DS-09057
(Replaces DS-09041)

Iowa Department of Transportation

DEVELOPMENTAL SPECIFICATIONS
FOR
WARM MIX ASPHALT

Effective Date
December 21, 2010

THE STANDARD SPECIFICATIONS, SERIES 2009, ARE AMENDED BY THE FOLLOWING MODIFICATIONS AND ADDITIONS. THESE ARE DEVELOPMENTAL SPECIFICATIONS AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

~~If the Developmental Specifications (DS) for Asphalt Concrete Mixtures have been applied on the contract documents, amend the DS with the following modifications and additions.~~

2303.01, Description.

Add the following articles**:**

C. Warm Mix Asphalt (WMA) refers to asphalt concrete mixtures produced at temperatures approximately 50°F (28 °C) or more below those typically used in production of HMA. Temperature reductions may be achieved through approved additives or water injection systems. The goal with WMA is to produce mixtures with similar strength, durability, and performance characteristics as HMA using substantially reduced production temperatures.

D. Unless explicitly stated, produce and place WMA mixtures meeting the same requirements established for HMA mixtures.

2303.02, D, Hot Mix Asphalt Mixture.

Rename the article:

D. Asphalt Concrete Mixture.

Replace Article 6**:**

6. Prepare gyratory asphalt concrete mixture designs for base, intermediate, and surface mixtures. Follow the procedure outlined in Appendix A of this specification. Submit a mixture design complying with Appendix A of this specification. Propose both a production and a compaction temperature between 215ºF (102ºC) and 280ºF (138ºC) for WMA mixture designs.

Add the following Article:

8. WMA is ~~required~~ optional for ~~surface, intermediate, and base~~ all mixtures. An HMA control section may be specified on the plans.

2303.02, E, 2, Anti-strip Agent.

Add the following to Article a:

For all WMA mixtures, evaluate the moisture sensitivity of the proposed asphalt mixture design using the method described in Appendix B of this specification.

Replace Article c:

c. A moisture susceptibility evaluation will not be required for base repair, patching, or temporary pavement for HMA mixtures.

Add the following Article:

i. Optimize the dosage rate for an anti-stripping agent listed in Article DS-2303.02, E, 2, h, for all WMA mixtures using the method described in Appendix B of this specification. Determine the optimum dosage rate by comparing the dry strength of WMA specimens prepared with asphalt binder not containing the anti-strip additive to conditioned WMA specimens prepared with asphalt binder containing the anti-strip additive. If the tensile strength ratio without the anti-strip agent is improved by 5% or more with the agent at the optimum dosage rate, use the anti-stripping agent in the WMA mixture at the optimum rate. If the WMA technology manufacturer provides documentation indicating an anti stripping agent is a primary component of the formulation, the dosage rate of the WMA additive may be optimized in lieu of an additional anti-stripping agent.

2303.02, E, Other Materials.

Add the following Article:

5. WMA Technologies.

Chemical additives, organic additives, or water injection systems approved by the ~~District Materials Engineer~~ Bituminous Engineer may be used at the rate established by the mixture design in the production of WMA. Once production of a bid item has begun with a WMA technology, continue its use throughout the remainder of the bid item's production unless otherwise approved by the District Materials Engineer.

2303.03, B, Equipment.

Replace the first paragraph with the following:

Provide sufficient equipment of the various types required to produce, place, and compact each layer of asphalt concrete mixture as specified, such that the mixture is workable at the minimum placement and compaction temperature desired, regardless of storage or haul distance considerations.

Modify the asphalt mixing plant as required by the manufacturer when introducing a WMA technology. Plant modifications may include additional plant instrumentation, the installation of water injection systems and/or WMA additive delivery systems, tuning the plant burner and adjusting the flights in order to operate at lower production temperatures and/or reduced tonnage.

2303.03, C, 2, c, 5.

Replace the Article:

5) Place other fabrics with a heavy coat of asphalt binder at a rate of 0.20 to 0.25 gallons per square yard (0.9 to 1.1 L/m^2). Use the same binder grade used in the asphalt concrete mixture. For binders containing a WMA technology, place at a temperature between 260°F and 315°F (127°C and 160°C), otherwise place at a temperature between 295°F and 315°F (145°C and 160°C).

2303.03, C, 3, d, 2.

Delete the Article:

~~**2)** Coating aids may be added with the Engineer's approval.~~

2303.03, C, 3, d, 4.

Replace the Article:

4) Adhere to the following temperature restrictions during production:

a) Keep the production temperature of WMA mixtures between 215ºF (102ºC) and 280ºF (138ºC) until placed on the grade.

b) Do not produce WMA mixtures more than 10ºF (5 ºC) below the target temperature designated in the mixture design without the approval of the Engineer.

c) Keep the production temperature of HMA mixtures between 215ºF (102ºC) and 330ºF (165ºC) until placed on the grade.

d) Asphalt concrete mixtures not meeting these requirements will be rejected.

2303.03, C, 3, d, 7.

Delete the Article:

~~**7)** Ensure mixture temperature allows for the specified compaction and density to be attained. Do not discharge HMA into the paver hopper when its temperature is less than:~~

- ~~245°F (120°C) for a nominal layer thickness of 1 1/2 inches (40 mm) or less, or~~
- ~~225°F (110°C) for a nominal layer thickness of more than 1 1/2 inches (40 mm).~~

2303.03, C, 4, c, 2.

Replace Tables 2303.03-1 and 2303.03-2:

Table 2303.03-1: Base and Intermediate Course Lifts of Asphalt Mixtures

Nominal Thickness - inches (mm)	Road Surface Temperature, ºF (ºC)
1 1/2 (40)	40 (4)
2 - 3 (50 - 80)	35 (2)
Over 3 (Over 80)	35 (2)

Table 2303.03-2: Surface Course Lifts of Asphalt Mixtures

Nominal Thickness - inches (mm)	Road Surface Temperature, ºF (ºC)
1 (30)	40 (4)
1 1/2 (40)	40 (4)
2 and greater (50 and greater)	40 (4)

2303.03, D, 3, b, 8.

Add the following to Article a:

Compact loose WMA field samples, transported to the laboratory, at 240ºF (115ºC).

Add the following Article:

f) Evaluate reheating effects of WMA mixtures using the method described in Appendix C. Report results to the DME for information only.

Appendix A - METHOD OF DESIGN OF WARM MIX ASPHALT MIXTURES

Follow Materials I.M. 510 for the design of HMA mixtures. For WMA mixtures, supplement Materials I.M. 510 with the following:

PROCEDURE

A. MATERIALS SELECTION

1. WMA Process Selection

a) **WMA Technology**
Select the WMA process that will be used in consultation with the specifying agency and technical assistance personnel from the WMA suppliers. Consideration should be given to a number of factors including: (1) available performance data, (2) the cost of the warm mix additives, (3) planned production and compaction temperatures, (4) planned production rates, (5) plant capabilities, and (6) modifications required to successfully use the WMA process with available field and laboratory equipment.

b) **WMA Temperatures**
Determine the temperatures that will be used for plant mixing (production) and field compaction. Binder grade selection depends on the production temperature. See Table 1 for production temperatures below which the high temperature grade of the binder should be increased one level.

2. Binder Grade
Increase the high temperature performance grade based on the proposed production temperature. Increase the high temperature performance grade by one grade when the plant discharge temperature is less than that specified in Table 1.

Recycled Asphalt Materials: If more than 20% but less than 30% of the total binder contribution is from a recycled source, the designated high temperature binder grade will remain unchanged if the production temperature falls below that indicated in Table 1.

Table 1 - Production Temperatures below which the High Temperature Grade Should be Increased One Grade.

Specified PG High Temperature Grade	Aging Index (AI)[1]											
	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6
	Minimum WMA Mixing Temperature Not Requiring PG Grade Increase, °F											
52	<215	<215	<215	<215	<215	<215	220	220	225	225	230	230
58	<215	<215	<215	220	225	230	235	235	240	240	245	245
64	<215	<215	220	230	235	235	240	245	245	250	250	250
70	<215	220	230	240	245	245	250	255	255	260	260	260

Note: [1.] $AI = \frac{(G^*/\sin\delta)_{RTFOT}}{(G^*/\sin\delta)_{Tank}}$ at the high temperature performance grade temperature.

3. Additives
Use additives as required by the proposed WMA process or to obtain acceptable coating, workability, compactibility, and moisture susceptibility.

F. MIXTURE BATCHING, CURING & TESTING
For WMA mixtures not utilizing a water-injection system, the WMA technology should be used in fabricating specimens in the mixture design phase. Mixture designs for mixtures utilizing a water-injection system ~~may~~ will be verified ~~by~~ after submitting raw materials to the Central Materials Laboratory. Methods for WMA specimen preparation are process specific. Consult the manufacturer for detailed WMA specimen fabrication procedures or use the same procedures in Materials I.M. 510 for batching, curing and testing of WMA mixtures with the following exceptions:

3. Heat the combined aggregate batch and binder containing the WMA technology (at the dosage recommended by the manufacturer) to the proposed production temperature ± 5°F (± 3°C). Verify

temperature using a thermometer in the pan. The mixing bowl and utensils shall also be heated before mixing operations begin. Always keep the mixing bowl buttered.

10. Cure all samples for 2 hours at the proposed production temperature. One hour into curing, all samples are removed, thoroughly stirred and placed back into the oven for remainder of curing time.

11. Place approximately 4800 g of material into the mold for gyratory specimens. Compact specimens at the proposed production temperature per Materials I.M. 325G.

G. MIXTURE PERFORMANCE EVALUATION

In addition to the requirements in Materials I.M. 510, check all WMA mixtures for moisture susceptibility using the method in Appendix B.

DOCUMENTATION

Report proposed production temperature, compaction temperature, WMA technology, additional equipment requirements from the manufacturer, manufacturer name, proposed dosage rate, and any manufacturer recommendations on Form #820956.

Appendix B - METHOD OF TEST FOR DETERMINING THE MOISTURE SUSCEPTIBILITY OF WARM MIX ASPHALT MIXTURES

SCOPE

This test method is intended to determine the moisture susceptibility of asphalt paving mixtures by measuring the tensile strength ratio (TSR). The apparatus and procedures are identical with those specified in AASHTO T 283-07 with the following variations.

1. When performing moisture sensitivity testing in the WMA mixture design phase, the WMA technology and field production temperatures should be used in fabricating specimens as described in Appendix A of this specification. Methods for WMA specimen preparation are process specific. Consult the manufacturer for detailed specimen fabrication procedures. Specimens for WMA mixtures utilizing a water-injection system may be fabricated without the WMA technology. (Note: Indirect tensile strengths for lab specimens fabricated without the WMA technology may be significantly different than those for specimens fabricated from plant-produced mixture containing the WMA technology. Acceptance is based on plant-produced mixture)

2. 150 mm diameter gyratory compacted specimens will be used unless it is determined that the saturation of the conditioned specimens does not penetrate completely to the center of the specimen or if the sample size is insufficient to provide enough material to fabricate 150 mm diameter specimens, in which cases 100 mm diameter gyratory compacted specimens may be used.

3. Condition the mixture in a flat shallow pan at an even thickness of 21-22 kg/m^3 in a forced draft oven at the proposed compaction temperature for 2 hours. Stir the mixture once after the first hour.

   Note – Do not use the conditioning procedure in AASHTO T 283 or AASHTO R 30 for WMA

4. Compact test specimens to 7.0 ± 0.5 percent air voids in accordance with AASHTO T 312.

5. Group, condition and test the specimens in accordance with AASHTO T 283.

REPORT

Determine and report the indirect tensile strengths and TSR as the ratio of the wet strength of the conditioned WMA specimens to the unconditioned dry strength of WMA specimens

Appendix C –REHEAT EVALUATION OF WARM MIX ASPHALT MIXTURES

The following procedure is adapted from Materials I.M. 511 Appendix B. This procedure is intended to be used for information only. In the case of dispute resolution, follow Materials I.M. 511 Appendix B, and use the field compaction temperature when heating is required for testing.

The Contractor's QMA laboratory technician shall split the sample selected for correlation. The split will provide material for 3 individual maximum specific gravity, G_{mm}, test samples and material for 3 sets of laboratory density, G_{mb}, specimens.

The Contractor's technician will split and retain sufficient material for 2 G_{mm} test samples and 2 sets of laboratory density specimens. The remainder of the field sample will be submitted to the DOT laboratory. From this portion the DOT laboratory will split and test an additional G_{mm} sample and an additional set of laboratory density specimens, after reheating.

Immediately after splitting, the Contractor's technician will return one set of laboratory density samples to the oven and heat to 240ºF (115ºC). Once this temperature is reached, this set is removed from the oven, compacted as per Materials I.M. 325 or Materials I.M. 325G, cooled to ambient temperature and G_{mb} determined. The second set of samples is cooled to ambient temperature, reheated to 240ºF (115ºC) then compacted as per Materials I.M. 325 or Materials I.M. 325G, cooled to ambient temperature and G_{mb} determined. This dual testing is intended to indicate the differences in test results, which can be expected, between samples tested on the original heat of the mixture and those tested at a later time (hot-to-cold testing).

The Contractor's technician will cool and separate both G_{mm} samples. The Contractor's technician will test one G_{mm} sample. The second G_{mm} sample will be sealed in a plastic bag and submitted to the appropriate DOT laboratory for testing. The DOT laboratory will test the sample without any significant reheating (not more than 5 minute's oven reheating to facilitate breaking up sample).

Use the following outline for testing. All tests noted in this outline must be performed in accordance with the applicable Materials I.M.

1. Contractor Testing Responsibilities

    A. Obtain field sample and split to obtain 2 sets of laboratory density, G_{mb}, specimens and 2 Maximum specific gravity, G_{mm}, specimens and submit the remainder of field sample to DOT laboratory for testing.

    B. Bulk Density Testing

        1) Set #1 – Immediately after splitting, return specimens to the oven, reheat to 240ºF (115ºC), compact specimens as per Materials I.M. 325 or Materials I.M. 325G, cool to ambient temperature and test for density.

        2) Set #2 – Cool to ambient temperature, return to oven, reheat to 240ºF (115ºC), compact as per Materials I.M. 325 or Materials I.M. 325G, cool to ambient temperature and test for density.

        3) Compare values obtained in #1 and #2 to determine possible reheat factor.

    C. Maximum Density Testing

        Sample #1 – Cool sample and perform Rice Test.

        Sample #2 – Cool sample, place in plastic bag and submit to the DOT laboratory for testing.

    D. Submit remainder of field sample to DOT laboratory for testing.

2. DOT Laboratory Testing Responsibilities

    A. Bulk Density Testing

        1) From the field sample supplied by the Contractor, split one set of G_{mb} specimens, place in oven, heat to 240ºF (115ºC), compact as per Materials I.M. 325 or Materials I.M. 325G, cool to ambient temperature and test for density.

B. Maximum Density Testing

1) From the field sample supplied by the Contractor, split one G_{mm} specimen and perform Rice Test.

2) Test the G_{mm} sample supplied by the Contractor.

3) Compare values obtained in #1 and #2 to determine possible deviation in G_{mm} results that might occur between the Contractor's split G_{mm} sample and the DOT G_{mm} sample split from a field sample.

3. Document results and submit to the DME.