans. 2. All dowel bars shall have a parting compound, such as curing compound, grease or other Engineer approved equal applied to them prior to placement. 3. Any dowel bar delivered to the project that displays rust/oxidation, pinholes, questionable blemishes, or deviates from the round shall be rejected. 4. Corrosion resistant dowel bars shall be 1½-inch outside diameter plain round steel bars 18-inches in length and meet the requirements one of the following types (details available in WSDOT Section 9-07.5(2)): • Stainless Steel Clad dowel bars • Stainless Steel Tube dowel • Stainless Steel Solid dowel bars • Corrosion-resistant, low-carbon, chromium plain steel bars • Zinc Clad dowel bars
	Cold Weather Work	When the air temperature is expected to reach the freezing point during the day or night and the pavement has not reached 50-percent of its design strength or 2500-psi whichever is greater the concrete shall be protected from freezing.
	Opening to Traffic	The pavement may be opened to traffic when the concrete has developed a compressive strength of 2500-psi as determined from cylinders, made at the time of placement, cured under comparable conditions, and tested in accordance with AASHTO T 22.

REFERENCES

AASHTO (2008), “Guide Specifications for Highway Construction,” American Association of State Highway and Transportation Officials.
Michigan DOT (2003), “Standard Specifications for Construction,” Michigan Department of Transportation.
Mn/DOT (2005), “Mn/DOT Standard Specifications for Construction,” Minnesota Department of Transportation.
MoDOT (2004), “Missouri Standard Specifications for Highway Construction,” Missouri Department of Transportation.
TxDOT (2004), “Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges,” Texas Department of Transportation.
Virginia DOT (2007), “Road and Bridge Specifications,” Virginia Department of Transportation.
WSDOT (2010), “Standard Specifications for Road, Bridge, and Municipal Construction, M41-10, Washington State Department of Transportation.

AASHTO Specification Designation 552 "Description"
Subsealing and Stabilization

Agency/Organization	Specification Section
	Description
AASHTO (Section 552)	"Find and fill existing voids in the pavement system by drilling injection holes, placing material, monitoring the pavement profile, testing for deflection after grouting, and resealing pavement joints."
Michigan DOT	Not available.
Minnesota DOT	Not available.
Missouri DOT	Not available.
Texas DOT	Not available.
Virginia DOT	Not available.
Washington DOT	Not available.

AASHTO Specification Designation 552 "Materials"
Subsealing and Stabilization

<table>
<tr><th rowspan="2">Agency/Organization</th><th>Specification Section</th></tr>
<tr><th>Materials</th></tr>
<tr><td>AASHTO (Section 552)</td><td>AASHTO references to Subsection 551.02 which lists:
<table>
<tr><th>Material</th><th>AASHTO Subsection</th></tr>
<tr><td>Portland Cement</td><td>701.02</td></tr>
<tr><td>Limestone Dust</td><td>703.14</td></tr>
<tr><td>Chemical Admixtures</td><td>713.03(B)</td></tr>
<tr><td>Fly Ash</td><td>713.03(C)(1)</td></tr>
<tr><td>Grout for pavement jacking, Subsealing, and stabilization</td><td>713.04(A)</td></tr>
<tr><td>Water</td><td>714.01(A)</td></tr>
</table></td></tr>
<tr><td>Michigan DOT</td><td>Not available.</td></tr>
<tr><td>Minnesota DOT</td><td>Not available.</td></tr>
<tr><td>Missouri DOT</td><td>Not available.</td></tr>
<tr><td>Texas DOT</td><td>Not available.</td></tr>
<tr><td>Virginia DOT</td><td>Not available.</td></tr>
<tr><td>Washington DOT</td><td>Not available.</td></tr>
</table>

AASHTO Specification Designation 552 "Construction"
Subsealing and Stabilization

<table>
<tr><th rowspan="2">Agency/Organization</th><th colspan="2">Specification Section</th></tr>
<tr><th colspan="2">Construction</th></tr>
<tr><td>AASHTO (Section 552)</td><td colspan="2">All construction related items are:
<table>
<tr><td>Grout Plant</td><td>The Grout Plant shall conform to Subsection 551.03(A) and the following: The Contractor may substitute a paddle-type mixer for the high-speed colloidal mixer when using limestone dust grout. Furnish an injection pump with a pressure capability of 250 to 300 psi when pumping a grout slurry mixed to a 12-second flow cone time. Furnish an injection pump that can continuously pump at rates as low as 1.5 gal/min.</td></tr>
<tr><td>Vertical Movement Testing</td><td></td></tr>
<tr><td>Drilling and Subsealing</td><td></td></tr>
<tr><td>Radial Cracks</td><td></td></tr>
<tr><td>Hole Patching</td><td>Agency should specify drill hole fill material.</td></tr>
<tr><td>Weather Conditions</td><td></td></tr>
<tr><td>Unanticipated Conditions</td><td></td></tr>
<tr><td>Resealing Pavement Joints</td><td></td></tr>
</table></td></tr>
<tr><td>Michigan DOT</td><td colspan="2">Not available.</td></tr>
<tr><td>Minnesota DOT</td><td colspan="2">Not available.</td></tr>
<tr><td>Missouri DOT</td><td colspan="2">Not available.</td></tr>
<tr><td>Texas DOT</td><td colspan="2">Not available.</td></tr>
<tr><td>Virginia DOT</td><td colspan="2">Not available.</td></tr>
<tr><td>Washington DOT</td><td colspan="2">Not available.</td></tr>
</table>

REFERENCES

AASHTO (2008), “Guide Specifications for Highway Construction,” American Association of State Highway and Transportation Officials.
Michigan DOT (2003), “Standard Specifications for Construction,” Michigan Department of Transportation.
Mn/DOT (2005), “Mn/DOT Standard Specifications for Construction,” Minnesota Department of Transportation.
MoDOT (2004), “Missouri Standard Specifications for Highway Construction,” Missouri Department of Transportation.
TxDOT (2004), “Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges,” Texas Department of Transportation.
Virginia DOT (2007), “Road and Bridge Specifications,” Virginia Department of Transportation.
WSDOT (2010), “Standard Specifications for Road, Bridge, and Municipal Construction, M41-10, Washington State Department of Transportation.

AASHTO Specification Designation 557 "Description"
Partial Depth Patching

Agency/Organization	Specification Section
	Description
AASHTO (Section 557)	"Construct partial-depth patches of spalls, potholes, and corner breaks in portland cement concrete pavements."
Michigan DOT (Section 603) Concrete Pavement Restoration	"Restore pavement condition." "Concrete pavement restoration will include, but not be limited to: (1) Repairing portions of a concrete pavement with reinforced and nonreinforced Portland cement concrete and with the type of joint specified, (2) Diamond grinding Portland cement concrete pavement, (3) Resawing and sealing existing longitudinal pavement joints, and (4) Sawing, cleaning, and sealing cracks in concrete pavements."
Minnesota DOT	Does not have a specific related specification
Missouri DOT	Does not have a specific related specification
Texas DOT	Does not have a specific related specification
Virginia DOT	Does not have a specific related specification
Washington DOT (Section 5-01.3(5))	Partial Depth Spall Repair

AASHTO Specification Designation 557 "Materials"
Partial Depth Patching

<table>
<tr><th>Agency/Organization</th><th>Specification Section
Materials</th></tr>
<tr><td>AASHTO (Section 557)</td><td>AASHTO references to Subsection 557.02 which lists:
<table>
<tr><th>Material</th><th>AASHTO Subsection</th></tr>
<tr><td>Portland Cement</td><td>701.02</td></tr>
<tr><td>Coarse Aggregate for Concrete</td><td>703.01(B)</td></tr>
<tr><td>Masonry Mortar Aggregate</td><td>703.13</td></tr>
<tr><td>Chemical Admixtures</td><td>713.03(B)</td></tr>
<tr><td>Water</td><td>714.01(A)</td></tr>
<tr><td>Calcium Chloride</td><td>714.02</td></tr>
<tr><td>Rapid Setting Patching Materials</td><td>Approved List</td></tr>
<tr><td>Fine Aggregate for Epoxy Concrete</td><td>Gradation specified by manufacturer</td></tr>
</table></td></tr>
<tr><td>Michigan DOT
(Section 603)</td><td>For concrete repairs, the type of mix to be used is based on time from casting to traffic opening as follows:
<table>
<tr><th>Time from Casting to Traffic Opening</th><th>Grade of Concrete</th></tr>
<tr><td>≤ 8 hours</td><td>Type P-MS</td></tr>
<tr><td>12 to 72 hours</td><td>Type P-NC</td></tr>
<tr><td>3 days</td><td>Grade HE</td></tr>
<tr><td>≥ 7 days</td><td>Grade P1</td></tr>
</table></td></tr>
<tr><td>Minnesota DOT</td><td>Does not have a specific related specification</td></tr>
<tr><td>Missouri DOT</td><td>Does not have a specific related specification</td></tr>
<tr><td>Texas DOT</td><td>Does not have a specific related specification</td></tr>
<tr><td>Virginia DOT</td><td>Does not have a specific related specification</td></tr>
<tr><td>Washington DOT
(Sections 5-01.3(1)A and 5-01.3(5))</td><td>The Contractor shall use either concrete patching materials or portland cement concrete for the rehabilitation of cement concrete pavement. Concrete patching materials shall be used for spall repair and dowel bar retrofitting and may be used for concrete panel replacement; portland cement concrete is only allowed for concrete panel replacement.</td></tr>
</table>

AASHTO Specification Designation 557 "Construction"
Partial Depth Patching

<table>
<tr><th>Agency/Organization</th><th colspan="2">Specification Section</th></tr>
<tr><th></th><th colspan="2">Construction</th></tr>
<tr><td>AASHTO (Section 557)</td><td colspan="2">All construction related items are:
<table>
<tr><td>Concrete Mix Design for Patches</td><td>Provide one of the following concrete designs for partial-depth and full-depth patches, as specified in the contract:
1. Accelerated Strength Portland Cement Concrete Patch Mixtures: Use Type I or Type III portland cement to provide concrete with a minimum strength of 3,000 psi in 24 hours.
2. Normal Set Portland Cement Concrete Patch Mixture
3. Rapid Setting Patching Materials: Rapid setting patching materials must reach a minimum compressive strength of 3,000 psi in 24 hours.
4. Epoxy Resin Patching Mortars: Use only Agency-approved materials. Prepare epoxy resin patching mortars according to the manufacturer's recommendations.</td></tr>
<tr><td>Preparation of Partial Depth Patch Area</td><td>Construct partial-depth patches at specified locations or as directed by the Engineer. Make a vertical saw cut around the perimeter of the patch area to a minimum depth of 2 in. Use pneumatic tools to remove concrete within the patch area to a minimum depth of 2 in. until sound and clean concrete is exposed. If the depth of the repair exceeds 4 in., remove the entire area to full depth and replace as specified in AASHTO Section 558 (Full Depth Patching). Limit the maximum size of pneumatic hammers to 30 lb. Sandblast exposed concrete faces to remove loose particles, oil, dust, traces of asphalt concrete, and other contaminates before patching. Remove sandblasting residue before placing the bonding agent.</td></tr>
<tr><td>Placing Patch Material</td><td>Place and consolidate the patch mixture to eliminate voids at the interface of the patch and existing concrete. If a partial-depth repair area joins a working joint, use an insert, or other bond-breaking medium, to maintain working joints or cracks. Form the new joint to the same width as the existing joint or crack.

Details are contained in AASHTO Section 557 that are applicable for each of the concrete mix designs noted above.</td></tr>
</table></td></tr>
</table>

<table>
<tr><th rowspan="2">Agency/Organization</th><th>Specification Section</th></tr>
<tr><th>Construction</th></tr>
<tr><td>Michigan DOT
(Section 603)</td><td>Relevant construction related items are:<table>
<tr><td>Size of Patches</td><td>Make repairs 6 feet or longer. When the area to be repaired leaves a section of pavement less than 6 feet from an existing joint or less than 15 feet from the next area to be repaired, remove that section also. For repairs more than 15 feet long, cast the repair area in adjacent lanes, ramps, or shoulders separately.</td></tr>
<tr><td>Placing Concrete</td><td>Place concrete the same day that the existing pavement is removed. Immediately before the concrete placement, wet the faces of the existing pavement and the surface of the aggregate base with water.</td></tr>
<tr><td>Opening to Traffic</td><td>The repair areas may be opened to traffic when the new concrete has attained a flexural strength of 300 psi and all joints have been sawed.</td></tr>
</table></td></tr>
<tr><td>Minnesota DOT</td><td>Does not have a specific related specification</td></tr>
<tr><td>Missouri DOT</td><td>Does not have a specific related specification</td></tr>
<tr><td>Texas DOT</td><td>Does not have a specific related specification</td></tr>
<tr><td>Virginia DOT</td><td>Does not have a specific related specification</td></tr>
<tr><td>Washington DOT
(Section 5-01.3(5))</td><td>1. If jackhammers are used for removing pavement, they shall not weigh more than 30-pounds, and chipping hammers shall not weigh more than 15-pounds. All power driven hand tools used for the removal of pavement shall be operated at angles less than 45-degrees as measured from the surface of the pavement to the tool.
2. The patch limits shall extend beyond the spalled area a minimum of 3.0-inches. Repair areas shall be kept square or rectangular. Repair areas that are within 12.0-inches of another repair area shall be combined.
3. A vertical saw cut shall be made to a minimum depth of 2.0-inches around the area to be patched. The Contractor shall remove material within the perimeter of the saw cut to a depth of 2.0-inches, or to sound concrete. The surface patch area shall be sand blasted and all loose material removed. All sandblasting residue shall be removed using dry oil-free air.
4. Spall repair shall not be done in areas where dowel bars are encountered.
5. When a partial depth repair is placed directly against an adjacent longitudinal joint, a bond-breaking material such as polyethylene film, roofing paper, or other material as approved by the Engineer shall be placed between the existing concrete and the area to be patched.
6. Patches that abut working transverse joints or cracks require placement of a compressible insert. The new joint or crack shall be formed to the same width as the existing joint or crack. The compressible joint material shall be placed into the existing joint 1.0-inch below the depth of repair. The compressible insert shall extend at least 3.0-inches beyond each end of the patch boundary.
7. Patches that abut the lane/Shoulder joint require placement of a formed edge, along the slab edge, even with the surface. The patching material shall be mixed, placed, consolidated, finished and cured according to manufacturer’s recommendations.</td></tr>
</table>

REFERENCES

AASHTO (2008), “Guide Specifications for Highway Construction,” American Association of State Highway and Transportation Officials.

Michigan DOT (2003), “Standard Specifications for Construction,” Michigan Department of Transportation.

Mn/DOT (2005), “Mn/DOT Standard Specifications for Construction,” Minnesota Department of Transportation.

MoDOT (2004), “Missouri Standard Specifications for Highway Construction,” Missouri Department of Transportation.

TxDOT (2004), “Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges,” Texas Department of Transportation.

Virginia DOT (2007), “Road and Bridge Specifications,” Virginia Department of Transportation.

WSDOT (2010), “Standard Specifications for Road, Bridge, and Municipal Construction, M41-10, Washington State Department of Transportation.

AASHTO Specification Designation 558 "Description"
Full Depth Patching

Agency/Organization	Specification Section
	Description
AASHTO (Section 558)	"Construct full-depth patches of portland cement concrete pavement."
Michigan DOT (Section 603)	Refer to AASHTO 557 summary.
Minnesota DOT	Does not have a specific related specification
Missouri DOT	Does not have a specific related specification
Texas DOT (Item 361)	"Repair concrete pavement to full depth."
Virginia DOT	Does not have a specific related specification
Washington DOT (Section 5-01.3(4))	Replace Portland Cement Concrete Panel

AASHTO Specification Designation 558 "Materials"
Full Depth Patching

<table>
<tr><th>Agency/Organization</th><th>Specification Section
Materials</th></tr>
<tr><td>AASHTO (Section 558)</td><td>AASHTO references to Subsection 558.02 which lists:
<table>
<tr><th>Material</th><th>AASHTO Subsection</th></tr>
<tr><td>Portland Cement</td><td>701.02</td></tr>
<tr><td>Aggregate for Untreated Base Course</td><td>703.03</td></tr>
<tr><td>Reinforcing Steel</td><td>711.01</td></tr>
<tr><td>Chemical Admixtures</td><td>713.03(B)</td></tr>
<tr><td>Fly Ash</td><td>713.03(C)(1)</td></tr>
<tr><td>Calcium Chloride</td><td>714.02</td></tr>
<tr><td>Epoxy Resin Adhesives</td><td>AASHTO M235</td></tr>
</table></td></tr>
<tr><td>Michigan DOT
(Section 603)</td><td>For concrete repairs, the type of mix to be used is based on time from casting to traffic opening as follows:
<table>
<tr><th>Time from Casting to Traffic Opening</th><th>Grade of Concrete</th></tr>
<tr><td>≤ 8 hours</td><td>Type P-MS</td></tr>
<tr><td>12 to 72 hours</td><td>Type P-NC</td></tr>
<tr><td>3 days</td><td>Grade HE</td></tr>
<tr><td>≥ 7 days</td><td>Grade P1</td></tr>
</table></td></tr>
<tr><td>Minnesota DOT</td><td>Does not have a specific related specification</td></tr>
<tr><td>Missouri DOT</td><td>Does not have a specific related specification</td></tr>
<tr><td>Texas DOT (Item 361)</td><td>The following materials related items apply:
<table>
<tr><td>Hydraulic Cement Concrete for Pavement</td><td>If the time allowed for opening to traffic is less than 72 hr following concrete placement, provide Class HES concrete designed to attain a minimum average flexural strength of 255 psi or a minimum average compressive strength of 1,800 psi within the designated time frame. Otherwise provide Class P concrete conforming to Item 360, "Concrete Pavement." Type III cement is permitted for Class HES concrete.</td></tr>
<tr><td>Asphalt Concrete</td><td>If required, furnish asphalt concrete material for overlay and asphalt shoulder repair in accordance with Item 340, "Dense-Graded Hot-Mix Asphalt (Method)."</td></tr>
</table></td></tr>
<tr><td>Virginia DOT</td><td>Does not have a specific related specification</td></tr>
<tr><td>Washington DOT
(Section 5-01.3(4))</td><td>Portland cement concrete is only allowed for concrete panel replacements (as opposed to patching materials).</td></tr>
</table>

AASHTO Specification Designation 558 "Construction"
Full Depth Patching

<table>
<tr><th rowspan="2">Agency/Organization</th><th colspan="2">Specification Section</th></tr>
<tr><th colspan="2">Construction</th></tr>
<tr><td>AASHTO (Section 558)</td><td colspan="2">All construction related items are:<table>
<tr><td>Concrete Mix Design for Patches</td><td>Provide one of the following concrete designs for partial-depth and full-depth patches, as specified in the contract:
1. Accelerated Strength Portland Cement Concrete Patch Mixtures: Use Type I or Type III portland cement to provide concrete with a minimum strength of 3,000 psi in 24 hours.
2. Normal Set Portland Cement Concrete Patch Mixture
3. Rapid Setting Patching Materials: Rapid setting patching materials must reach a minimum compressive strength of 3,000 psi in 24 hours.
4. Epoxy Resin Patching Mortars: Use only Agency-approved materials. Prepare epoxy resin patching mortars according to the manufacturer's recommendations.</td></tr>
<tr><td>Preparation of Patch Area</td><td>Repair in accordance with specified full-depth patching requirements for the following pavement types:
1. Mesh-Reinforced, Plain-Doweled, and Plain-Jointed Pavement
2. Continuously Reinforced Concrete
3. Detailed patching requirements are provided in AASHTO Section 558.03(C).</td></tr>
</table></td></tr>
<tr><td>Michigan DOT (Section 603)</td><td colspan="2">Refer to AASHTO 557 summary.</td></tr>
<tr><td>Minnesota DOT</td><td colspan="2">Does not have a specific related specification</td></tr>
<tr><td>Missouri DOT</td><td colspan="2">Does not have a specific related specification</td></tr>
</table>

<table>
<tr><th rowspan="2">Agency/Organization</th><th>Specification Section</th></tr>
<tr><th>Construction</th></tr>
<tr><td>Texas DOT (Item 361)</td><td>Construction related items are:<table>
<tr><td>Repair Area</td><td>Make repair areas rectangular, at least 6 ft. long and at least 1/2 a full lane in width unless otherwise shown on the plans.</td></tr>
<tr><td>Repair Process Steps</td><td>1. Saw-cut full depth through the concrete around the perimeter of the repair area before removal.
2. Schedule work so that concrete placement follows full-depth saw cutting by no more than 7 days unless otherwise shown on the plans or approved.
3. Remove or repair loose or damaged base material, and replace or repair it with approved base material to the original top of base grade. Place a polyethylene sheet at least 4 mils thick as a bond breaker at the interface of the base and new pavement. Allow concrete used as base material to attain sufficient strength to prevent displacement when placing pavement concrete.
4. Broom finish the concrete surface unless otherwise shown on the plans.</td></tr>
</table></td></tr>
<tr><td>Virginia DOT</td><td>Does not have a specific related specification</td></tr>
<tr><td>Washington DOT (Section 5-01.3(4))</td><td>1. Concrete slabs to be replaced as shown in the Plans shall be at least 6.0-feet long and full width of an existing pavement panel. The portion of the panel to remain in place shall have a minimum dimension of 6-feet in length and full panel width; otherwise the entire panel shall be removed and replaced.
2. There shall be no new joints closer than 3.0-feet to an existing transverse joint or crack.
3. A vertical full depth saw cut is required along all longitudinal joints and at transverse locations and, unless the Engineer approves otherwise, an additional vertical full depth relief saw cut located 12-inches to 18-inches from and parallel to the initial longitudinal and transverse saw cut locations is also required.
4. Removal of existing cement concrete pavement shall not cause damage to adjacent slabs that are to remain in place.
5. In areas that will be ground, slab replacements shall be performed prior to pavement grinding. When new concrete pavement is to be placed against existing cement concrete pavement.</td></tr>
</table>

REFERENCES

AASHTO (2008), “Guide Specifications for Highway Construction,” American Association of State Highway and Transportation Officials.

Michigan DOT (2003), “Standard Specifications for Construction,” Michigan Department of Transportation.

Mn/DOT (2005), “Mn/DOT Standard Specifications for Construction,” Minnesota Department of Transportation.

MoDOT (2004), “Missouri Standard Specifications for Highway Construction,” Missouri Department of Transportation.

TxDOT (2004), “Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges,” Texas Department of Transportation.

Virginia DOT (2007), “Road and Bridge Specifications,” Virginia Department of Transportation.

WSDOT (2010), “Standard Specifications for Road, Bridge, and Municipal Construction, M41-10, Washington State Department of Transportation.

AASHTO Specification Designation 560 "Description"
Diamond Grinding Concrete Pavement

Agency/Organization	Specification Section
	Description
AASHTO (Section 560)	"Grind and texture existing portland cement concrete pavement longitudinally using a diamond grinder."
Michigan DOT (Section 603) Concrete Pavement Restoration	"Restore pavement condition." "Concrete pavement restoration will include, but not be limited to: (1) Repairing portions of a concrete pavement with reinforced and nonreinforced Portland cement concrete and with the type of joint specified, (2) Diamond grinding Portland cement concrete pavement, (3) Resawing and sealing existing longitudinal pavement joints, and (4) Sawing, cleaning, and sealing cracks in concrete pavements."
Minnesota DOT	Has related specifications for new construction but not a full specific diamond grinding specification.
Missouri DOT	Has related specifications for new construction but not a full specific diamond grinding specification.
Texas DOT (Item 585)	"Measure and evaluate the ride quality of pavement surfaces."
Virginia DOT	No specific specification.
Washington DOT (Section 5-01.3(9))	Portland cement concrete pavement grinding.

AASHTO Specification Designation 560 "Materials"
Diamond Grinding Concrete Pavement

Agency/Organization	Specification Section
	Materials
AASHTO (Section 560)	There are no materials requirements in AASHTO Section 560.
Michigan DOT (Section 603)	There are no materials requirements in Michigan DOT Section 603 for diamond grinding.
Minnesota DOT	Not applicable.
Missouri DOT	Not applicable.
Texas DOT	There are no relevant materials requirements in TxDOT Item 585.
Virginia DOT	No specific specification
Washington DOT (Section 5-01.3(9))	There are no relevant materials requirements in WSDOT Section 5-01.3(9).

AASHTO Specification Designation 560 "Construction"
Diamond Grinding Concrete Pavement

<table>
<tr><th rowspan="2">Agency/Organization</th><th>Specification Section</th></tr>
<tr><th>Construction</th></tr>
<tr><td>AASHTO (Section 560)</td><td>Construction related items are:
<table>
<tr><td>Diamond Grinding and Texture</td><td>1. Uniformly grind and texture the entire pavement surface area until the surface on both sides of the transverse joints and all cracks are in the same plane and meet the required smoothness. Exclude shoulders.
2. Begin and end grinding from locations normal to the pavement centerline.
3. Texture: Provide the surface of the ground pavement with a corduroy-type texture consisting of parallel grooves between 3/32 in. and 5/32 in. wide, with a distance between the grooves of 1/16 in. to 1/8 in. and a difference between the peaks of the ridges and the bottom of the grooves of ____ in.</td></tr>
<tr><td>Equipment</td><td>1. Furnish a self-propelled grinding machine with diamond blades mounted on a multiblade arbor and a minimum cutting head width of 3 ft.</td></tr>
<tr><td>Tolerances</td><td>1. After the Contractor completes grinding and texturing, the Engineer will test the pavement surface for smoothness to ensure it meets the surface tolerance for new pavement specified in AASHTO Subsection 401.03(K)(1). Grind the adjacent shoulders or pavement to provide the required cross slope for drainage.
2. Provide a uniform pavement cross slope without depressions or misalignment of slope greater than ____in. in ____ft when tested by stringline or straightedge placed perpendicular to the centerline.</td></tr>
</table></td></tr>
<tr><td>Michigan DOT (Section 603)</td><td>Relevant construction related items are
<table>
<tr><td>Faulted Pavement</td><td>Faulted areas at transverse cracks and joints in excess of 1⁄16 inch after initial grinding must be reground until faulting is less than 1⁄16 inch.</td></tr>
<tr><td>Texture</td><td>Grind to a parallel corduroy type texture consisting of grooves 1⁄16 to 1⁄8 inch wide, 1⁄16 inch deep and 1⁄16 to 1⁄8 inch on center. Grind to a finished uniform texture. Make the transverse slope of the pavement uniform with no depressions or misalignment of slope greater than 1⁄8 inch when checked with a 10-foot straightedge.</td></tr>
</table></td></tr>
<tr><td>Minnesota DOT</td><td>Does not have a specific related specification</td></tr>
<tr><td>Missouri DOT</td><td>Does not have a specific related specification</td></tr>
</table>

<table>
<tr><th rowspan="2">Agency/Organization</th><th>Specification Section</th></tr>
<tr><th>Construction</th></tr>
<tr><td>Texas DOT (Item 361)</td><td>Relevant construction related items are:<table><tr><td>Equipment</td><td>When grinding is required, provide self-propelled powered grinding equipment that is specifically designed to smooth and texture pavements using circular diamond blades. Provide equipment with automatic grade control capable of grinding at least 3 ft. of width longitudinally in each pass without damaging the pavement.</td></tr></table></td></tr>
<tr><td>Virginia DOT</td><td>Does not have a specific related specification</td></tr>
<tr><td>Washington DOT (Section 5-01.3(9))</td><td>1. The pavement shall be ground in a longitudinal direction beginning and ending at lines normal to the pavement centerline. The minimum overlap between longitudinal passes shall be 2.0-inches. Ninety-five-percent of the surface area of the pavement to be ground shall have a minimum of ⅛-inch removed by grinding.
2. The final surface texture shall be uniform in appearance with longitudinal corduroy type texture. The grooves shall be between 3⁄32 and 5⁄32-inches wide, and no deeper than 1⁄16-inch. The land area between the grooves shall be between 1⁄16 and ⅛-inches wide.</td></tr>
</table>

REFERENCES

AASHTO (2008), “Guide Specifications for Highway Construction,” American Association of State Highway and Transportation Officials.

Michigan DOT (2003), “Standard Specifications for Construction,” Michigan Department of Transportation.

Mn/DOT (2005), “Mn/DOT Standard Specifications for Construction,” Minnesota Department of Transportation.

MoDOT (2004), “Missouri Standard Specifications for Highway Construction,” Missouri Department of Transportation.

TxDOT (2004), “Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges,” Texas Department of Transportation.

Virginia DOT (2007), “Road and Bridge Specifications,” Virginia Department of Transportation.

WSDOT (2010), “Standard Specifications for Road, Bridge, and Municipal Construction, M41-10, Washington State Department of Transportation.

AASHTO Specification Designation 561 "Description"
Milling Pavement

Agency/Organization	Specification Section
	Description
AASHTO (Section 561)	"Strip pavement by a cold milling process before resurfacing."
Michigan DOT	Limited specification information.
Minnesota DOT (Section 2232)	"This work shall consist of improving the profile, cross slope, and surface texture of an existing pavement surface by machine (cold) milling preparatory to placement of another course thereon."
Missouri DOT	Limited specification information.
Texas DOT (Item 585)	Limited specification information.
Virginia DOT	Limited specification information.
Washington DOT	Limited specification information.

AASHTO Specification Designation 561 "Materials"
Milling Pavement

Agency/Organization	Specification Section
	Materials
AASHTO (Section 561)	There are no materials requirements in AASHTO Section 561.
Michigan DOT (Section)	Not applicable.
Minnesota DOT	There are no materials requirements in Mn/DOT Section 2232.
Missouri DOT	Not applicable.
Texas DOT	Not applicable.
Virginia DOT	Not applicable.
Washington DOT	Not applicable.

AASHTO Specification Designation 561 "Construction"
Milling Pavement

Agency/Organization	Specification Section Construction
AASHTO (Section 561)	Construction related items are: **Milling Setup** 1. Mill the surface in a longitudinal direction. For the initial pass, use as a reference the curb, longitudinal edge of pavement, or a string attached to the pavement surface. Furnish a milling machine with a steering guide or reference that allows the operator to follow the guidance reference within 2 in. When milling next to previously milled pavement, use the edge of the milled trench as the longitudinal reference for succeeding passes. 2. Provide a milled surface with a uniform texture free of excessive gouges, ridges, and grooves. 3. Provide an end transition on a 4:1 (1:4) slope to the existing pavement surface at each end of the milling work each day. End the milling passes as close to each other as practical. Do not leave longitudinal joints more than 2 in. deep exposed during nonworking hours.
Michigan DOT	Not applicable.
Minnesota DOT (Section 2232)	Construction related items are: **Equipment** 1. Pavement milling shall be accomplished with a power operated, self-propelled cold milling machine capable of removing concrete and bituminous surface material as necessary to produce the required profile, cross slope, and surface texture uniformly across the pavement surface. The machine shall also be equipped with means to control dust and other particulate matter created by the cutting action. 2. The machine shall be equipped to accurately and automatically establish profile grades along each edge of the machine, within plus or minus 1/8 inch, by referencing from the existing pavement by means of a ski or matching shoe, or from an independent grade control. The machine shall be controlled by an automatic system for controlling grade, elevation, and cross slope at a given rate.
Missouri DOT	Does not have a specific related specification
Texas DOT	Does not have a specific related specification
Virginia DOT	Does not have a specific related specification
Washington DOT	Does not have a specific related specification

REFERENCES

AASHTO (2008), “Guide Specifications for Highway Construction,” American Association of State Highway and Transportation Officials.

Michigan DOT (2003), “Standard Specifications for Construction,” Michigan Department of Transportation.

Mn/DOT (2005), “Mn/DOT Standard Specifications for Construction,” Minnesota Department of Transportation.

MoDOT (2004), “Missouri Standard Specifications for Highway Construction,” Missouri Department of Transportation.

TxDOT (2004), “Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges,” Texas Department of Transportation.

Virginia DOT (2007), “Road and Bridge Specifications,” Virginia Department of Transportation.

WSDOT (2010), “Standard Specifications for Road, Bridge, and Municipal Construction, M41-10, Washington State Department of Transportation.

AASHTO Specification Designation 563 "Description"
Portland Cement Concrete Unbonded Overlays

Agency/Organization	Specification Section Description
AASHTO (Section 563)	"Place portland cement concrete unbonded overlays, including pavement patching of existing surface, applying a bond breaker, repairing curb, and disposing of removed material."
Michigan DOT (Sections 601 and 602)	"Construct a jointed Portland cement concrete pavement, unbonded overlay, base course, or shoulder, with or without reinforcement." Both MDOT Sections 601 (Portland Cement Concrete Pavements) and 602 (Concrete Pavement Construction) were reviewed.
Minnesota DOT (Section 2301)	No specific specification for PCC unbonded overlays. Presumably Section 2301 applies and a summary of Section 2301 is included.
Missouri DOT (Sections 506.20 and 506.30)	[506.20] "This work shall consist of placing an interlayer material on an existing concrete pavement and constructing an unbonded concrete overlay in accordance with the details and locations shown on the plans. The standard unbounded concrete overlay design thickness is either 8 or 5 inches. The eight-inch overlays are constructed similarly to new concrete pavement in terms of joint spacing and use of dowel bars and tie bars. The five-inch overlays are sawed into smaller panels and require no steel. The overlay shall be placed in accordance with Section 502, except as herein stated." [506.30] "This work shall consist of constructing an unbonded concrete overlay on an existing asphalt surface in accordance with the details and locations shown on the plans. All work shall be performed in accordance with Section 506.20, except that an interlayer shall not be used."
Texas DOT	No specific specification for PCC unbonded overlays.
Virginia DOT	No specific specification for PCC unbonded overlays.
Washington DOT	No specific specification for PCC unbonded overlays.

AASHTO Specification Designation 563 "Materials"
Portland Cement Concrete Unbonded Overlays

<table>
<tr><th>Agency/Organization</th><th>Specification Section
Materials</th></tr>
<tr><td>AASHTO
(Section 563)</td><td>Major materials related items
<table>
<tr><td>Portland Cement</td><td>1. AASHTO Subsection 701.02. Meets AASHTO M85
2. Use only Type I or Type II cement</td></tr>
<tr><td>Asphalt Cements</td><td>AASHTO Subsection 702.01(A). Meets AASHTO M320</td></tr>
<tr><td>Asphalt Concrete</td><td>Place a uniform layer to a minimum depth of 1 in.</td></tr>
<tr><td>Curing Materials</td><td>AASHTO Subsection 713.02. Includes three options:
1. Burlap cloth (AASHTO M182)
2. Sheet materials (AASHTO M171)
3. Liquid membrane forming compounds (AASHTO M148)</td></tr>
<tr><td>Water</td><td>AASHTO Subsection 714.01(A). Meets AASHTO M157.</td></tr>
<tr><td>Reinforcing Steel</td><td>Use deformed epoxy-coated bars</td></tr>
</table></td></tr>
<tr><td>Michigan DOT
(Section 601)</td><td>Major materials related items
<table>
<tr><td>Cement</td><td>Section 901</td></tr>
<tr><td>GGBFS</td><td>Section 901</td></tr>
<tr><td>Fly Ash</td><td>Section 901</td></tr>
<tr><td>Coarse Aggregate</td><td>Section 902</td></tr>
<tr><td>Fine Aggregate</td><td>Section 902</td></tr>
<tr><td>Concrete Admixtures</td><td>Section 903</td></tr>
<tr><td>Water</td><td>Section 911</td></tr>
</table>
<table>
<tr><td>Certified Batch Plants</td><td>Supply Portland cement concrete from certified portable and stationary concrete batch plant facilities meeting the requirements of the National Ready Mixed Concrete Association (NRMCA) certification program for automatic control and automatic systems.

When no fully automated NRMCA certified facility is within 25 miles of the project limits, the Engineer may waive NRMCA certification and/or automation requirements</td></tr>
<tr><td>Additional Water at Placement Site</td><td>Do not add more water than the approved concrete mix design will allow based on maximum water content and maximum water/cementitious material ratio.</td></tr>
<tr><td>Concrete Placing Temp</td><td>Concrete must be between 45°F and 90°F at the time it is placed.</td></tr>
<tr><td>Air Content</td><td>At the time of placement, concrete must have 6.5 ± 1.5 percent entrained air. However, concrete furnished for slipform placement and having a slump of 1.5 inches or less, may have a minimum of 4.5 percent entrained air.</td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Agency/Organization</th><th colspan="2">Specification Section</th></tr>
<tr><th></th><th colspan="2">Materials</th></tr>
<tr><td>Minnesota DOT
(Section 2301)</td><td colspan="2">Major materials related items
<table>
<tr><td>Minimum Cementitious Content</td><td>530 lb/CY with a minimum of portland cement = 400 lb/CY when using fly ash or GGBFS.</td></tr>
<tr><td>Total Alkalis in Portland Cement</td><td>0.60%</td></tr>
<tr><td>Total Alkalis in Cementitious Material</td><td>≤ 5 lb/CY</td></tr>
<tr><td>Water Cement Ratio</td><td>The target W/C ratio is 0.40 for large paving projects (>5,000 CY). Incentives and disincentives associated with lower or higher W/C ratios are shown below
<table>
<tr><th>Mean Value of W/C (termed QI)</th><th>Payment Incentive or Disincentive per CY ($/CY)</th></tr>
<tr><td>≤0.35</td><td>+ 4.00</td></tr>
<tr><td>0.36</td><td>+ 3.00</td></tr>
<tr><td>0.37</td><td>+ 2.00</td></tr>
<tr><td>0.38</td><td>+ 1.25</td></tr>
<tr><td>0.39</td><td>+ 0.□0</td></tr>
<tr><td>0.4</td><td>0.00</td></tr>
<tr><td>0.41</td><td>- 0.50</td></tr>
<tr><td>0.42</td><td>- 1.25</td></tr>
<tr><td>0.43</td><td>- 2.00</td></tr>
<tr><td>0.44</td><td>- 3.00</td></tr>
<tr><td>≥ 0.45</td><td>Determined by the Concrete Engineer</td></tr>
</table></td></tr>
</table></td></tr>
<tr><td rowspan="3">Missouri DOT
(Section 506.20)</td><td>Interlayer</td><td>The interlayer material shall be a minimum of 1 in. thick new bituminous ….</td></tr>
<tr><td>Concrete</td><td>Materials for an unbonded overlay shall be in accordance with MoDOT Section 502. That information states that all material for the concrete shall conform to Section 501.</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td>Texas DOT</td><td colspan="2">No specific specification for PCC unbonded overlays.</td></tr>
<tr><td>Virginia DOT</td><td colspan="2">No specific specification for PCC unbonded overlays.</td></tr>
<tr><td>Washington DOT</td><td colspan="2">No specific specification for PCC unbonded overlays.</td></tr>
</table>

AASHTO Specification Designation 563 "Construction"
Portland Cement Concrete Unbonded Overlays

<table>
<tr><th>Agency/Organization</th><th colspan="2">Specification Section</th></tr>
<tr><th></th><th colspan="2">Construction</th></tr>
<tr><td>AASHTO
(Section 563)</td><td colspan="2">Major construction related items
<table>
<tr><td>Surface Preparation and Pavement Patching</td><td>1. Patching Pavement: Fill deep spalls with asphalt concrete or concrete before placing the interlayer treatment.
2. Full Depth Removal and Patching: Remove pavement full depth or stabilize as specified in AASHTO Section 558. Construct full depth patches before placing the overlay.</td></tr>
<tr><td>Placing and Finishing Concrete</td><td>Concrete Overlay: Concrete must meet AASHTO Subsection 501.03. Subsection 501.03 recap follows
1. Mix Design Options
<table>
<tr><th>Property</th><th>Value</th><th>AASHTO Test Method</th></tr>
<tr><td>Compressive Strength (min)</td><td>3,500 psi</td><td>T22</td></tr>
<tr><td>Flexural Strength (min)</td><td>550 psi</td><td>T97</td></tr>
<tr><td>Flexural Strength (min)</td><td>650 psi</td><td>T177</td></tr>
<tr><td>Slump</td><td>3/8 to 3 in.</td><td>T119</td></tr>
<tr><td>Cement Content
Without Air (min)
With Air (min)</td><td>
564 lb/CY
598 lb/CY</td><td></td></tr>
<tr><td>Fly Ash
Type C
Type F</td><td>
30% max[1]
25% max[1]</td><td>Note 1: % max cement replacement</td></tr>
<tr><td>GGBFS</td><td>50% max[1]</td><td>See Note 1</td></tr>
<tr><td>Water/Cementitious Ratio
Without Air (max)
With Air (max)</td><td>
0.53
0.49</td><td></td></tr>
<tr><td>Entrained Air</td><td>5 to 8%</td><td>T152, T196, or T199</td></tr>
</table></td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Agency/Organization</th><th colspan="2">Specification Section</th></tr>
<tr><th></th><th colspan="2">Construction</th></tr>
<tr><td>AASHTO
(Section 563)
(continued)</td><td>Placing and Finishing Concrete (continued)</td><td>
2. Mixing and Placing Limitations
a. Stop mixing and concreting operations if shaded ambient air temperature away from artificial heat is 40°F or less. Resume operations only when the ambient air temperature is 40°F and rising.
b. Place mixed concrete only when its temperature is between 50°F and 85°F.

3. Longitudinal Joints
<table>
<tr><td>Dimensions</td><td>Saw the first cut or insert the joint material to one third of the depth.</td></tr>
<tr><td>Tiebars</td><td>Place [30 in.] long No. 5 tiebars of Grade 60 steel, spaced [30 in.] center-to-center to one half of the depth of the PCCP. Ensure that tiebars are placed perpendicular to the face of the joint, centered in the slab depth, and parallel to the finished surface.</td></tr>
<tr><td>Construction</td><td>Form or saw longitudinal joints in the plastic concrete. Saw the joints within 4 to 24 hours after placing the concrete and immediately after completing the transverse joints. Allow only the saw on the pavement during sawing operations.</td></tr>
<tr><td>Sealing</td><td>Seal joints after the curing period and before opening the pavement to traffic. Use sandblasting followed by an oil-free air jet to clean the faces and joint openings before sealing. Seal joints only when they are completely dry. Do not dry joints with a heat lance. Use an approved backer rod to seal the lower portion of the joint groove to a uniform depth to prevent sealant from entering beneath the specified depth. Ensure that backer rod is compatible with the sealant type specified and install according to manufacturers’ recommendations.</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><th>Agency/Organization</th><th colspan="3">Specification Section</th></tr>
<tr><th></th><th colspan="3">Construction</th></tr>
<tr><td>AASHTO
(Section 563)
(continued)</td><td></td><td>Placing and Finishing Concrete (continued)</td><td>
4. Contraction Joints
<table>
<tr><td>Location and Dimensions</td><td>Form or saw joints as narrowly as possible, to at least one third of the pavement depth.</td></tr>
<tr><td>Load Transfer</td><td>Install load transfer dowel bars of specified grade and size, spaced at […] centers, and secured with a wire basket or implanted mechanically. Place dowel bars one half of the depth parallel to the surface and pavement edge to an alignment tolerance of [±1/4 in.]. Vibrate concrete around all dowel bars without misaligning them.</td></tr>
<tr><td>Construction</td><td>Place formed joints while the concrete is plastic. Begin relief-cut joint sawing immediately after the concrete hardens to the stage that it can be sawed without raveling. Saw all joints between 4 and 24 hours after placing concrete but before uncontrolled shrinkage cracking develops.</td></tr>
<tr><td>Sealing</td><td>Similar to longitudinal joint construction.</td></tr>
</table>
5. Transverse Construction Joints: Install transverse construction joints at the end of each day’s placement. Form bulkheads when stopping the placement in an emergency or at the end of each day’s pour.

6. Surface Tolerances: AASHTO provides for two profile measurement methods
a. Straightedge: This method applies to all paving. Test the surface with a 10-ft straightedge at random locations. The Engineer will identify pavement areas that deviate more than [3/16 in.] from the straightedge as defective work.
b. Profilograph: Describes a California-type profilograph.

7. Curing
a. Cure the concrete for at least 3 days immediately after the finishing operation.
b. Protect the concrete for at least 10 days or until the concrete achieves a compressive strength of (2,200 psi).
</td></tr>
</table>

<table>
<tr><th>Agency/Organization</th><th>Specification Section</th></tr>
<tr><td></td><td>Construction</td></tr>
<tr><td>AASHTO
(Section 563)
(continued)</td><td>
<table>
<tr><td>Placing and Finishing Concrete (continued)</td><td>8. Tolerance and Price Adjustments for Pavement Thickness:
Price adjustments in accordance with the table below:
<table>
<tr><th>Deficiency in Thickness as Determined by Cores (in.)</th><th>Contract Price Allowed</th></tr>
<tr><td>0 to 0.20</td><td>100</td></tr>
<tr><td>0.21 to 0.30</td><td>80</td></tr>
<tr><td>0.31 to 0.40</td><td>72</td></tr>
<tr><td>0.41 to 0.50</td><td>68</td></tr>
<tr><td>0.51 to 0.75</td><td>57</td></tr>
<tr><td>0.76 to 1.00</td><td>50</td></tr>
<tr><td>> 1.00</td><td>Remove and Replace</td></tr>
</table></td></tr>
<tr><td>Opening to Traffic</td><td>Compressive Strength—Opening to Traffic. Do not open the overlay to traffic or construction equipment until the concrete bonded overlay attains a minimum compressive strength of 3,500 psi and all joints have been cleaned and filled with joint material.</td></tr>
<tr><td>Test Properties</td><td>Slump: Use concrete having a maximum slump, as determined of 3 in. for concrete placed by vibration or 4 in. for hand-placed concrete.</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><th>Agency/Organization</th><th>Specification Section</th></tr>
<tr><td></td><td>Construction</td></tr>
<tr><td>Michigan DOT
(Section 602)</td><td>Major construction related items
<table>
<tr><td>Surface Texture</td><td>When the pavement has set sufficiently to maintain texture, drag the surface longitudinally using one or two layers of an approved damp fabric material. Maintain fabric contact with the surface across the entire width of concrete being placed. Immediately after dragging, groove all surfaces other than concrete base courses and shoulders. Orient the grooves generally perpendicular to the centerline and form the grooves in the plastic concrete cleanly without slumping of the edges or severe tearing of the surface. Provide a surface texture consisting of 1/8 inch wide grooves spaced 1/2 inch on center and 1/8 to 1/4 inch deep.</td></tr>
<tr><td>Se□ling Joints with Hot-Poured Sealants</td><td>Seal the joints immediately after the joints are cleaned. Joint surfaces must be dry when sealed. Do not place sealant when temperature is less than 50°F.</td></tr>
<tr><td>Profile</td><td>While the concrete is still plastic, test the slab surface for trueness to the required grade and cross section using a 10-foot straightedge. If high or low spots exceeding 1/8 inch in 10 feet (1/4 inch for concrete shoulders and inch for concrete base course and temporary concrete pavement) are found, suspend paving operations and correct the finishing procedures. Correct high spots in pavements that exceed these tolerances.</td></tr>
<tr><td>Weather and Temperature Limitations</td><td>1. Protect the concrete from freezing until the concrete has attained a compressive strength of at least 1,000 psi.
2. Do not place concrete if portions of the base, subbase, or subgrade layer are frozen, or if the grade exhibits poor stability from excessive moisture levels.
3. Do not place concrete when the temperature of the plastic concrete at the point of placement is above 90°F.</td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Agency/Organization</th><th>Specification Section</th></tr>
<tr><td></td><td>Construction</td></tr>
<tr><td>Minnesota DOT
(Section 2301)</td><td>Major construction related items
<table>
<tr><td>High-Early Strength Concrete</td><td>High-early concrete is defined as a concrete mixture having a cementitious content greater than 600 pounds per cubic yard. High Early mixes shall be designed to provide a maximum water/cementitious ratio of 0.40 and a minimum flexural strength of 500 psi or a minimum compressive strength of 3000 psi in 48 hours. High early mixes may have up to 100 % portland cement. High-early mixes are not eligible for incentive payments for water/cementitious ratio.</td></tr>
<tr><td>Minimum Strength Requirements for Opening Pavements to Construction and General Public Traffic</td><td>New pavement shall be closed to use by construction and general public traffic for 7 days or according to the values listed in the table below, whichever is the shorter.
<table>
<tr><th>Slab Thickness (in.)</th><th>Flexural Strength (psi)</th></tr>
<tr><td>6.0</td><td>500</td></tr>
<tr><td>6.5</td><td>500</td></tr>
<tr><td>7.0</td><td>500</td></tr>
<tr><td>7.5</td><td>480</td></tr>
<tr><td>8.0</td><td>460</td></tr>
<tr><td>8.5</td><td>440</td></tr>
<tr><td>9.0</td><td>390</td></tr>
<tr><td>9.5</td><td>350</td></tr>
<tr><td>10.0</td><td>350</td></tr>
<tr><td>≥ 10.5</td><td>350</td></tr>
</table></td></tr>
<tr><td>Placing Concrete</td><td>1. All main line pavement constructed by standard or vibratory machine placement methods shall be constructed in a single layer of concrete.
2. Water shall not be added to the surface of the concrete to aid in finishing without the approval of the Engineer. The Engineer will only give this approval to replace evaporated surface water directly behind the paver caused by a halt in forward progress from a short-term breakdown in equipment or supply of concrete.
3. Should placement of concrete be temporarily suspended, the placement operations shall be resumed in such manner that will not result in a cold joint or honeycombing. If the suspension period exceeds 90 minutes, a standard header joint shall be constructed.</td></tr>
</table></td></tr>
</table>

Agency/Organization	Specification Section		
	Construction		
Minnesota DOT (Section 2301) (continued)	Joint Construction	Initial joint sawing shall be approximately **1/8 inch** wide and to the full joint depth. The initial sawing shall be accomplished as soon as the condition of the concrete will permit without raveling and before random cracking occurs. The sequence of initial sawing shall be at the Contractor's option.	
	Surface Finish	Mn/DOT uses a standard longitudinal carpet drag followed by transverse tining.	
	Concrete Curing	The Contractor shall: (1) Cure and protect the concrete by the blanket curing method or one of the membrane curing methods. (2) Cure the entire pavement surface and edges as soon as surface conditions permit after the finishing operations. (3) Continue curing and protecting the concrete for at least 72 hours. (4) Place the curing media on the pavement edges within 30 minutes after removal of the forms when side forms are used. (5) Extend the minimum curing period to 96 hours when fly ash or Portland-pozzolan cement substitutions are used.	
	Surface Smoothness	The Contractor shall test the pavement surface for surface smoothness and ride quality. Surface Smoothness and Ride Quality shall be measured with a **25 foot** California type profilograph, or a Lightweight Inertial Profiler (IP), which produces a profilogram (profile trace of the surface tested). Either type of device must be certified according to the procedure on file in the Mn/DOT Concrete Engineering Unit.	
	Thickness Requirements	Where the cores show a thickness deficiency exceeding **½ inch**, but less than **1 inch**, the pavement represented by those cores will not be excluded from the pay quantities; however, a deduction will be made from the moneys due the Contractor equal to the product of the defective areas and **$20.00 per square yard**. Pavement represented by cores showing a thickness deficiency of **1 inch** or more will be excluded from all payments **plus** a deduction will be made from the moneys due the Contractor equal to the product of the defective areas and **$20.00 per square yard**. These deductions will be assessed in lieu of removing and replacing the areas of pavement which are deficient in thickness.	

<table>
<tr><th rowspan="2">Agency/Organization</th><th colspan="2">Specification Section</th></tr>
<tr><th colspan="2">Construction</th></tr>
<tr><td>Missouri DOT
(Section 506.20)</td><td colspan="2">Major construction related items<table>
<tr><td>Surface Preparation</td><td>All holes greater than 2 inches wide and one inch deep in the surface of the traffic lanes, excluding shoulders, shall be filled with patching material and shall be compacted to a flat, tight surface.</td></tr>
<tr><td>Bituminous Interlayer</td><td>The surface temperature of a bituminous interlayer shall not exceed 90°F prior to the overlay placement. The temperature may be controlled with any means approved by the Engineer, including, but not limited to white curing compound and water misting.</td></tr>
<tr><td>Dowel Bars</td><td>Dowel bars for eight-inch unbounded overlays shall be installed the full width of the unbonded overlay and the baskets, if used, shall be firmly anchored to the interlayer surface.</td></tr>
<tr><td>Tie Bars</td><td>Tie bars shall be installed between lanes in an eight-inch unbounded concrete overlay.</td></tr>
<tr><td>Concrete Temperature</td><td>The concrete temperature shall not exceed 95°F when delivered to the site.</td></tr>
<tr><td>Contraction Joints</td><td>Sawing of the contraction joints shall not cause excessive raveling. Standard joint spacing for a five-inch unbounded concrete overlay is 6 feet transversely and longitudinally. Standard joint spacing for an eight-inch unbounded overlay is 15 ft transversely and 12 ft across the full lane width. New transverse joints will not be required to match existing transverse joints. The minimum depth of the sawed joints shall be one-third the pavement thickness and the width of the joint shall be 1/8-inch maximum. The joints shall not be sealed, unless open more than ¼ inch, but shall be cleaned of all deleterious material after sawing. Concrete panels with cracking outside of the sawed joints shall be considered unacceptable.</td></tr>
<tr><td>Opening Strength</td><td>The unbounded concrete overlay may be opened for light-weight traffic when the concrete has attained a minimum compressive strength of 2500 psi. The concrete pavement shall not be opened to all types of traffic until the concrete has attained a minimum compressive strength of 3000 psi. Compressive strength for opening to traffic shall be determined either by compressive strength tests in accordance with AASHTO T 22 or the maturity method.</td></tr>
</table></td></tr>
<tr><td>Texas DOT</td><td colspan="2">No specific specification for PCC unbonded overlays.</td></tr>
<tr><td>Virginia DOT</td><td colspan="2">No specific specification for PCC unbonded overlays.</td></tr>
<tr><td>Washington DOT</td><td colspan="2">No specific specification for PCC unbonded overlays.</td></tr>
</table>

REFERENCES

AASHTO (2008), “Guide Specifications for Highway Construction,” American Association of State Highway and Transportation Officials.

Michigan DOT (2003), “Standard Specifications for Construction,” Michigan Department of Transportation.

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AASHTO Specification Designation 567 "Description"
Cracking and Seating

Agency/Organization	Specification Section
	Description
AASHTO (Section 567)	"Crack existing portland cement concrete pavement and roll the broken concrete until surface material is well-seated before placing an asphalt pavement overlay."
UK (Section 716)	No general description
Michigan DOT	No specific specification.
Minnesota DOT	No specific specification.
Missouri DOT	No specific specification.
Texas DOT	No specific specification.
Virginia DOT	No specific specification.
Washington DOT	No specific specification.

AASHTO Specification Designation 567 "Materials"
Cracking and Seating

Agency/Organization	Specification Section
	Materials
AASHTO (Section 567)	No materials related specifications.
UK (Section 716)	No materials related specifications
Michigan DOT	No specific specification.
Minnesota DOT	No specific specification.
Missouri DOT	No specific specification.
Texas DOT	No specific specification.
Virginia DOT	No specific specification.
Washington DOT	No specific specification.

AASHTO Specification Designation 567 "Construction"
Cracking and Seating

Agency/Organization	Specification Section	
	Construction	
AASHTO (Section 567)	Construction related items are:	
	Cracking and Seating Equipment	1. Use a device to crack the concrete pavement that exerts a minimum of 12,000 ft-lb of energy with a spade or guillotine-type cracker mounted on a vehicle with controlled forward and transverse movement. Crack the pavement full depth, while maintaining aggregate interlock between the pieces. Do not use any device that causes undue displacement of the concrete or damages drainage facilities, utilities, or other property, or destabilizes the base or subgrade. 2. Seat the cracked concrete with a vibratory roller. 3. Furnish vibratory rollers with separate controls for energy and propulsion. Furnish vibratory rollers with a variable amplitude and frequency system capable of producing a frequency of 2,000 vibrations per minute and meeting the following requirements: • Diameter of drum 4 ft • Length of drum 6.5 ft • Unit static force on drum 125 lb/in. of width • Total applied force on drum 325 lb/in. of width
	Surface Preparation	Remove existing asphalt patching or overlay before cracking the pavement.
	Test Section	The Engineer will designate test sections to be used before full production cracking operations begin. Crack the test sections using varying energy and striking patterns until a pattern is established that cracks the pavement to the extent required. Use the pattern established to crack the remaining pavement as long as the crack pattern meets the specified size requirements. If the production pattern stops producing cracks to the extent required, use another test section to identify a new successful pattern. Furnish and apply water to dampen the pavement surface after cracking so the extent of breakage can be seen.
	Cracking Operations	1. Perform cracking one lane at a time to produce pieces approximately 1.2 to 1.8 ft2 in area. Orient the greatest dimension of the pieces transverse to the pavement centerline. Prohibit cracking within 2.5 ft of any transverse joint or other location. 2. Produce cracks that are continuous without extensive spalling along the crack. Extensive spalling is spalling more than 1 in. deep. Do not shatter the pavement or base during cracking operations. 3. Apply water randomly once each day to the surface to

<table>
<tr><th>Agency/Organization</th><th colspan="2">Specification Section</th></tr>
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<tr><td>AASHTO (Section 567) (continued)</td><td></td><td>verify the specified extent of breakage. Adjust the energy or striking pattern based on these check sections.</td></tr>
<tr><td></td><td>Seating Operations</td><td>1. After cracking, roll the concrete to seat firmly and lay the cracked pieces to an even surface. Continue rolling until the surface material is well-seated and uniformly compacted.
2. Remove soft spots or rocking pieces detected and undercut unsuitable material as directed. Backfill these areas with crushed aggregate base to the bottom of adjacent portland cement concrete pavement and cover the crushed aggregate base with hot mix asphalt concrete.
3. Perform rolling only under dry pavement conditions.</td></tr>
<tr><td></td><td>Maintenance</td><td>Maintain the pavement according to the traffic control plan if the pavement is opened to traffic after the cracking and seating operation and before placing the first asphalt concrete course. Maintain the pavement for traffic according to the Traffic Control Plan. Perform asphalt concrete pavement construction within two weeks of completing the cracking and seating operations.</td></tr>
<tr><td>UK Dept. for Transport Specifications (Section 716 and NG 716) Cracking and Seating of Existing Jointed Unreinforced Concrete Pavements and Hydraulically Bound Mixture Bases</td><td colspan="2">Construction related items are:

<table>
<tr><td>Cracking and Seating Equipment</td><td>1. Layers shall be cracked and seated with plant and equipment to which the Overseeing Organization's consent has been given and shall comply with this clause.
2. Suitable plant with a guillotine action capable of delivering variable pre-set impact loads to the concrete surface. The plant used to crack the hydraulically bound pavement layer or layers shall be self-propelled and have all wheels fitted with rubber tires.</td></tr>
<tr><td>Surface Preparation</td><td>Any existing asphalt overlay and surfacing shall be removed from the area to be treated for the full width of each lane.</td></tr>
<tr><td>Test Section</td><td>3. The test section shall be no less than 250 m2 nor greater than 420 m2.
4. The work on the test section shall proceed as follows:
a. Cracking shall proceed in stages as directed by the Overseeing Organization in groups of four to six bays [slabs] in jointed concrete pavements. Each group that is cracked and seated shall be assessed in accordance with clauses contained in the UK specification.
b. In Stage 1 of the main trial the Contractor shall set up his plant and equipment and demonstrate that he can produce the required pattern and</td></tr>
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Agency/Organization	Specification Section		
	Construction		
UK Dept. for Transport Specifications (Section 716 and NG 716) Cracking and Seating of Existing Jointed Unreinforced Concrete Pavements and Hydraulically Bound Mixture Bases (continued)	Test Section (continued)	quality of transverse cracks in accordance with the UK specification. c. In Stage 2 and each subsequent Stage of the main trial, a group of four bays [slabs] in jointed concrete pavement, shall be cracked starting from one end to produce transverse cracks at each of the spacings stated. d. Seating: After cracking in both Stage 1 and Stage 2, the pavement shall be seated with the number of roller passes specified in the UK specification. 5. Compliance with the cracking and seating requirements for the main trial shall be assessed as follows: a. The surface pattern of cracking shall be checked before seating but after applying clean water and allow to dry as specified. b. The depth and the vertical direction of cracking shall be determined by coring through the full depth of the hydraulically bound pavement layer symmetrically at the crack position. Core diameter shall be in accordance with items in the UK specification. In Stage 2 and in subsequent Stages of the main trial, the number of cores shall be in accordance with requires in the UK specification. In cases where cracks are not visible in the surface, the locations of cores will be generally within the impact points and transversely in line with the impact points. If any shattering or multiple cracking is present in the extracted core then there is deemed to have been 'shattering failure.'
	Cracking Operations	1. Proceed with pavement cracking at spaces determined by test section based on effective stiffness modulus computed from FWD tests (refer to UK specification 717). Generally a 0.75 m to 2 m spacing. 2. Surface cracking checked by applying water on all areas, allowing it to surface dry and then core every 300 m2 or less of surface treated. If the cores indicate multiple cracks, shattered base or no cracking then the operation is suspended and new test cycle required. 3. Any longitudinal cracking in wheelpaths that extends beyond two transverse cracks is considered a failure and requires a new test cycle and slab repair.
	Seating	Minimum of six passes with a 20 tonne pneumatic tired

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<tr><td>Operations</td><td>roller. Effective stiffness modulus confirmed with FWD tests after seating.</td></tr>
<tr><td>Maintenance</td><td>Surface of cracked and seated pavement will be cleaned of all debris before contractor conducts FWD tests. Computed effective stiffness modulus must be accepted before paving. Does not appear that they allow traffic before paving.</td></tr>
</table></td></tr>
<tr><td>Michigan DOT</td><td colspan="2">No specific specification.</td></tr>
<tr><td>Minnesota DOT</td><td colspan="2">No specific specification.</td></tr>
<tr><td>Missouri DOT</td><td colspan="2">No specific specification.</td></tr>
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<tr><td>Washington DOT</td><td>Construction related items are:
<table>
<tr><td>Cracking and Seating Equipment</td><td>1. Equipment shall be self-propelled and self-contained guillotine-type drop weight.
2. Equipment shall impact the pavement with a variable force which can be controlled in force and point of impact.</td></tr>
<tr><td>Surface Preparation</td><td>1. 1. Prior to cracking, any existing HMA shall be removed from the PCCP to be cracked.</td></tr>
<tr><td>Test Section</td><td>1. 1. A test section will be used to assess early cracking operations (numerous details are associated with the test section).</td></tr>
<tr><td>Cracking Operations</td><td>1. Pavement shall be cracked into segments nominally measuring 6 ft. transversely and 4 ft. longitudinally. [Note: Most WSDOT JPCP slabs are 12 ft. wide and 15 ft. between contraction joints.]
2. The pavement cracking tool shall not impact the pavement within 1 ft. of another break line, pavement joint, or edge of pavement.
3. Cracking of the slabs shall not deviate from vertical by more than 4 in. between the surface and bottom of the pavement.
4. Longitudinal cracks shall not be closer than 5 ft. from the longitudinal edge of the panel.</td></tr>
<tr><td>Seating Operations</td><td>1. Seating shall be by a pneumatic roller not less than 35 tons. Tires must be inflated to 60 psi minimum.
2. Roller speed shall not exceed 5 mph.
3. Seating must be done with not less than 5 passes over the cracked concrete. A pass shall be one movement of a roller in either direction.</td></tr>
<tr><td>Maintenance</td><td>1. Public traffic shall not be allowed on the cracked pavement until a minimum of 0.35 ft. of HMA has been placed.</td></tr>
</table></td></tr>
</table>

REFERENCES

AASHTO (2008), “Guide Specifications for Highway Construction,” American Association of State Highway and Transportation Officials.

Michigan DOT (2003), “Standard Specifications for Construction,” Michigan Department of Transportation.

Mn/DOT (2005), “Mn/DOT Standard Specifications for Construction,” Minnesota Department of Transportation.

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WSDOT (2010b), “I-5, Joe Leary Slough to Nulle Road Paving,” Chapter 2: Technical Requirements, Design-Build Contract, Washington State Department of Transportation, December 8, 2010.

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