Warm Mix Asphalt Processes Applicable to North Dakota

NDDOT Project Number:
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EXPERIMENTAL PROJECT REPORT

EXPERIMENTAL PROJECT

EXPERIMENTAL PROJECT NO.: 1 | NDSU | 2011 | | 01 | | | 8

CONSTRUCTION PROJ NO: SPR-R033(003)

LOCATION: 28

EVALUATION FUNDING: 48 — 1 HP&R; 2 CONSTRUCTION; 3 DEMONSTRATION; 4 X IMPLEMENTATION

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PROPRIETARY FEATURE? 51 — Yes; No

SHORT TITLE

TITLE 52: Evaluation of the Rut Resistance Performance of Warm Mix Asphalts in North Dakota

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KEY WORDS

KEY WORD 1

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KEY WORD 4

UNIQUE WORD

PROPRIETARY FEATURE NAME

CHRONOLOGY

Date Work Plan Approved	Date Feature Constructed:	Evaluation Scheduled Until:	Evaluation Extended Until:	Date Evaluation Terminated:
277 April 2011	281	285	289	293 February 2012

QUANTITY AND COST

QUANTITY OF UNITS (ROUNDED TO WHOLE NUMBERS) 297

UNITS: 1 LIN. FT; 2 SY; 3 SY-IN; 4 CY; 5 TON; 6 LBS; 7 EACH; 8 X LUMP SUM

UNIT COST (*Dollars, Cents*) 306: $17,554

AVAILABLE EVALUATION REPORTS

315 — CONSTRUCTION; PERFORMANCE; FINAL X

EVALUATION

CONSTRUCTION PROBLEMS 318 — 1 NONE

PERFORMANCE 319 — 1 EXCELLENT; 2 GOOD

APPLICATION

320 — 1 ADOPTED AS PRIMARY STD.; 2 PERMITTED ALTERNATIVE; 4 X PENDING; 5 REJECTED

(Explain in remarks if 3, 4, 5, or 6 is checked)

REMARKS

321

The primary objective of this research was to perform a literature review and survey of surrounding states to evaluate the WMA additives and processes that would be applicable to North Dakota. A recommendation of techniques, equipment, and additives will be provided in this research. Also any specification changes to account for differences in production and/or placement of WMA as compared to HMA will be provided.

Form FHWA 1461

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1 INTRODUCTION

1.1 History of WMA

Warm mix asphalt (WMA) represents a group of technologies that allow production and placement of asphalt mixes at lower temperatures. This is achieved through reducing the viscosity of asphalt and complete coating of aggregate at lower temperature (D'Angelo, 2008). The first WMA pavements were constructed in Europe in 1995 by experimenting with Aspha-min zeolite. Shell Bitumen began experimenting with WAM (Warm Asphalt Mix) in Norway in 1996, which has now developed into WAM Foam. The first pavements were constructed with Sasobit in 1997 in Hamburg, Germany. In 2002, a National Asphalt Pavement Association (NAPA) study tour introduced WMA technology to the U.S. Later on in 2005, NAPA and Federal Highway Administration (FHWA) formed WMA Technical Working Group (WMA TWG). The primary goal of WMA TWG was to develop a data collection framework for WMA trials that agencies would use for their own evaluations on WMA technologies (Prowell, 2011). In 2008, the WMA TWG published a WMA Guide Specification for Highway Construction in AASHTO format which is available in Appendix C.

1.2 Advantages of WMA Compared to HMA

WMA is typically produced at temperatures 35 to 100°F lower than HMA. The characteristic of WMA, that has higher workability at lower temperature, also results in better compaction in the field. This results in less permeability and lower aging of the binder. The fact that WMA is softer than HMA is also an advantage in areas with low temperatures because the risk of thermal cracking is lower. Lower mixing and compaction temperatures also result in less fuel consumption and reduction in CO_2 and fumes emission, which imposes less health risk on workers and shows better stewardship toward the environment. Considering paving benefits, there are several advantages to using WMA. The ability to pave in cooler temperatures, haul longer distances, compact mix with less effort, incorporate higher percentage of RAP, place thick lifts, and open roads to traffic in a shorter period of time are some of the benefits of using WMA (Prowell, 2011).

1.3 Aim of this Study

The aim of this study is to conduct a literature study and collect data on the materials, construction, and performance of WMA to determine the additives and processes that would perform best on NDDOT projects. The main objectives are:

a. Evaluate the applicability of WMA processes and additives, as used in target states, to North Dakota projects.

b. Recommend techniques, equipment, and additives that are most suitable for the use of WMA in North Dakota.

c. Recommend specification changes to account for differences in production and/or placement of WMA, as compared to HMA.

For the literature review task, literature on the use of WMA technologies in the US and in other states/countries was collected. This task also included a collection of published data and information on the processes, the specifications, and the materials as used in the construction of WMA in the northern and central tier states.

The second task was to collect specific data on the design, performance, and constructability of WMA applications in neighboring states. A questionnaire was prepared and sent to target states, followed by phone interviews to collect additional data/information on using WMA from local authorities and state agencies (DOTs) of other states. The objective of this section is to:

1. Identify the WMA additives and processes currently used in the following northern and central tier states and provinces: Montana, South Dakota, Minnesota, Iowa, Wisconsin, Michigan, Nebraska, Kansas, Missouri, Illinois, Indiana, Ohio, New York, Pennsylvania, Vermont, New Hampshire, Maine, Colorado, Utah, Nevada, Wyoming, Idaho, Oregon, Washington, Manitoba, Saskatchewan, and Alberta.

2. Identify the selection method used by states/provinces to approve a particular WMA process (approved products list, field experimentation, experience of others, etc.), and how they developed that selection process.

3. Collect individual state/province WMA specifications.

After finishing data collection and analysis of questionnaire, a guideline is suggested for use of warm mix asphalt in North Dakota.

1.4 Orientation of the Report

The authors organized the information so that general topics are discussed first and in-depth information that will clarify, as much as possible, all aspects embedded in each topic follow. The report starts with an introduction that discusses the history of WMA, as well as its accompanying advantages. The aims of the study covered in this report, in addition to the orientation of the report, are both discussed in the introduction section as well.

The literature section also serves as a means to acquaint the reader with detailed description of each of the WMA technologies utilized, up to the time this report was made. The mix design modifications required for the utilization of WMA are also covered in the literature section.

Following the literature section, a section about the specifications and publications of the current agencies, to date, is furnished.

The analysis of a survey about WMA, as distributed by the research team and disseminated amongst the various agencies to fill, is explained in the section titled "Survey Analysis" that follows the specifications and publications section.

To sum up all the results and knowledge achieved through this study, a conclusion section is made at the end of this report.

Appendices A, B, C, D, E, F, G and H in this report include: survey form, survey responses, specifications of target states, specifications of other resources, list of publications by target states, list of publications of other resources, research papers review, and recommendations of NCHRP and other studies, respectively.

1.5 Acknowledgement

The research team at North Dakota State University would like to acknowledge the help and support of North Dakota Department of Transportation in conducting research and also appreciate Mr. Anthony Waldenmaier's help in this project.

2 LITERATURE STUDY

2.1 Warm Mix Asphalt Technologies

2.1.1 WMA Technology Description

In general, WMA technologies can be categorized as those utilizing water, those entailing organic additives, or those using chemical additives or surfactants.

For the techniques that involve the introduction of small amounts of water to hot asphalt, either through a foaming nozzle, damp aggregate, or a mineral filler; the theory behind such approach lies on the fact that when a given volume of water is steamed at atmospheric pressure, it expands by a factor of approximately 1700 (Cengel, 2006). The introduction of water into hot asphalt results in the transformation of water into steam, allowing the binder phase to undergo an expansion of approximately 5 to 10 times. Such increase in fluids content eases the coating and compaction ability of the binder.

In the case of WMA technologies utilizing organic additives, a decrease of the binder viscosity is achieved. This would allow for better wettability for the aggregate, in addition to better compactability. Selection of the organic additive should be made adequately, so as to ensure that the melting point of the additive is higher than the expected in-service temperature; otherwise pavement permanent deformation can occur.

WMA technologies that involve the utilization of chemical additives or surfactants are mainly directed towards the different mechanisms that help the asphalt cement coat the aggregate at lower temperatures, while imposing a lubricating effect to improve compaction (Prowell, 2011).

2.1.2 Chemical Processes

2.1.2.1 CECABASE® RT

Contact: Arkema Group

http://www.arkema.com/sites/group/en/innovation/our_solutions/cecabase_rt_warm_asphalt_mix.page

Liquid at ambient temperatures, a water free (non-aqueous) surfactant that works in two ways: first it reduces the surface tension at the aggregate interface resulting in better coating at lower temperatures (also assumed to be able to increase stripping resistance), and second it acts as a lubricant at temperatures higher than 190°F (90°C), thus improving lay down and compaction.

Dosage: 0.3 to 0.5 percent by weight of binder.

Reduction in Production Temperature/Fuel Consumption: 70°F (40°C)

Modifications to Mix Design/Plant: The addition of CECABASE in mix design should match the addition method in field. In the plant, CECABASE should be pre-blended with the binder before mixing. Liquid additive that is soluble in binder can be added at the terminal, storage tank or through in-line injection (Prowell, 2011).

2.1.2.2 Evotherm ™

Contact: MeadWestvaco Asphalt Innovations

www.evotherm.com

Evotherm was developed in the United States to increase coating, adhesion, and workability at lower temperatures. Evotherm has three types: ET (Emulsion Technology), DAT (Dispersed Asphalt Technology) and 3G (Third Generation).

Dosage: 0.25 to **0.75** percent by weight of binder.

Reduction in Production Temperature/Fuel Consumption: 100°F (55°C)

Modifications to Mix Design/Plant: Modifications to mix design depend on the type of Evotherm used. For Evotherm DAT, asphalt binder is should be heated to produce a viscosity of 170 centistokes. Aggregate should be heated to a temperature 27˚F greater than intended mixing temperature. For Evotherm 3G, no changes are required for the mix design process. For the plant changes, in terminally blended Evotherm 3G, no modifications are required. For Evotherm DAT, an injection point is needed. For Evotherm ET, the plant setting should be adjusted to account for 30 percent water in emulsion (Prowell, 2011).

2.1.2.3 HyperTherm™/QualiTherm

Contact: Coco Asphalt Engineering (Canada)

http://www.cocoasphaltengineering.com/warm_mix.aspx

QPR ® (United States)

http://www.qprshopworx.com/products/asphalt-engineering/qpr%C2%AE-qualitherm/

Non-aqueous fatty-acid based chemical additive first developed in Canada.

Dosage: 0.2 to 0.3 percent of total weight of the binder.

Reduction in Production Temperature/Fuel Consumption: Mixing as low as 248°F (120°C) and compaction as low as 194°F (90°C)

Modifications to Mix Design/Plant: For mix design, appropriate amount can be added to the hot binder using a low shear mixer. In the plant, HyperTherm can be added to the liquid asphalt at binder terminal or in-line injected at the asphalt plant. Requirements are similar to Evotherm DAT (Prowell, 2011).

2.1.2.4 Rediset™WMX

Contact: Akzo Nobel Surfactants

www.azkonobel.com

Combines cationic surface-active agents (surfactants) and rheology modifiers (organic additives) in a solid form and does not contain water. The surfactants provide "active adhesion" that relates to better coating and anti-stripping.

Dosage: 1.5 to 2.5 percent by weight of asphalt binder.

Reduction in Production Temperature/Fuel Consumption: Allows up to 60°F (33°C) reduction in coating and compaction temperatures.

Modifications to Mix Design/Plant: No Change to Mix Design procedure except for the temperatures. No anti-stripping agent is needed. Either pre-blended with the binder or added to the mixture after adding the binder. For the plant, if pre-blended type is used, no modification is needed. It can also be stored in a small heated tank in liquid form and then be injected in to the binder line. Can also be added directly into the mixing drum close to where the asphalt is added (Prowell, 2011).

2.1.3 Foaming Processes

2.1.3.1 Accu-Shear™

Contact: Stansteel® Asphalt Plant Products

http://www.stansteel.com/accushear.asp

Allows a combination of liquids (water and/or additives) to be injected simultaneously into the asphalt line.

Dosage: Dependent on the additive/manufacturer.

Reduction in Production Temperature/Fuel Consumption: Allows up to 50-70˚F (122-158°C) reduction in coating and compaction temperatures.

Modifications to Mix Design/Plant: Changes to mix design are dependent on the type of liquid that is being added to the binder. For the plant, the machine should be tied into the plant's asphalt line and controls (Prowell, 2011).

2.1.3.2 Advera® WMA

Contact: PQ Corporation

www.adverawma.com

A synthetic zeolite composed of alumninosilicates and alkali metals.

Dosage: 0.25 (0.15 to 0.3) percent by total weight of mix.

Changes to Mix Design: Reduction in Production Temperature/Fuel Consumption: Typically 50°F (28°C) less than HMA

Modifications to Mix Design/Plant: Advera should be thoroughly blended with the binder prior to mixing, and it should not be heated in an oven before being blended with the binder. In the plant, Advera is added using a designed feeder. For a drum plant, the material could be added close to the point where the binder is added. For batch plants, the pipe is installed as close as possible to the center of the pug mill (Prowell, 2011).

2.1.3.3 AQUABlack™ WMA System

Contact: Maxam Equipment, Inc.

http://maxamequipment.com/AQUABlackWMA.htm

Uses a stainless steel foaming gun in conjunction with a center convergence nozzle to produce foaming.

Dosage: NA

Reduction in Production Temperature/Fuel Consumption: Lowers fuel consumption as much as 15 %.

Modifications to Mix Design/Plant: Can be installed on any existing asphalt plant. Must be added to the binder line just before entering the drying drum (Prowell, 2011).

2.1.3.4 AquaFoam

Contact: AquaFoam, LLC

www.aquafoamllc.com

Two nozzles at 180 degrees to one another and perpendicular to the asphalt stream.

Dosage: 1.5 percent by total mix weight.

Reduction in Production Temperature/Fuel Consumption: NA

Modifications to Mix Design/Plant: A water addition of 1.5 percent by total mix weight is reasonable for most mixes. Additional water may be added to stiffer mixes. In the plant, the system is mounted in the asphalt line just before it enters the drum (Prowell, 2011).

2.1.3.5 Aspha-Min®

Contact: Aspha-min GmbH

www.aspha-min.com

Composed of aluminosilicates and alkali metals that contain approximately 20 percent water of crystallization. It is coarser than Advera®.

Dosage: 0.3 percent by total weight of mixture

Changes to Mix Design: Usually

Reduction in Production Temperature/Fuel Consumption: Typically 54°F (30°C) less than HMA.

Modifications to Mix Design/Plant: Aspha-Min is added to the mixture at the same time as asphalt. For batch plants, it can be added to the pug mill by melt bags or weigh bucket. For drum plant, it can be added through the reclaimed asphalt pavement (RAP) collar or a specially built vane feeder (Prowell, 2011).

2.1.3.6 Double Barrel® Green

Contact: Astec Industries, Inc.

www.astecinc.com

Uses a multi nozzle foaming device. Have developed two generations of the machine.

Dosage: 1 lb of water per ton of mix.

Reduction in Production Temperature/Fuel Consumption: Production temperatures are typically 250-275°F (121-135° C) and compaction temperatures as low as 220°F (104°C)

Modifications to Mix Design/Plant: No changes to mix design, uses the standard HMA mix design. For the plant it is needed to install the foaming manifold and corresponding feeder lines (Prowell, 2011).

2.1.3.7 Eco-Foam II

Contact: AESCO/MADSEN

http://www.asphaltequipment.com/whatsnew.htm

Uses the principle of shear zone turbulence to enhance mixing/foaming process.

Dosage: 1 to 2 percent of the liquid asphalt flow rate.

Reduction in Production Temperature/Fuel Consumption: 50-60°F (28-33°C)

Modifications to Mix Design/Plant: No changes to mix design, uses the standard HMA mix design. In the plant, the system is installed outside the dryer drum (Prowell, 2011).

2.1.3.8 LEA (Low Emission Asphalt)

Contact: McConnaughay Technologies

www.maconnaughay.com

Heated coarse aggregates (302°F – 150°C) are added to binder (already blended with coating and adhesive additive) at ambient temperature. After coating of coarse aggregate, it is added to cold, wet, fine aggregate.

Dosage: 0.4 percent by weight of binder (for coating additives)

Reduction in Production Temperature/Fuel Consumption: Final mix temperature is less than 212°F (100° C)

Modifications to Mix Design/Plant: In the mix design, 60 to 70 percent of the total aggregate is coarse and the temperature is recommended to be 36°F (20°C) cooler than HMA. 3 to 4 percent water shall be added to the fine aggregates. For the plant, a volumetric pump is needed to add cohesive additives to the binder. An injection port must be added to asphalt line or pug mill. Fully coating of coarse aggregate before adding fines should be assured (Prowell, 2011).

2.1.3.9 Meeker Warm Mix

Contact: Meeker Equipment

http://www.meekerequipment.com/

Dosage: NA

Reduction in Production Temperature/Fuel Consumption: NA

Modifications to Mix Design/Plant: Could be added to both batch plant and mixer. Meeker's foamer is added to the binder piping, and for drum plant it is installed just before entering the mixer mixing chamber (Prowell, 2011).

2.1.3.10 Terex® WMA System

Contact: Terex Roadbuilding

www.terexrb.com

Uses a single expansion chamber that produces foams just outside the drying drum, then immediately injects the foamed asphalt into the mixing drum to coat the aggregate.

Dosage: NA

Reduction in Production Temperature/Fuel Consumption: 90°F (32.2°C) / 10-20% in fuel.

Modifications to Mix Design/Plant: Simply installed onto an existing drum (Prowell, 2011).

2.1.3.11 Tri-Mix Warm Mix Injection System

Contact: Tarmac International, Inc.

www.tarmacinc.com

Uses two opposed high pressure injection nozzles followed by a downstream static mixer to foam the binder or adds a water-based chemical additive such as Evotherm DAT.

Dosage: Water up to 4 percent by total weight of binder.

Reduction in Production Temperature/Fuel Consumption: 70-100°F (39-56°C) when using Evotherm.

Modifications to Mix Design/Plant: Installed in the asphalt line (Prowell, 2011).

2.1.3.12 Ultrafoam GX2™ System
Contact: Gencor Industries

www.gencorgreenmachine.com/ultrafoam.html

Dosage: 1.5 to 2 percent water by weight of total asphalt binder.

Reduction in Production Temperature/Fuel Consumption: NA

Modifications to Mix Design/Plant: The only changes to plant are to install the foaming system (Prowell, 2011).

2.1.3.13 WAM Foam
Contact: Shell Bitumen

www.shell.com/bitumen

Uses two stages of adding binder, one nominally soft (20 to 30 percent of the total binder content) and the other nominally hard. Soft binder satisfies the demand of absorption by coarse aggregate and foaming is produced by adding ambient temperature water to hard binder.

Dosage: 2 to 5 percent by mass of the hard asphalt fraction

Reduction in Production Temperature/Fuel Consumption: Up to 35% in energy consumption.

Modifications to Mix Design/Plant: For batch plant, the original asphalt line is used for soft asphalt and second line is needed for hard binder. Also a foaming nozzle and expansion chamber is needed above the pug mill. For the drum plant the condition is the same, one line for soft binder and one for hard binder. The hard asphalt line and nozzle do not extend deep inside the drum (Prowell, 2011).

2.1.4 Organic Processes

2.1.4.1 AstechPER®
Contact: Engineered Additives, LLC.

www.engineeredadditives.com

Liquid at ambient temperature. Formulated for high-RAP or reclaimed asphalt shingles (RAS) mixes. Designed to mimic the malthenes phase of the asphalt binder. Either in pre-blended form or should be blended into binder by a low shear mixer.

Dosage: 0.5 to 0.75 percent by the total weight of RAP plus RAS in the mix.

Reduction in Production Temperature/Fuel Consumption: NA

Modifications to Mix Design/Plant: Can be pre-blended in to the binder at the terminal or injected into the binder before binder enters the plant (Prowell, 2011).

2.1.4.2 Sasobit®

Contact: Sasol Wax North America Corporation

www.sasolwax.us.ocm

A synthetic paraffin wax.

Dosage: 1.5 (0.8 to 4) percent by weight of the total (including RAP and RAS) binder.

Reduction in Production Temperature/Fuel Consumption: 50°F (28°C) / Up to 19% in fuel cost

Modifications to Mix Design/Plant: Pre-blended with the binder, mix design proceeds with no change. For drum plants, can be blown into the drum through a feeder approximately the same time as asphalt. It can also be added in-line with the binder in a molten state (Prowell, 2011).

2.1.4.3 SonneWarmix™

Contact: Sonneborn, Inc.

www.sonnewarmix.com

A high melt point paraffinic hydro carbon blend.

Dosage: 0.5 to 1.5 percent by weight of the total binder.

Reduction in Production Temperature/Fuel Consumption: 50°F (28°C) reduction in compaction temperature

Modifications to Mix Design/Plant: Added to liquid asphalt at the terminal or refinery, no other modification is required (Prowell, 2011).

2.1.4.4 Thiopave™

Contact: Shell Silver Solutions

www.shell.com/home/content/sulphur/

Dosage: replaces up to 25% (by mass) of the bitumen in the asphalt mixture.

Reduction in Production Temperature/Fuel Consumption: 36-72°F (20-40°C) reduction in compaction temperature

Modifications to Mix Design/Plant: In batch plants, installing a small chute above the pug mill is needed (Prowell, 2011).

2.1.4.5 TLA-X™ Warm Mix

Contact: Lake Asphalt of Trinidad and Tobago (1978)

http://www.trinidadlakeasphalt.com/home/products/tla-x-warm-mix-technology.html

A natural asphalt emulsion in its crude state, composed of soluble bitumen, mineral matter and minor components, mostly water. Reported benefits include excellent adhesion, homogenous blending with most binders, high stability and high resistance to cracking and deformation.

Dosage: NA

Reduction in Production Temperature/Fuel Consumption: 60-90°F

Modifications to Mix Design/Plant: Can be added directly to the asphalt binder or pneumatically blown into the asphalt mixture at the same time as the liquid asphalt binder (Prowell, 2011).

2.2 Mix Design

2.2.1 Introduction

The absence of a formal mixture design procedure represents a critical issue facing WMA industry. In the United States most of the WMA projects constructed had HMA substituted by WMA in the mix design with no change to the job mix formula. This doesn't take into consideration the lower mixing and compaction temperatures utilized in WMA (Bonaquist, 2011).

A project done under the National Cooperative Highway Research Program (NCHRP) termed "Mix Design Practices for Warm Mix Asphalt, NCHRP Project 09-43" had the objective of developing mixture design and analysis procedures that can be used with the wide range of WMA processes that are currently available or that are likely to become available in the future.

Differences between the Design of WMA and HMA

The design and analysis of HMA mixture generally consists of five major steps: (1) select materials, (2) design aggregate structure, (3) design binder content selection, (4) evaluate moisture sensitivity, and (5) analyze performance. Criteria for Steps 1 through 4 for HMA are contained in AASHTO M 323, Standard Specification for Superpave Volumetric Mix Design. AASHTO R 35, "Standard Practice for Superpave Volumetric Design for Hot Mix Asphalt (HMA)," provides procedures for Steps 1 through 4. Although there is not a standard practice addressing performance testing of HMA, several performance tests have been developed and have received some level of acceptance by the industry. Performance tests are available for measuring mixture modulus, rutting resistance, and resistance to fatigue cracking and thermal cracking. Several modifications to current HMA mix design procedures are needed to address the wide range of WMA processes currently available, and likely to become available in the future (Bonaquist, 2011).

The major steps in the mixture design and analysis process that may incur differences for WMA in comparison to HMA can be illustrated as follows:

2.2.2 Materials Selection

Some elements of materials selection may require modification for WMA. Aggregate requirements for warm mix will not be different than requirements for hot mix, but it may be necessary to select different binder grades for WMA. The lower temperatures used in WMA, as compared to HMA, probably result in less aging during plant mixing and construction; therefore, a stiffer high-temperature binder grade may be needed for satisfactory rutting performance. This effect, however, may be offset by the addition of warm mix additives and the changes that these additives and water have on binder aging. The lower production temperatures may also limit the types and quantity of recycled asphalt materials that can be used in WMA. Design of HMA assumes substantial mixing of new and recycled binders, which may not be possible at the lower production temperatures used in warm mix. Lower production temperatures may also limit the effectiveness of some anti-strip additives. Finally, WMA design will require the selection of an appropriate warm mix additive and dosage rate (Bonaquist, 2011).

Both the binder grade selection and the allowable RAP content are affected by the selection of the WMA process and the associated temperature for production. For the case of binder selection, temperature heavily impacts the aging occurring during plant production. Table 1 illustrates the minimum production temperatures required to avoid having to increase the high temperature binder grade, based on the influence of both the aging index of the asphalt binder and the binder grade. From this table, it can be concluded that the higher the aging index and the higher the PG grade, the greater the WMA production temperature would have to be to avoid increasing the binder grade by one high temperature grade (Bonaquist, 2011).

TABLE 3.1 Minimum WMA Production Temperatures (°F) Without Increasing High Temperature Grade (Bonaquist, 2011)

PG High-Temperature Grade	Aging Index											
	1.4	1.6	1.8	2	2.2	2.4	2.6	2.8	3	3.2	3.4	3.6
	Minimum WMA Mixing Temperature Not Requiring PG Grade Increase (°F)											
52	170	190	200	205	210	215	220	220	225	225	230	230
58	185	205	215	220	225	230	235	235	240	240	245	245
64	190	210	230	230	235	235	240	245	245	250	250	250
67	200	220	230	235	240	245	250	255	255	255	260	260
70	200	220	230	240	245	245	250	255	255	260	260	260
76	210	225	235	245	250	255	260	260	265	265	265	270
82	215	235	245	250	255	260	265	265	270	270	275	275

For RAP content, as a result of the blending between virgin and RAP binders, it is thought that the allowable RAP content might need to be different for WMA compared to HMA. However, for the absence of substantial mixing between the virgin and RAP binders at WMA process temperatures, it is suggested that the RAP content of WMA would need to be limited. It is also suggested that HMA specifications can be applied to WMA for allowable RAP content at production temperatures at or above 265°F (130°C) (Bonaquist, 2011).

2.2.3 Design Aggregate Structure

The design of the aggregate structure may also require some modifications for WMA. Since the goal of WMA is to produce mixtures with strength and performance characteristics similar to those of HMA, the volumetric criteria used in design should not differ from those used for HMA. However, the procedures used to fabricate and condition specimens may require some modification. Most WMA process developers have prepared laboratory procedures for specimen fabrication. Additionally, mixture coating, workability, and compactability must be evaluated directly instead of using viscosity-based mixing and compaction temperatures. In many WMA processes, it is impossible to directly measure the viscosity of the binder. Additionally, there is increasing evidence that the temperature reductions associated with many WMA processes are not related to the change in viscosity of the binder (Hanz et al., 2010 - Baumgardner, 2010).

For determination of the design aggregate structure for WMA, it is suggested that the same procedures as in AASHTO M323 for HMA be followed, having the short-term oven aging for WMA as 2 hours at the compaction temperature. In addition, the degree of coating is determined using the standard AASHTO T195(Bonaquist, 2011).

2.2.4 Design Binder Content Selection

The selection of the design binder content should not require substantial modification other than specimen-fabrication. An important step in achieving WMA with performance characteristics comparable to HMA is to use the same volumetric criteria in the design of both mixtures (Bonaquist, 2011).

2.2.5 Evaluate Moisture Sensitivity and Performance Analysis

Evaluation of the mixture for moisture sensitivity and performance also will not require substantial modification other than specimen fabrication. Although there is concern that some WMA may exhibit greater moisture sensitivity than HMA (Hurley et al., 2005 – Hurley et al., 2006), AASHTO T 283, "Resistance of Compacted Hot Mix Asphalt (HMA) to Moisture-Induced Damage," is a fairly reliable indicator of moisture-induced adhesive failure, which is the mechanism of greatest concern for WMA. Thus, the same process used with HMA is employed to evaluate WMA moisture susceptibility.

The primary products of NCHRP Project 09-43 are:

(1) A draft appendix to AASHTO R 35 titled "Special Mixture Design Considerations and Methods for Warm Mix Asphalt (WMA)."

(2) A draft standard practice titled "Standard Practice for Measuring Properties of Warm Mix Asphalt (WMA) for Performance Analysis Using the Mechanistic-Empirical Pavement Design Guide Software."

2.2.6 Summary

The major conclusions drawn from the research completed in NCHRP Project 09-43 are as follows:

1. Volumetric Properties

For HMA mixtures with 1.0 percent binder absorption or less, the volumetric properties of WMA designed with the procedures developed under NCHRP Project 09-43 were essentially the same as those obtained from an HMA design. However, the compactability, moisture sensitivity, and rutting resistance of the WMA may be significantly different than those of the HMA.

2. Binder Grade Selection

The same grade of binder should be used in WMA and HMA mixtures designed for the same project location. High-temperature grade bumping may be necessary for WMA processes with extremely low production.

3. RAP in WMA

RAP and new binders do mix at WMA process temperatures, provided the mixture is held at elevated temperatures for a sufficient length of time. To ensure good mixing of RAP and new binders, it is recommended that the planned field compaction temperature for WMA exceed the high-temperature grade of the "as recovered" RAP binder.

4. Short-Term Oven Conditioning

For WMA, it is appropriate to use 2 hours of oven conditioning at the compaction temperature, the same short-term conditioning that is used for design of HMA mixtures.

5. Coating, Workability, and Compactability

For the wide range of WMA processes available, viscosity-based mixing and compaction temperatures cannot be used to control coating, workability, and compactability. The combination of RAP and low WMA process and compaction temperatures may lead to WMA mixtures that are more sensitive to changes in temperature than similar HMA mixtures.

6. Moisture Sensitivity

Moisture sensitivity, as measured by AASHTO T 283, will likely be different for WMA and HMA mixtures designed using the same aggregates and binder, but the standard can still be used.

7. Rutting Resistance

Because lower short-term conditioning temperatures are used for WMA mixtures, as compared to HMA mixtures, binder aging in WMA mixtures is less. This result in lower flow numbers for WMA mixtures produced with the same aggregates and binder, as compared to HMA mixtures.

8. Performance Evaluation

For the same aggregates and binders, WMA mixtures designed in accordance with the draft appendix to AASHTO R 35 will have similar properties as HMA mixtures. Volumetric properties will essentially be the same, but the stiffness of the WMA mixture will probably be lower for as-constructed conditions.

The draft appendix to AASHTO R 35 should be used on a trial basis by agencies and producers to provide additional data to further refine the WMA mixture design methods and criteria, before being considered for adoption.

2.3 Warm Mix Asphalt Study in North Dakota

A study on WMA was conducted in 2011 at North Dakota State University (Gullickson, 2011). The aim of the study was to determine which type of WMA is best suited for use in North Dakota based on previous WMA research, cost, asphalt performance in North Dakota climatic conditions, and a survey of North Dakota contractors' opinions of WMA. After a literature study on research findings related to WMA performance, a survey was prepared and sent to nine contractors in North Dakota, which were identified by looking at bid results from NDDOT paving projects. Six of the contractors responded to the survey on the condition of anonymity. In general, contractors are hesitant to invest in WMA technologies mainly due to lack of any clear directions by NDDOT for the use of WMA in North Dakota.

The survey consisted of seven questions. The first question was, "Which type of Warm Mix Asphalt would your company invest in if future projects required the use of one of the following WMA technologies? What factors drove your choice(s) for the previous question?" They could choose more than one of the listed options. Five out of six respondents chose water-based additives and four out of six selected chemical additives. Three of the contractors stated that they are also open to any technology specified by the owner. Regarding the factors that drove them to this conclusion, three chose technologies that they already have experience with and two chose water-based additives because of cost. The contractors are willing to invest more if NDDOT provides more guidance for what it wants, since their experience with WMA is mostly based from projects in other states.

The second question was, "How many years have you (or your company) worked in the asphalt pavement industry," with the minimum response of 20 years and the largest of 75 years. The aim of this question was to assure the credibility of the responses to the survey.

The third question was, "Have you (or your company) ever worked on a Warm Mix Asphalt project? If so, what was the most common type of additives among the WMA projects that your company completed?" Of the six respondents, four indicated that they have worked on WMA projects in their previous projects. Three of them stated that water-based WMA was the most common type, and the other two stated that chemical additives were also commonly used as water-based technologies. None of the respondents had any experience with organic additives.

The fourth question was, "As a contractor, what are the main issues you would face when beginning to work with Warm Mix Asphalt?" Two of the respondents considered that the additional cost would a main issue of implementing WMA, while two others cited that the owner's fear of unknown performance and the owner wanting extended warranties. Setting up equipment and addition of additives to the mixing process were other issues that were mentioned.

The fifth question was, "What benefits do you think the use of Warm Mix Asphalt would provide to your company?" Five of the contractors chose lower overall cost or at least reduced fuel cost, easier compaction effort, and ability to haul longer distances. Three of the respondents also mentioned reduced emission of fumes, worker safety, and extended paving seasons as the benefits of WMA.

The sixth question was, "What are the drawbacks you see to using WMA?" Five of the six contractors considered extra cost or extra equipment as a downfall, while two of them mentioned moisture damage or stripping.

The seventh and last question was, "Given your knowledge of asphalt performance in North Dakota's weather conditions, do you think any type(s) of Warm Mix Asphalt will perform better in North Dakota versus the other types? Please select which type you think will perform the best and then discuss your selection." The responses to this question were not uniform. Two of the contractors thought water-based (foaming) would be the best, two were unsure, and the other three chose between organic and chemical additives. The results of this question show that North Dakota contractors are not totally backing a particular type of technology and they are not ready to risk investing in a technology that is not confirmed by NDDOT.

Based on the literature study on the performance of WMA technologies, the results of the conducted survey, and cost issues, this research found water-based (foaming) technologies as the most suitable technology to be used in North Dakota.

3 SPECIFICATIONS AND PUBLICATIONS

The DOTs are at different stages regarding specifications for WMA. Some have already prepared a separate specification for WMA, some are in the process of making one and others consider HMA specification sufficient for WMA. In this section, a review of available information regarding this matter is provided. Currently, no uniform specification is accepted by all DOTs regarding WMA construction. The Warm Mix Asphalt Technical Working Group (TWG) has prepared a generic specification for use by agencies and it is available through their website http://www.warmmixasphalt.com/. Some agencies have a list of pre-approved processes, these lists are updated periodically. For new technologies or technologies not approved yet, there is an "Approval Process" in some agencies.

In appendices C and D, specifications, special provisions, list of approved technologies and approval processes for new technologies and other related official documents for WMA are provided. In this section an overview of the target states of study is provided.

3.1 Colorado

Colorado has developed a "Standard Practice for Contractor Non-Standard Asphalt Mix Approval" which is available in Appendix C, page C10.

Their list of approved processes (as of September 2011) consists of Advera, AQUABlack Solutions, Evotherm, Green Systems, and Ultra Foam GX20. The documents are available in Appendix C, page C15.

They have also published the final report of a project sponsored by Colorado DOT and conducted by NCAT titled "Three-Year Evaluation of the Colorado Department of Transportation's Warm-Mix Asphalt Experimental Feature on I-70 in Silverthorne, Colorado" (Aschenbrener, 2011). In this project, three additives (Advera, Sasobit, and Evotherm DAT) were used to build three sections of WMA and compare to HMA control sections. Production, constructability, laboratory performance testing, and field performance were observed. The results of their three-year study showed that field performance of WMA sections were comparable to HMA sections, and despite the harsh weather conditions, they were in excellent condition considering rutting, raveling, and cracking. Production and placement were done with no problem and field compactions were achieved at 30 to 50 ˚F lower than HMA control sections. Lab tests showed that VTM and VMA of WMA mixes were lower than HMA samples by 0.5% to 1%. Regarding moisture sensitivity, WMA had loser TSR values, but still passed the requirements. Dynamic modulus and flow number testing showed that HMA were stiffer than WMA samples, which was expected.

3.2 Idaho

For specifications at this time (Sep 2011), Idaho DOT is looking at NCHRP 9-43 and the appendix to R35 and discussing the need to require Commercial Mix labs in Idaho to purchase and use asphalt foaming equipment in the design of foaming WMA. Currently foaming WMA is designed per their Superpave HMA specs. Their WMA Technology Committee has produced a standard Change Order for inclusion in contracts where the contractor has proposed the use of WMA, with some requirements the contractor must meet in order to use WMA technology. This special provision is available in Appendix C, page C21.

Idaho DOT is in the process of formulating a formal approval process and has approved the technologies below strictly due to their success in other states. The only WMA process used in Idaho to date (Sep 2011) is Double Barrel Green. Their approved technologies (as of September 2011) are Evotherm by MeadWestvaco (chemical process), Double Barrel® Green by Aztec Industries, and Terex® WMA System by Terex Roadbuilding (foaming Processes). They allow no organic additives at this time.

3.3 Illinois

Illinois has a draft WMA special provision at this time (Sep 2011) and this draft version is subject to change prior to first use. This special provision, available in Appendix C, page C26, revises their standard specifications which can be accessed using this link: http://www.dot.il.gov/desenv/hwyspecs.html (accessed in Sep 2011)

Illinois has a new WMA specification that will be used for the first time on upcoming January Letting.

They have done some experimental projects with WMA but they were not let as WMA. They were an equal cost substitution requested by the contractor after the projects were awarded.

3.4 Indiana

Indiana DOT has prepared a thorough special provision for WMA, which is available in Appendix C, page C43.

3.5 Iowa

Iowa DOT has developed a specification for WMA with several revisions. The latest specification is available, with the previous revisions, in Appendix C, page C60.

Iowa has investigated WMA performance in field and laboratory-produced mixes. The technologies used in lab were Advera, Sasobit, and Evotherm. In the field study, Evotherm 3G/Revix, Sasobit, and double Barrel Green Foaming technologies were applied. The result of their study was published in 2011 titled "Investigation of Warm Mix Asphalt Using Iowa Aggregates" (Buss et al., 2011). The study showed that mixing and compaction temperature were reduced. Tensile strength ratio (TSR) values of WMA were lower than HMA, especially in the lab were none of the additives performed as well as the HMA. Regarding dynamic module, HMA samples had higher modulus which is expected and WMA samples had reduced flow numbers compared to HMA counterparts.

3.6 Kansas

Kansas DOT has developed a seven page special provision to their HMA standard specification, plus a list of approved technologies. Both of these are accessible in Appendix C, page C83. As of September 2011, their approved technologies are AQUAblack Solutions, Double Barrel Green, Terex, and Ultrafoam GX in Foaming technologies. For chemical and organic additives, they allow Advera, Aspha-Min, Evotherm, Redi-Set WMX, and Sasobit.

3.7 Maine

Their special provision for WMA is attached in Appendix C, page C93.

3.8 Michigan

Michigan DOT has developed a special provision for WMA that could be accessed in Appendix C, page C97.

In a report titled "Michigan Field Trial of Warm Mix Asphalt Technologies" (Hurley et al., 2009), they have published their observations of constructing a test section, M95, in Iron Mountain to evaluate field performance of Sasobit technology. The experimental study showed that placement was successfully done at 50°F lower than HMA control sections. Air voids of WMA samples measured in the lab were statistically different form the control samples. Regarding rutting, lab tests did not show statistical difference between WMA and HMA. In moisture susceptibility, similar performance to control was observed; even tensile strength was higher for Sasobit mixes. Dynamic modulus of Sasobit mixes were statistically the same as control. Finally, it was concluded that using WMA resulted in reduction of emission and fuel consumption.

3.9 Minnesota

Minnesota standard specification is permissive, which means they allow WMA on any project unless expressly prohibited. They also allow shingles permissively, and only on a few projects they have not allowed shingles.

Minnesota is most interested in evaluating WMA potential for satisfactory low-temperature cracking performance. To test WMA performance, they have paved six cells with WMA on the MnROAD Mainline, which carries fewer than one million ESALs per year. The mix used is a level 4 Superpave with PG 58-34 binder and 20 percent of RAP. They used Evotherm 3G in all mixes have also made a control section. Production was done at approximately 50°F cooler than HMA production, and the same compaction with HMA was achieved with less effort. The lab tests showed good tensile strength ratios, leading them to the conclusion that WMA is not prone to moisture damage. The DSR testing showed that WMA binders may be more susceptible to short term aging. In stiffness test, both WMA and HMA binders failed at approximately same temperature.

3.10 Missouri

Missouri DOT has not developed or adopted any particular warm mix additive/technology list yet. To allow WMA, they have removed and lowered some temperature restrictions in their standard specification. They allow contractors to choose the technology that they are more comfortable with as long as they follow the specifications. Acceptance or rejection of a new technology by the contractors is based on their own investigation and DOT does not mandate anything. Currently, foaming and Evotherm are the predominant technologies in their projects.

3.11 Montana

They have published a report in 2009 titled "Synthesis of Warm Mix Asphalt Paving Strategies for Use in Montana Highway Construction" (Perkins, 2009), in which a discussion is presented on available WMA technologies at that time, their advantages, and the required modifications. The report presents a thorough literature study on ongoing research of the time, including NCHRP Project 9-43 (which is completed now, September 2011, and a summary of it is presented in chapter 3 of this report) and some case studies on WMA, like two demonstration projects that were conducted in Yellowstone National Park and studies by NCAT and Montana DOT. The report further studies WMA specifications and special provisions in use by DOTs nationwide, and the report is finalized by proposing a roadmap for future research and implementation at MDT.

3.12 Nebraska

Nebraska DOT will be coming out with a permissive specification in January 2012, basically allowing the WMA materials that they have used and allow requests for any other materials, with approval by the Flexible Pavements Engineer. This draft specification is not available for distribution before January 2012.

In a research project to evaluate WMA technologies for use in Nebraska paving projects, three additives (Sasobit, Evotherm, and Advera synthetic zeolite) were used to build trial sections in Antelope County, Nebraska. Lab and field performance of samples of this sections were compared to HMA controls. They observed and compared two-year actual field performance of WMA and HMA sections, plus their long-term performance simulated through MEPDG. The results of their study showed that WMA additives do not significantly affect the viscoelastic stiffness of mixtures. Their WMA mixes generally had better rut resistance, particularly Sasobit. For moisture susceptibility, AASHTO T283 and semi-circular bend fracture tests were used, in which WMA samples showed more susceptibility. Both pavement types performed excellently in the two-year field performance monitoring and simulating. The long-term performance of WMA and HMA sections by MEPDG showed no major difference in performance between the two (Kim et al., 2010).

3.13 New Hampshire

They have a list or approved technologies, accessible in Appendix C, page C99. As of September 2011, they allow Aqua Foam, Double Barrel Green, Eco-Foam II, Maxam, Terex, and Ultrafoam GX in foaming technologies. Additionally, SONNEWARMix is approved for organic technologies and Evotherm in chemical technologies.

3.14 New York

The Specification for the use of WMA can be found in appendix C, page C101, which needs reference to their most current Standard Specifications Sections 401 and 402 (this can be obtained at: https://www.nysdot.gov/main/business-center/engineering/specifications/updated-standard-specifications-us). They also have a WMA Tech Approval Process which is available in Appendix C, plus a more in-depth description of the information they use, in the “Production, Testing and Compaction Details” provided by each WMA Technology as part of the Approval process.

NYDOT has an approved list of WMA Technologies which is also provided in Appendix C, page C116.

They are expected to write a document after their experimental work plan on WMA has been completed, but that is not expected in a near future.

3.15 Ohio

They have two publications on WMA, “Performance Assessment of Warm Mix Asphalt (WMA) Pavements” (Sargand et al., 2009) and “Mechanical Properties of Warm Mix Asphalt Prepared Using Foamed Asphalt Binders” (Abbas et al., 2011). The results of their study show that WMA mixes made by foaming are more workable and easily compacted, although they are produced at lower temperature. Their study showed that WMA mixes are slightly more susceptible to moisture damage, but can satisfy the minimum requirement on TSR. WMA prepared using natural gravel and unmodified binder is more prone to rutting than HMA counterparts. However, using appropriate aggregate and binders can help in overcoming any adverse effects that WMA have on mix performance.

3.16 Oregon

Their special provision for WMA and list of approved technologies are available in appendix C, page C123.

3.17 South Dakota

SDDOT has a research project currently underway on warm mix asphalt. The status of the research project and the Special Provision used for the warm mix are attached in Appendix C, page C129.

As of September 2011, the warm mix additives that they have used are Evotherm and water injection methods at the plant sites. They have plans to use Advera in the future. The mix designs were the standard gyratory designs and the warm mix changes were only to lower the mix delivery temperatures. They have asked for and tried to follow the warm mix additive supplier recommendations for mix design and additional testing. They have also followed the SDDOT Gyratory Special Provision for the testing requirements. The mixes are monitored in the field and samples are obtained for additional testing for the research project.

In their research project, no changes were made to the binder grade for the warm mix sections. The warm mix design and field samples were prepared and tested for moisture sensitivity. All control and warm mix sections had the same binder targets. The research project matrix is to try the warm mix with three aggregate types (limestone, quartzite, and a natural aggregate) and three different warm mix additives (Advera, Evotherm, and plant water injection systems). All the mixes are 12.5 nominal size and use the standard compaction specification. The mixes are checked using the Asphalt Pavement Analyzer for rut depth of both the control and the warm mix.

3.18 Utah

Utah DOT has no WMA specification at this time (September 2011) and they use the same specification they use for HMA, with the only exception that the temperature can be lowered until it is sufficiently workable. Gradation, volumetric parameters, and all other specifications. There is one sentence in their specifications for HMA that says that the contractor may use WMA if they so choose. Utah has seen little difference in how their WMA projects have performed as compared to their WMA projects, so it is typically left to the contractor's discretion.

3.19 Washington

They have added a section in their standard specification that discusses WMA (Division 5 (5-04), and they also have a single page of Process Approval that contractors are required to fill out and submit in order to receive approval to produce WMA on any WSDOT project. These documents are available in Appendix C, page C133.

Washington DOT has initiated an experimental study to evaluate long and short term performance of WMA produced with Sasobit. For this, they will monitor the section for five years considering friction, rutting and ride measurements, as well as overall pavement condition assessment with special emphasis on cracking and rutting resistance. The project is still ongoing, but an interim report titled "Evaluation of Warm Mix Asphalt" (Russell, 2009) has been published. Based on production and placement of Sasobit, they have concluded that mix design, production, and placement of WMA is the same as HMA. Compaction and placement were possible at the same density of HMA, but lower temperatures were obtained at a reduction of 30-50°F.

3.20 Wyoming

WYDOT has little experience with warm mix and has just constructed their first warm mix test section in August 2011, with a plant foaming process. They will most likely construct a test section summer 2012 with several different additives and processes.

4 SURVEY ANALYSIS

In the survey, questions were categorized into five subcategories:

- General observations
- Technologies
- Mix design
- Specification
- Acceptance plan

Under General Observation category, questions concerning WMA agencies' past experience relevant to production, cost, and previous projects were of concern.

4.1 Question 1 - General - Comparison between WMA and HMA

Q.1 Compare WMA to HMA in the following categories based on your agency experience. Please explain your choices in the comment box.

The first question was about comparing WMA to HMA for the following categories: bidding, contractor's willingness, constructability, performance, maintenance and cost. A section for the comments was also part of the question. FIGURE 4.1, illustrates the results for the first question. As can be seen from FIGURE 4.1, for all categories the majority of responses considered HMA and WMA of same ranking. On the other hand, WMA had the highest advantageous ranking in terms of constructability followed by contractors' willingness. In terms of the disadvantages of WMA compared to HMA, cost was the highest disadvantage of WMA, followed by performance, and the least disadvantageous in terms of constructability.

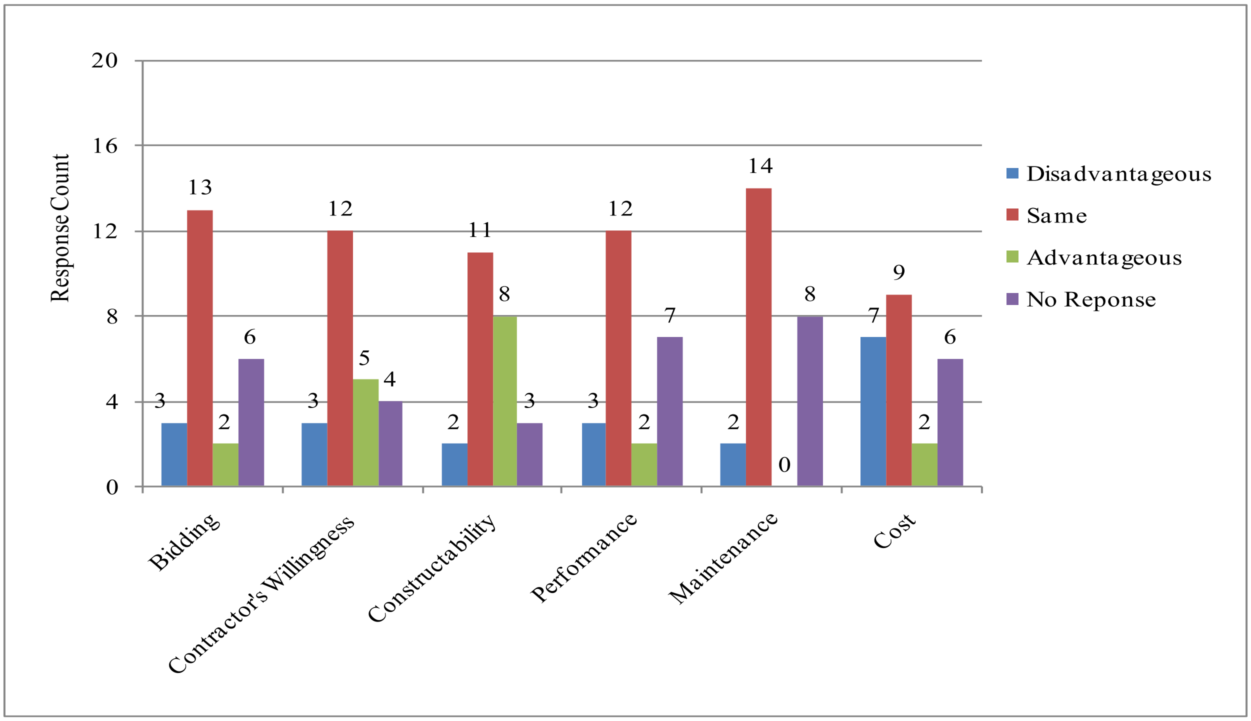

FIGURE 4.1 Comparison between WMA and HMA based on agencies' experience

4.2 Question 2 - General – Approximate Agencies' Yearly Production of WMA and HMA

Q.2 How much was the WMA and HMA approximate production (tonnage/year) based on the average of last five years?

This question was about the WMA and HMA approximate production (tonnage/year) based on the average of last five years. The question was a comment section, in which the respondents were able to state their production data as well as their accompanying explanation for it FIGURE 4.2.a and FIGURE 4.2.b illustrate the average yearly production for both HMA and WMA, respectively. As shown in FIGURE 4.2.a, for HMA production, South Dakota (Pierre), had the highest amount of production with an average of eight million tons/year, followed by Ohio (Columbus) with an average production of six million tons/year and then Washington (Olympia) averaging 4.8 million tons/year. The lowest three averages of HMA production were for Montana (Helena), Manitoba-Canada (Winnipeg) and Michigan (Lansing)/Vermont (Montpelier) averaging 25,600, 40,500, and 400,000 tons/year, respectively. For WMA, as illustrated in FIGURE 4.2.b, the production averages varied significantly for the different agencies. Ohio (Columbus) had the highest average with 1.9 million tons/year, followed by Indiana (Indianapolis) that averaged 500 thousand tons/year, while New York (Albany) came third with an average of 225 thousand tons/year. The lowest three averages of WMA production were for Utah (Salt Lake), Idaho (Boise) and Oregon (Salem) averaging 5000, 6000 and 10,000 tons/year, respectively.

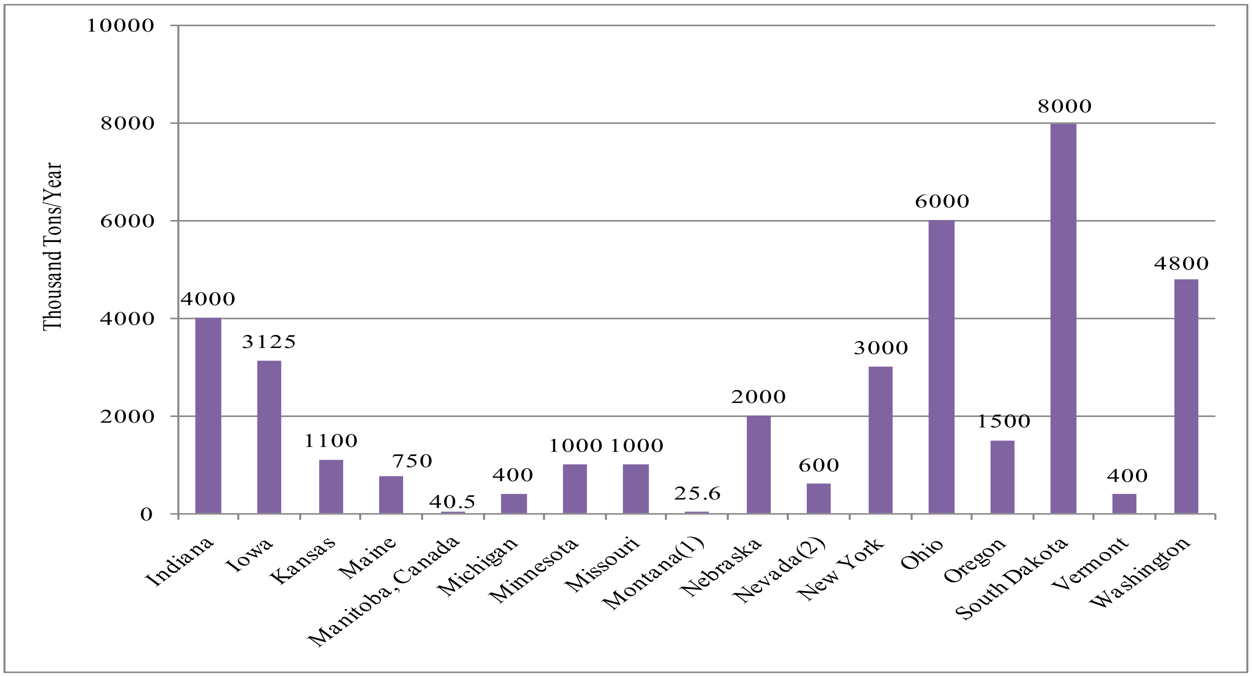

FIGURE 4.2.a Approximate HMA production (average of last five years)

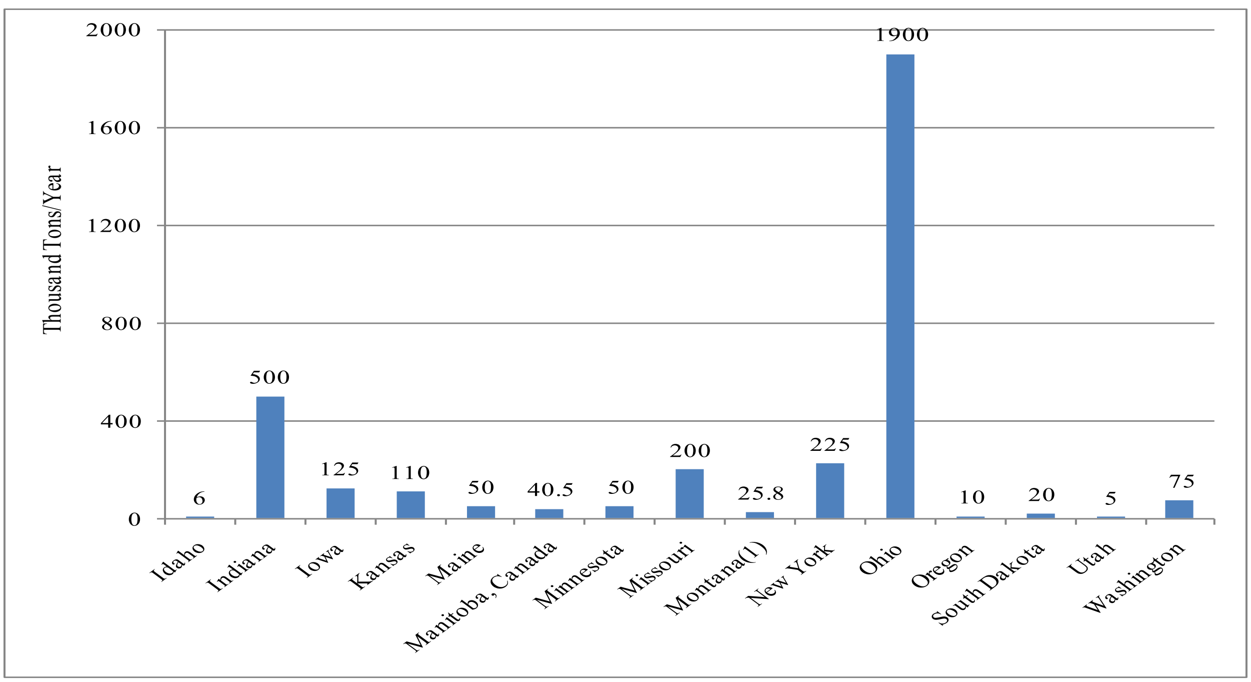

FIGURE 4.2.b Approximate WMA production (average of last five years)

4.3 Question 3 - General – HMA and WMA Bidding Cost Comparison

Q.3 How is WMA bidding cost compared to HMA?

Q.3 was a comparison between HMA and WMA in terms of bidding cost. This question was divided into two sections. There is a general section, asking about the overall rating of WMA cost and whether it is higher, lower, or the same compared to HMA. The second part of the question specifically inquires about the increase of WMA cost compared to HMA, by providing five choices for the increase in the bidding cost, which are 1 to 5%, 6 to 10%, 11 to 15%, 15 to 20% and 21% or more, from which the survey taker has to choose only one choice.

As illustrated in FIGURE 4.3.a, seven DOTs ranked WMA bidding cost to be the same as that of HMA, whereas eight choose to assign a more bidding cost for WMA when compared to HMA. On the other hand, for the exact amount of increase of WMA bidding cost compared to HMA, illustrated in FIGURE 4.3.b , four DOTs choose 1 to 5%, followed by three choosing 6 to 10%, while only one DOT choose 15 to 20%. Such variability in the increase of the bidding cost could be attributed to the different WMA technologies, that either requires additives, or modification to the plant itself.

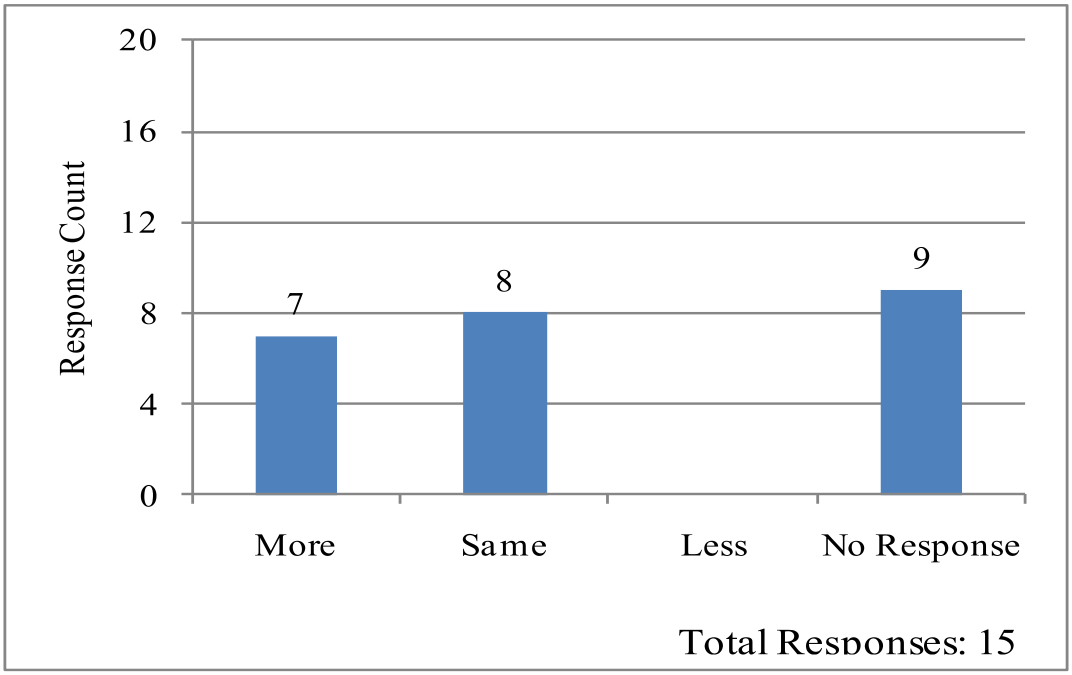

FIGURE 4.3.a WMA bidding cost compared to HMA

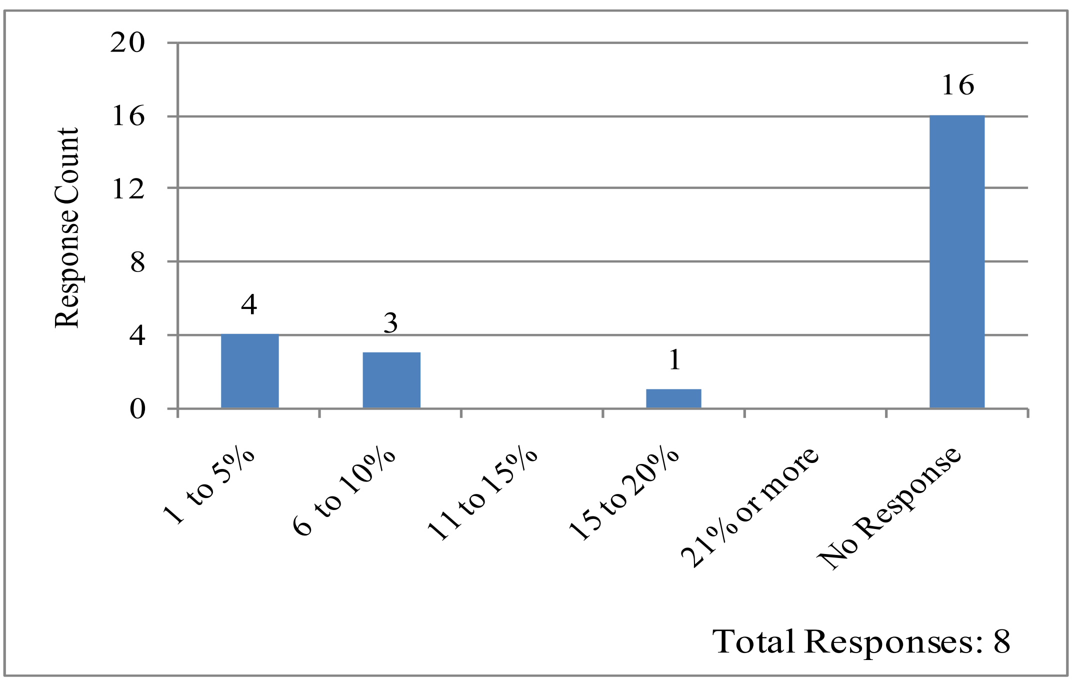

FIGURE 4.3.b Increase of WMA bidding cost compared to HMA

4.4 Question 4 – General – Cost Issues

Q.4 What is the approximate range of additional costs ($/ton) for WMA production at:
Q 4.1 Cost of Additives
Q 4.2 Total Cost Including Processing

4.4.1 Question 4.1 - General – WMA Additional Cost of Additives

The following question (Q.4.1) was about the approximate range of additional costs ($/ton) for WMA production in terms of cost of additives at both the refinery and field locations. New York (Albany) stated a $3-6/Liquid Ton increase at the refinery and $8/Liquid Ton increase at the field location for WMA cost of additives compared to HMA. Missouri (Jefferson City) stated that no increase is needed due to the usage of foaming technology at both the refinery and field location, with the only needed cost for initial equipment installation. Iowa (Ames) stated that no increase, at the refinery, is needed due to the usage of foaming technology.

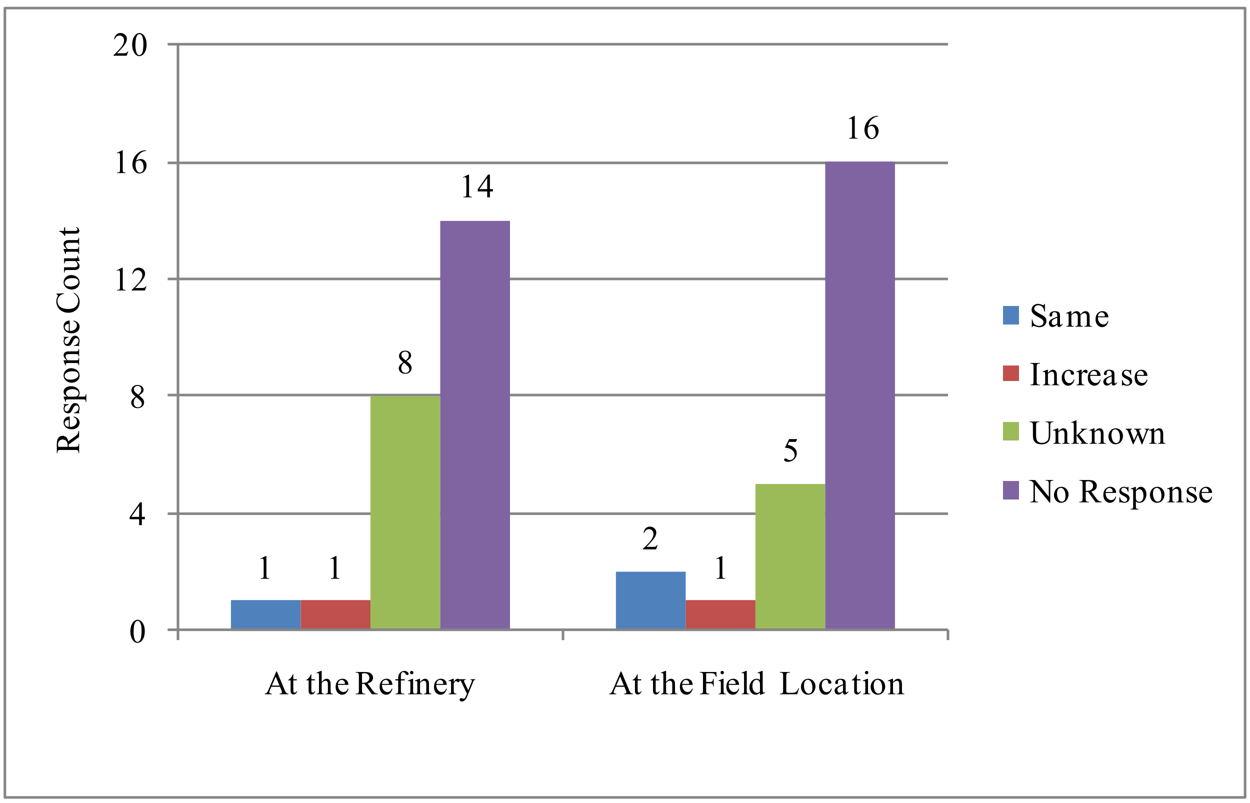

FIGURE 4.4.1 Additional costs for WMA production in terms of cost of additives

4.4.2 Question 4.2 - General - WMA Additional Total Cost

The approximate range of additional costs ($/ton) for WMA production in terms of total cost including processing, at both the refinery and field locations, was discussed in (Q.4.2). FIGURE 4.4.2 illustrates the percentage of states who responded for each section. Vermont (Montpelier) stated a $1-2 per ton increase for both locations. Washington (Olympia) provided a value for the increase at field location ($25,000 - $50,000). An increase of $2 per ton for the refinery location and $1.75 per ton for field location were stated by Minnesota (Maplewood). Iowa (Ames) stated an increase of $2-4 per ton for the refinery location only. Ohio (Columbus) and Michigan (Lansing) both stated that no increase is needed except for cost of initial equipment installation.

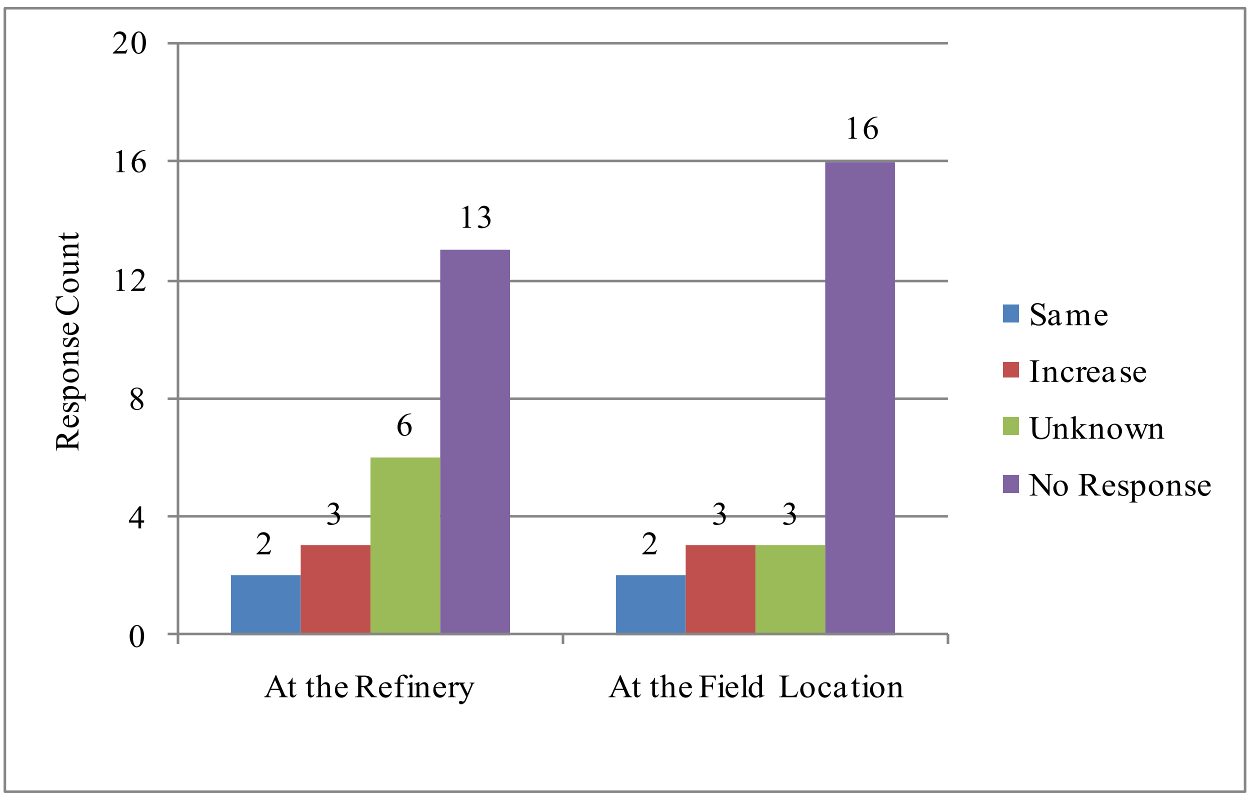

FIGURE 4.4.2 Additional costs for WMA production in terms of total cost including processing

4.5 Question 5 - General – Agencies' WMA Experiences

Q.5 Is it possible to provide information/data/documentation for some of your agency projects/experiences with WMA? (Please provide it through web link, email, or post)

The following question (Q.5) asked about information, data, and documentation for some of the agency projects or experiences with WMA. Detailed data obtained from this question, as well as all other additional data collected by the research team used in formalizing this report are all gathered in Appendix D – Case Studies and Reports on WMA. FIGURE 4.5 illustrates the number of states that has publication related to WMA.

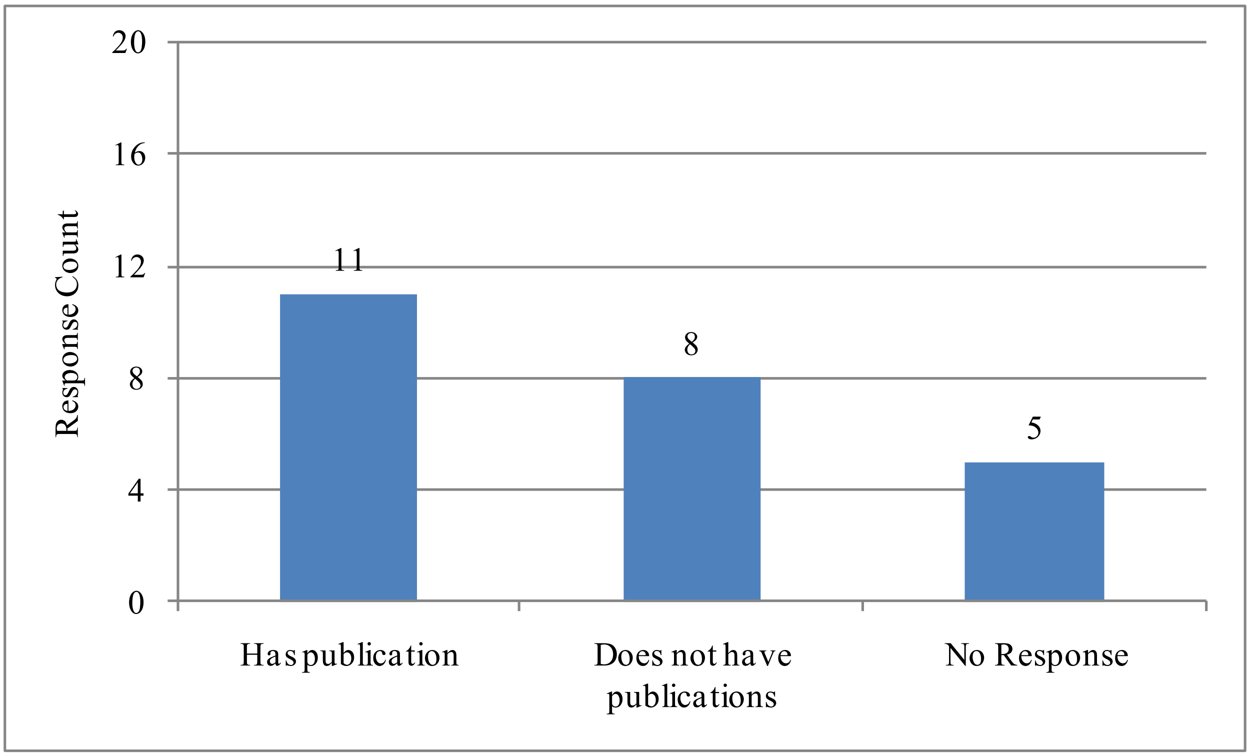

FIGURE 4.5 Agencies that have WMA publications

4.6 Question 6 - General –Agencies' Preferred WMA Process

Q.6 If you had to pick one WMA process, what would it be? Please explain why.

Q.6 asked the survey takers about a single WMA process to choose. As illustrated from FIGURE 4.6, an equal response count seven was recorded for both chemical and foaming processes, while the organic additives had only three responses. Five of the respondents could not choose a single technology.

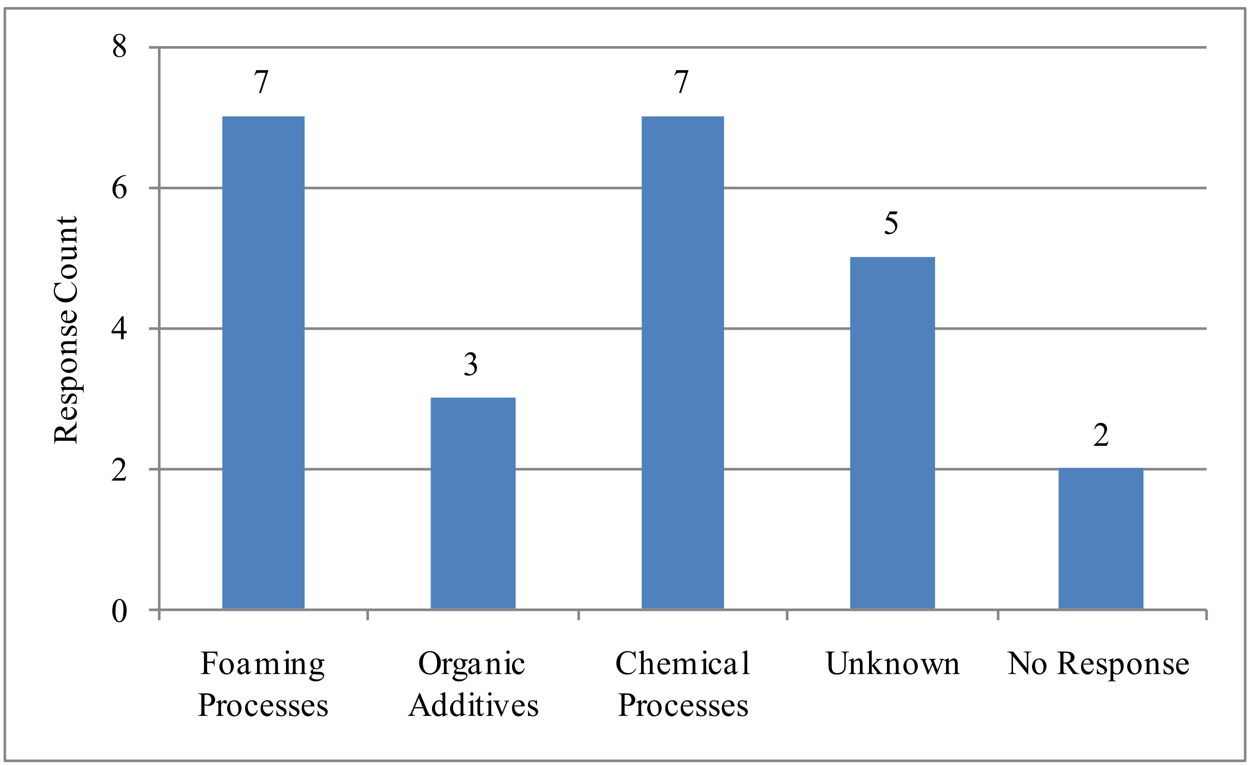

FIGURE 4.6 Distribution of WMA type preference

In the technologies section, questions concerning WMA agencies past experience relevant to technologies implemented for WMA utilization were of concern.

Questions (Q.7.1, Q7.2, and Q7.3) discussed number of constructed projects, ranges in temperature reductions after utilization of WMA technology and types of distresses (either moisture damage or rutting) together with the number of projects that had such distresses, for the agencies projects made with chemical processes, foaming processes and organic additives, respectively.

4.7 Question 7 – Technology – Evaluation of Processes

4.7.1 Question 7.1 - Technology – Chemical Processes

For each of the three main processes below please specify the followings: In how many of your agency projects was the technology implemented? How much reduction in mixing temperature could you achieve compared to HMA projects? Have you observed moisture damage and/or rutting on your warm mix projects? If yes, in how many projects did you observe them? If there were other distresses, please list them in the comment box.

In Q.7.1, chemical processes agencies past experience was discussed. As illustrated in FIGURE 4.7.1.a, Evotherm™ had the highest number of constructed projects among agencies with 54 projects done, followed by CECABASE®RT and HyperTherm™/QualiTherm that had only two and one, respectively. FIGURE 4.7.1.b discusses the ranges of temperature reductions for the different chemical processes. For Evotherm™, amongst the 13 agencies who choose such process, 10 picked the (40-60ºF) temperature range reduction while only three choose the (20-40ºF) range of reduction. For CECABASE®RT and HyperTherm™/QualiTherm, for the two agencies that choose them, the (40-60ºF) temperature range reduction was their choice. The number of projects that had either moisture damage or rutting, for the chemical processes chosen, is shown in FIGURE 4.7.1.c. The highest number of projects was assigned to Evotherm™ process, and it was the only process to show 13 projects suffering from moisture damage. This, however, does not give direct indication of the susceptibility of such process to moisture damage, but rather is attributed to it being the highest process in terms of number of projects.

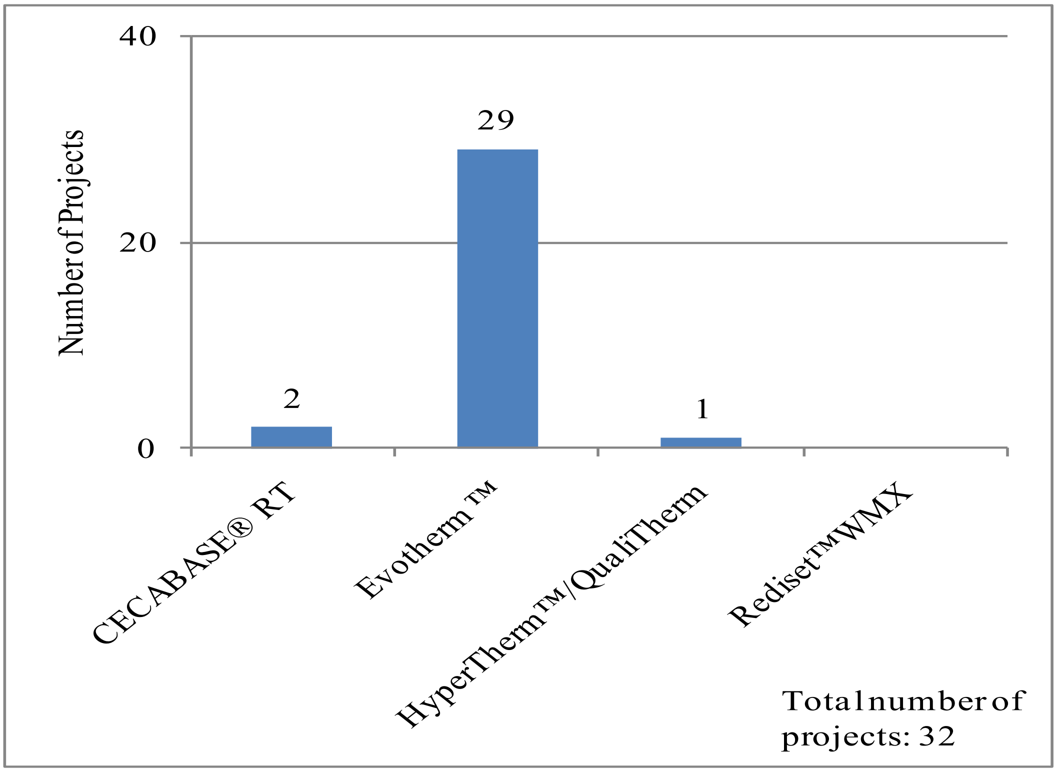

FIGURE 4.7.1.a Number of constructed projects for each chemical process

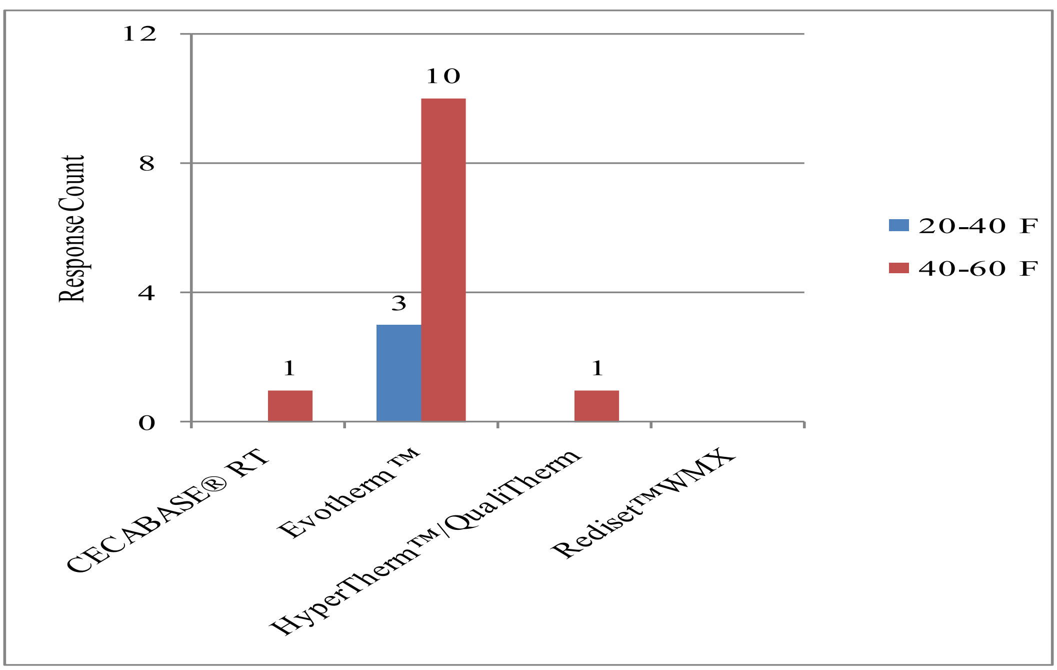

FIGURE 4.7.1.b Mixing temperature reduction (°F) achieved for each chemical process

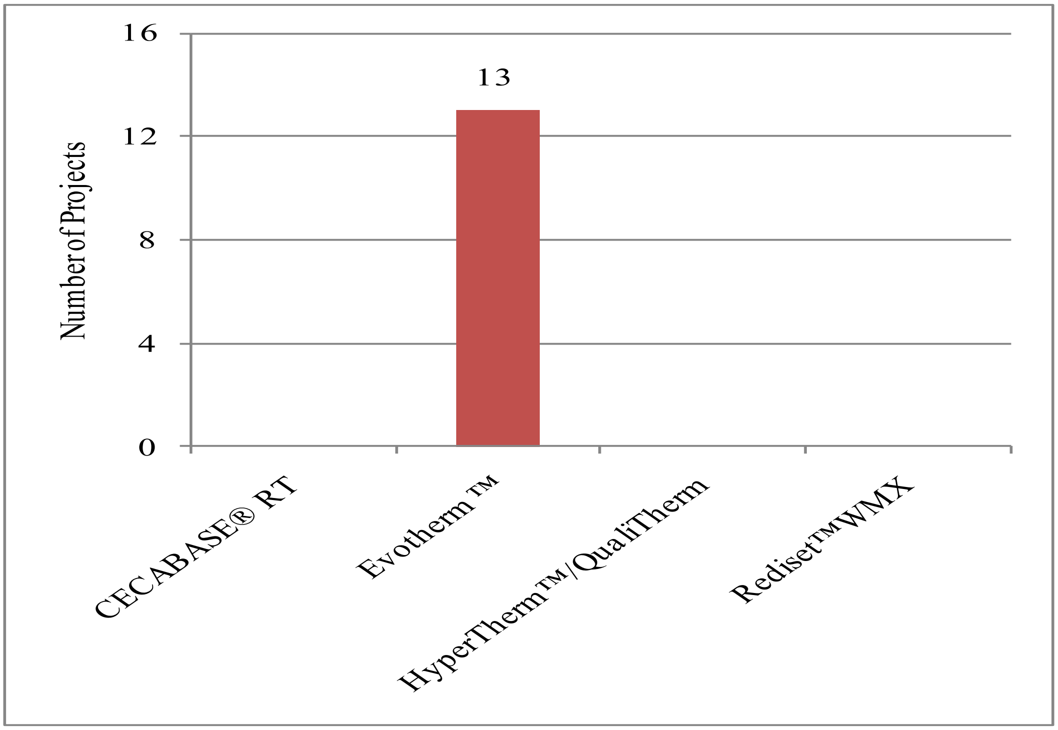

FIGURE 4.7.1.c Number of projects with moisture damage for each chemical process

4.7.2 Question 7.2 - Technology - Foaming Processes

The past experiences of agencies with foaming processes is discussed in Q.7.2. From FIGURE 4.7.2.a, a rather wide range of processes is available. Double Barrel® Green process had the highest number of projects (44), followed by AQUABlack™ WMA System (33 projects), while Terex® WMA System came third with a total number of 17 projects. Accu-Shear™, Aspha-Min®, Aquafoan, and Ultrafoam GX2™ System had the lowest number of projects with only one, one, three, and three projects respectively. As illustrated in FIGURE 4.7.2.b, the majority of foaming process was assigned the 20-40ºF temperature reduction range. The only exceptions were for Advera® WMA process that had 40-60ºF temperature reduction range chosen by some agencies, and LEA (Low Emission Asphalt) where an agency choose 80-100ºF as its temperature reduction range.

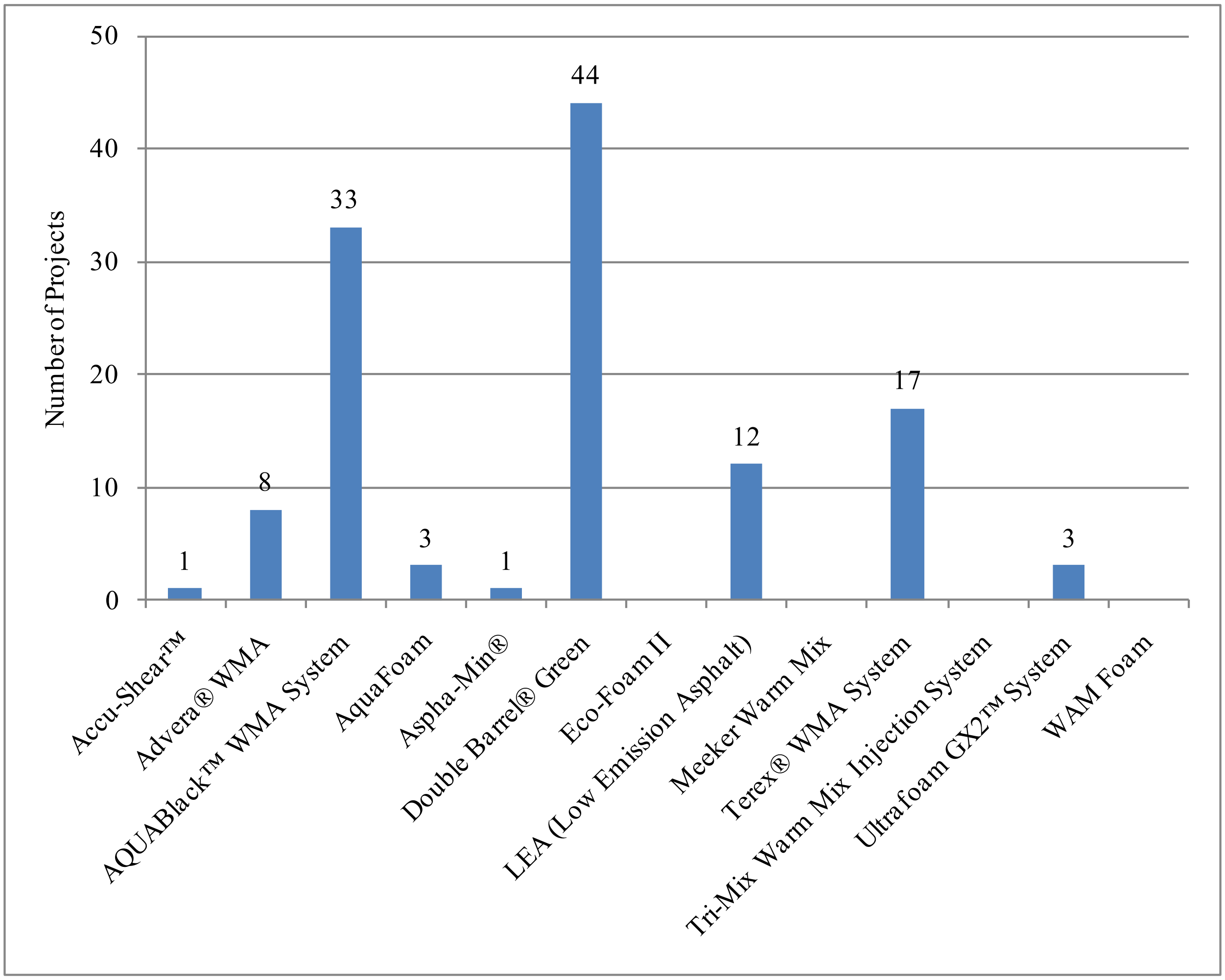

FIGURE 4.7.2.a Number of constructed projects for each foaming process

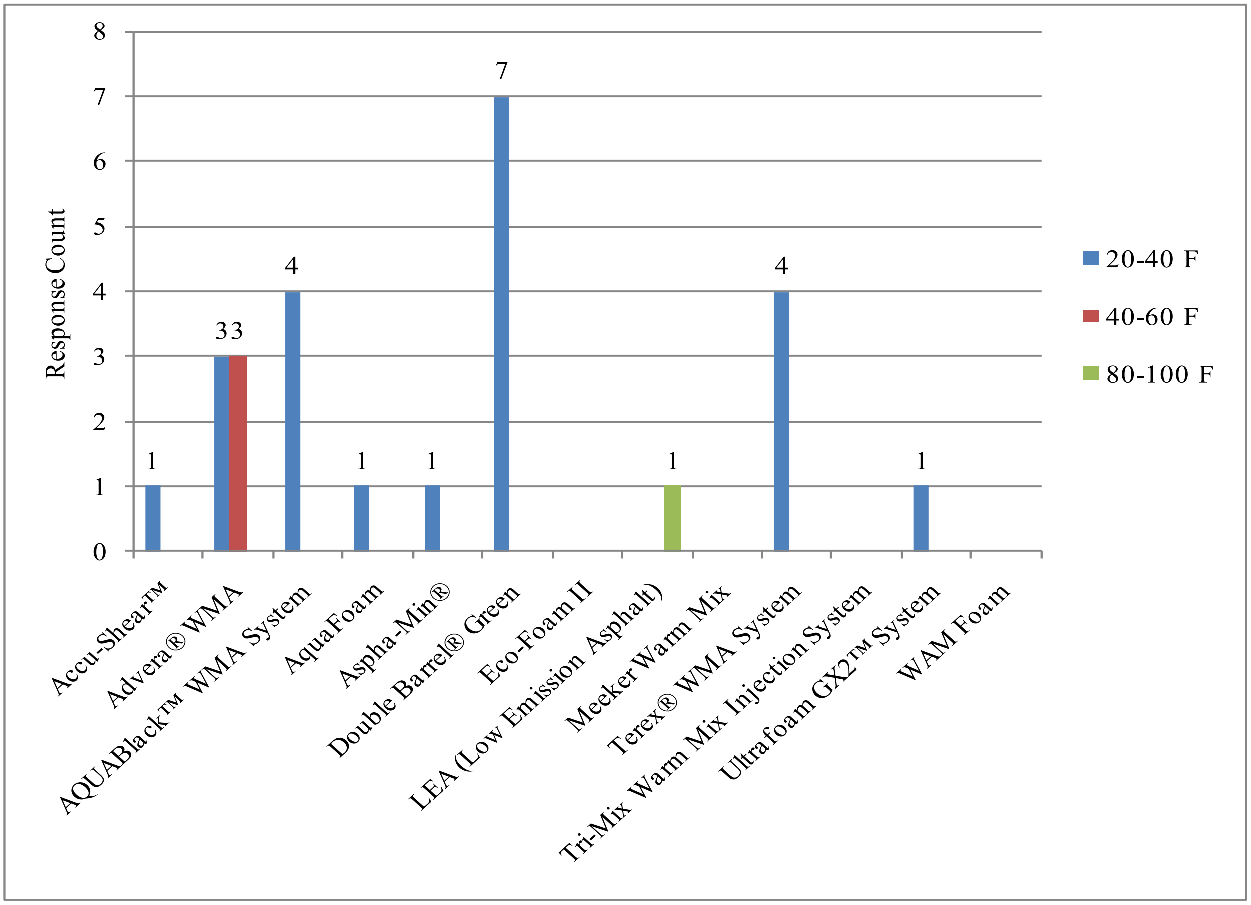

FIGURE 4.7.2.b Mixing temperature reduction (°F) achieved for each foaming process

4.7.3 Question 7.3 - Technology - Organic Additives

In Q.7.3, organic additives agencies' past experience is discussed. As illustrated in FIGURE 4.7.3.a, Sasobit® had the highest number of projects constructed among agencies with 16 projects done, followed by Thiopave™ and SonneWarmix™ that had only three and two projects, respectively. FIGURE 4.7.3.b discusses the ranges of temperature reductions for the different organic additives. For Sasobit®, among the eight agencies who choose such additive, four picked the 20-40ºF temperature range reduction, three choose the 40-60ºF range of reduction, and only one choose the 80-100ºF range of reduction. For Thiopave™ and SonneWarmix™, for the two agencies that choose them, the 20-40ºF temperature range reduction was their choice.

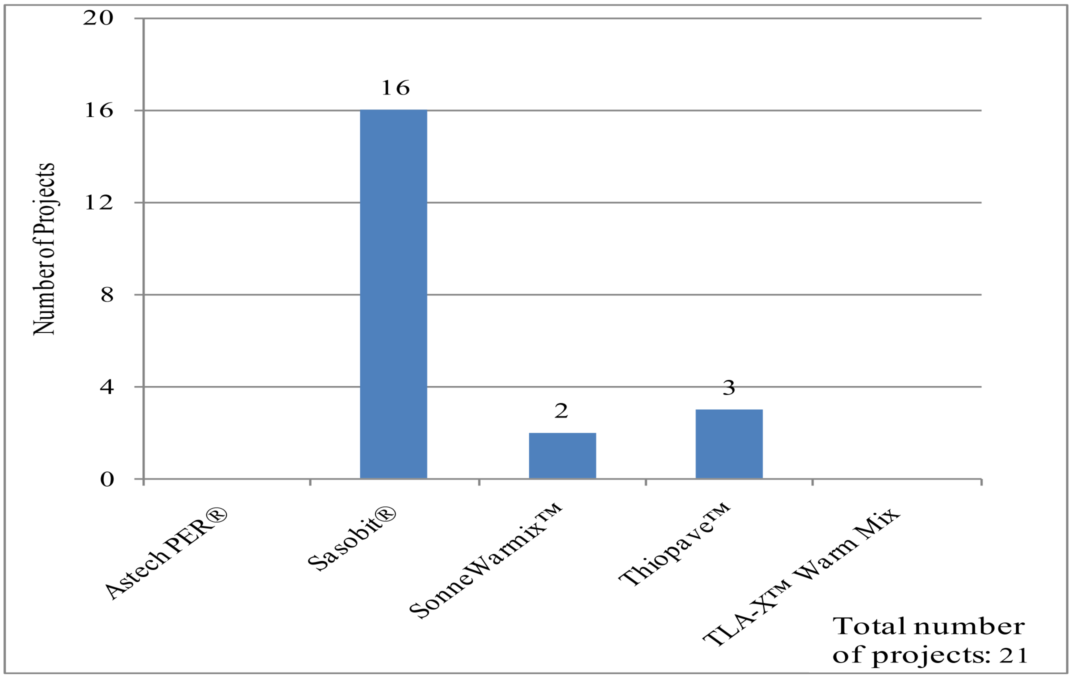

FIGURE 4.7.3.a Number of constructed projects for each organic additive

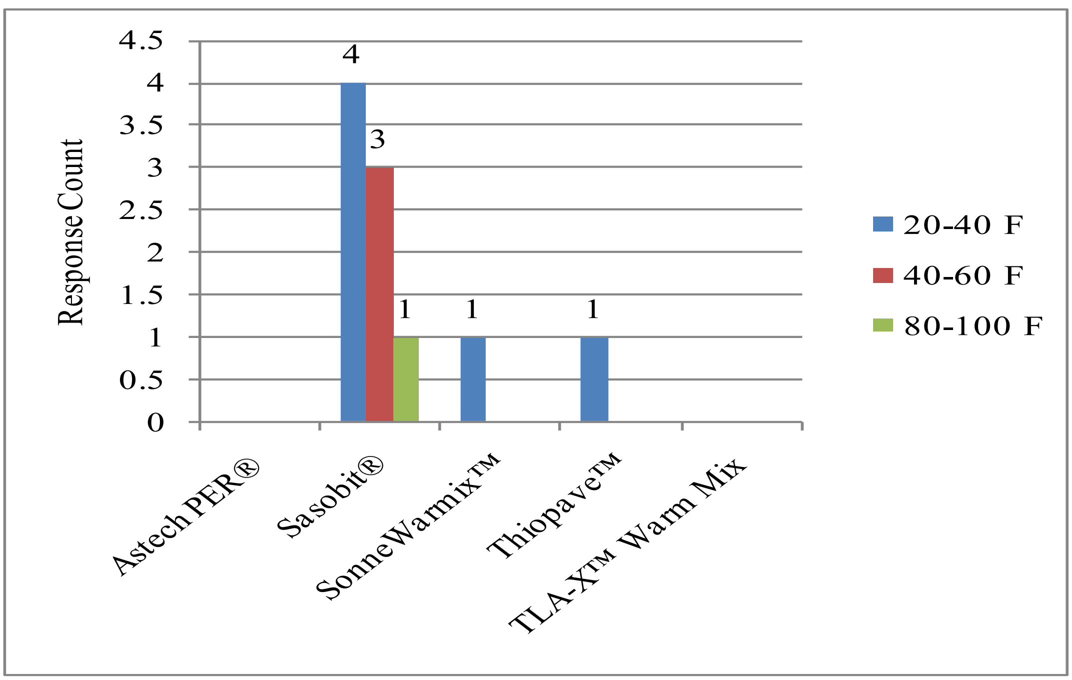

FIGURE 4.7.3.b Mixing temperature reduction (°F) achieved for each organic additive

In the mix design category, modifications in the mix design, in terms of material, binder and design aggregate structure were investigated. Lab testing modifications, amount of anti-stripping additives, and utilization of Reclaimed Asphalt Pavement (RAP) or Reclaimed Asphalt Shingles (RAS) in WMA were also investigated.

4.8 Question 8 - Mix Design - WMA Material Selection Modifications

Q.8 In your WMA Material Selection, which of the items below has been modified compared to HMA mix design? (Please explain in the comment box)

In Q.8, WMA mix design material selection modifications in terms of binder selection, aggregate properties, volumetric parameters (VMA & VFA), recycled asphalt pavement (content/gradation) and additives (types/percentage) compared to HMA were discussed. As can be seen from FIGURE 4.8, the majority of responses from agencies (14) determined the need for no modifications at any time. On the other hand, binder selection was among the items of WMA mix design material selection that needed modifications with a response count of two. Next, volumetric parameters (VMA & VFA), recycled asphalt pavement (content/gradation) and additives (types/percentage) that had all a response count of one from all the agencies who answered the question.

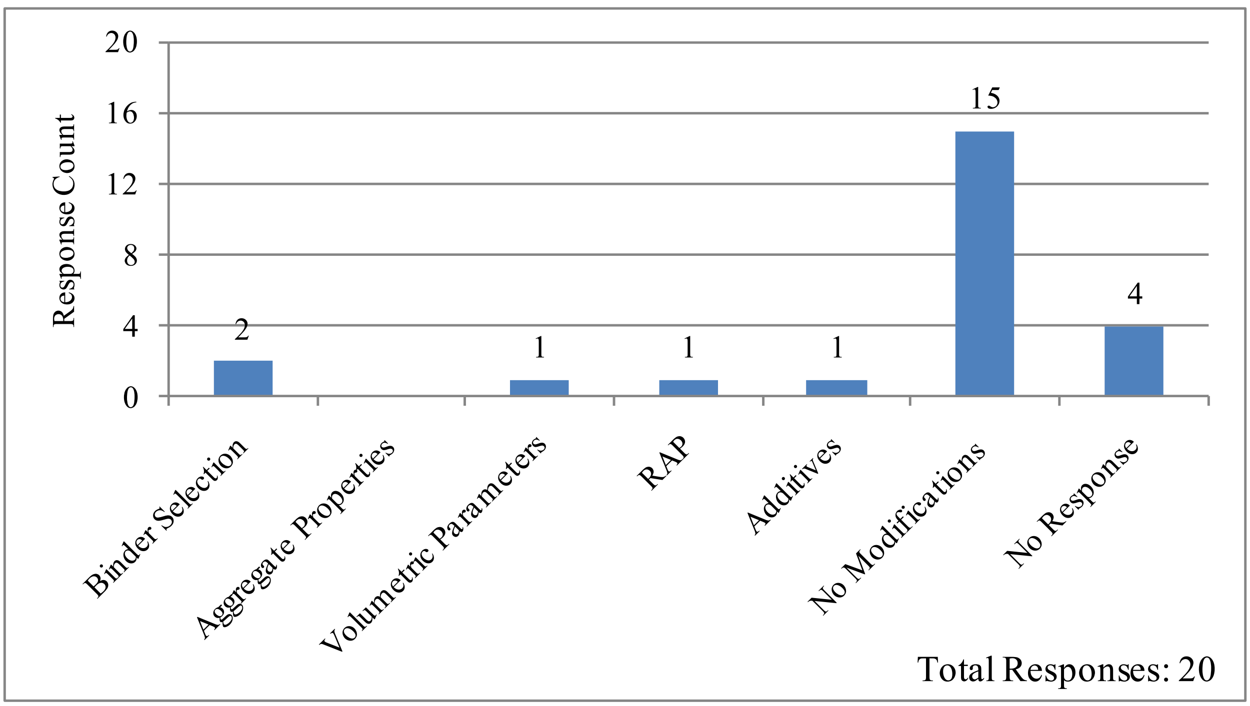

FIGURE 4.8 Modifications in WMA material selections items compared to HMA

4.9 Question 9 - Mix Design - WMA Binder Selection Modifications

Q.9 In your WMA Binder Selection, which of the items below has been modified compared to HMA mix design? (Please explain in the comment box)

In Q.9, WMA binder selection modifications in terms of binder content, binder grade, and binder preparation/testing compared to HMA were discussed. As can be seen from FIGURE 4.9, the majority of responses from agencies (18) determined the need for no modifications at any time. On the other hand, binder content was among the items of WMA mix design material selection that needed modifications, with a response count of two. Next, were binder grade and binder preparation/testing that both had a response count of one among the agencies who answered the question.

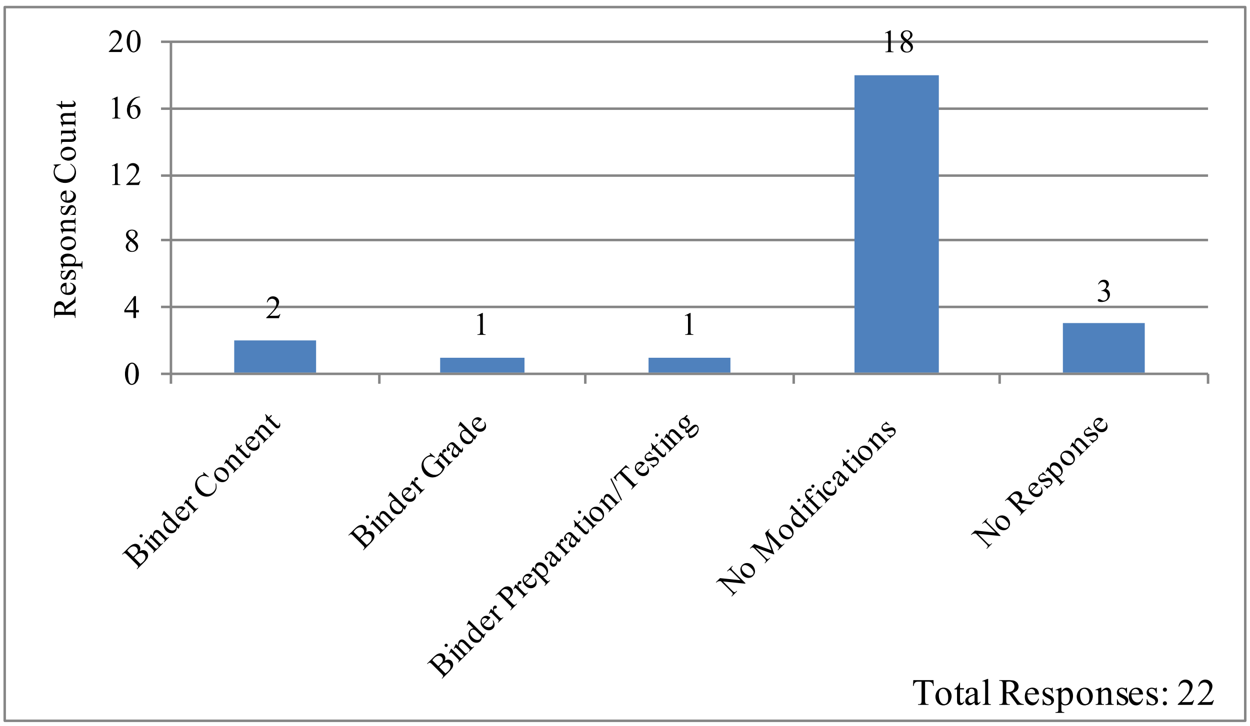

FIGURE 4.9 Modifications in WMA binder selection items compared to HMA

4.10 Question 10 - Mix Design - WMA Design Aggregate Structure Modifications

Q.10 In your WMA Design Aggregate Structure, which of the items below has been modified compared to HMA mix design? (Please explain in the comment box)

In Q.10, WMA design aggregate structure modifications in terms of aggregate sources, nominal maximum aggregate size, trial gradations and aggregate compaction, compared to HMA were discussed. As can be seen from FIGURE 4.10, 19 respondents determined the need for no modifications at any time, while only one agency (Saskatchewan) stated that no changes have taken place for the aggregate properties because WMA is in the early trial stages.

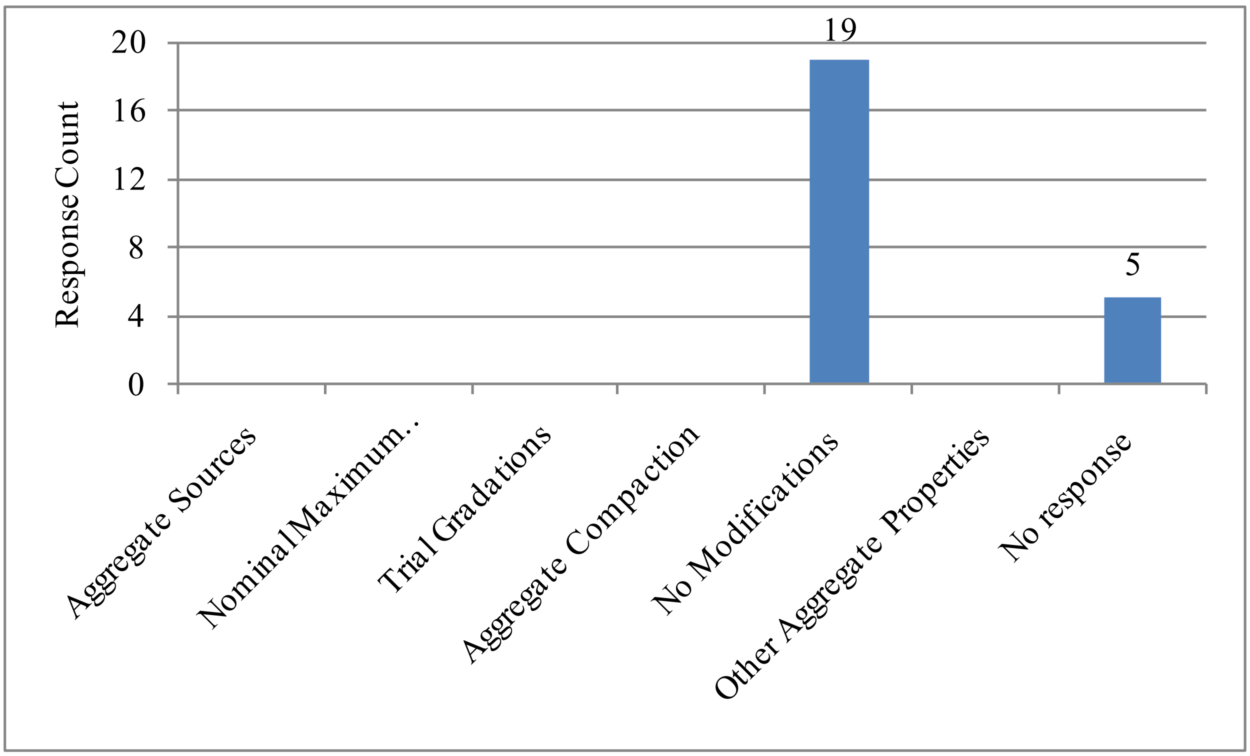

FIGURE 4.10 Modifications in WMA design aggregate structure compared to HMA

4.11 Question 11 - Mix Design - WMA Lab Performance Tests Modifications

Q.11 In your WMA Lab Performance Tests, which of the testing below has been modified compared to HMA mix design? (Please explain in the comment box)

In Q.11, WMA lab performance tests modifications in terms of rutting, thermal cracking, fatigue, and moisture sensitivity compared to HMA were discussed. As can be seen from FIGURE 4.11, the majority of responses from agencies determined the need for no modifications at any time, for both specimen preparation and testing procedures categories. On the other hand, moisture sensitivity was among the items of WMA lab performance tests that needed modifications, with three agencies attributing the modifications in specimen preparation, while only one agency choose modifications in testing procedure.

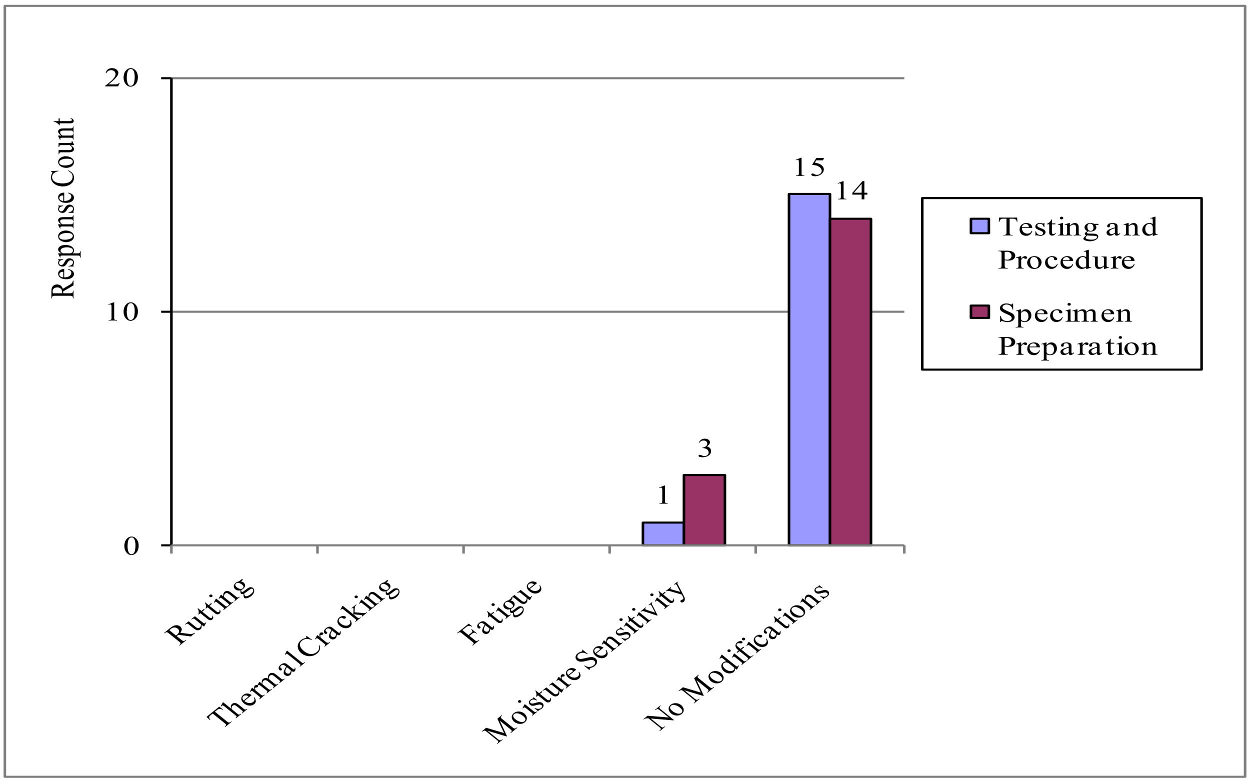

FIGURE 4.11 WMA lab performance tests modifications compared to HMA

4.12 Question 12 - Mix Design – WMA Anti-Stripping Agent Modifications

Q.12 Compared to HMA, does your agency require modifying the amount of anti-stripping agent used for WMA? If yes, please specify how? Also if any other types of additives are required for WMA, please specify in the comment box

In Q.12, WMA modifications in terms of the amount of anti-stripping agent used were investigated. As can be seen from FIGURE 4.12, the majority of responses from agencies (19) determined that no modifications were needed at any time. On the other hand, one agency responded with the need for modifications in the amount of anti-stripping agent for WMA.

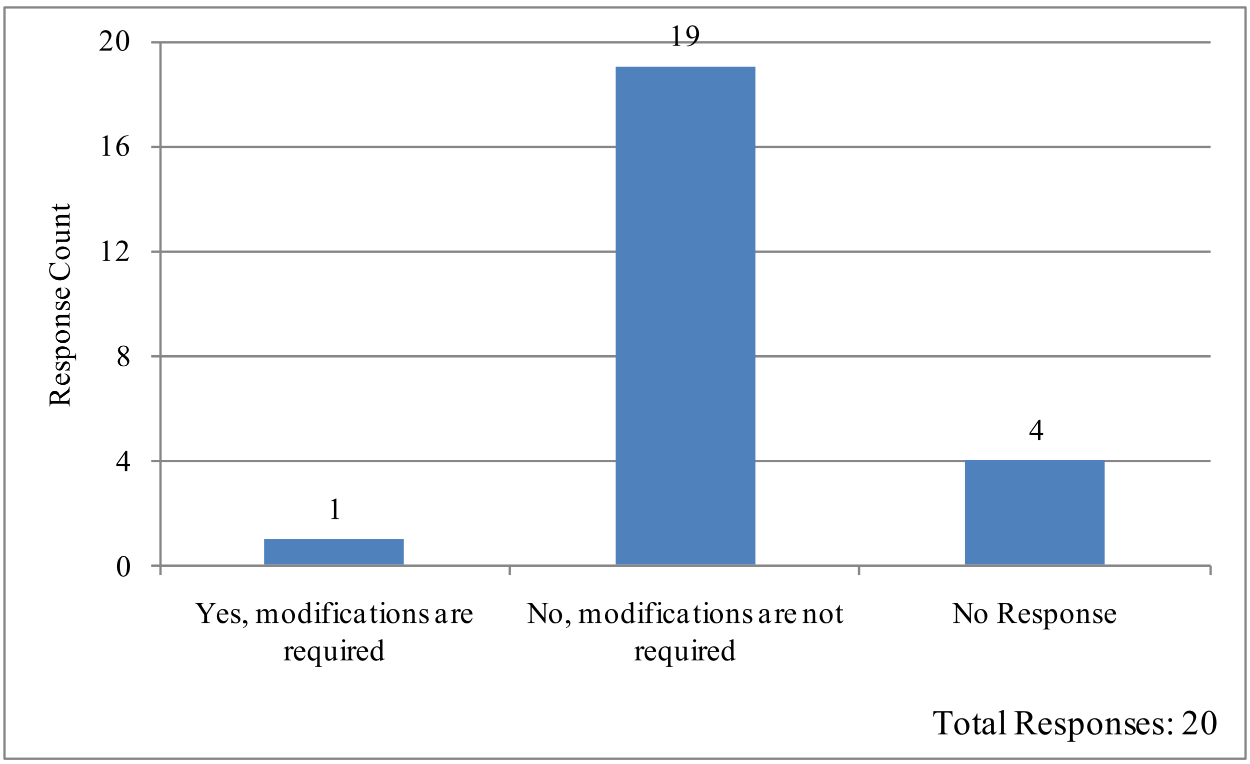

FIGURE 4.12 WMA requirements on anti-stripping agent compared to HMA

4.13 Question 13 - Mix Design - RAP and RAS Utilization in WMA

Q.13 For which of the following does your agency have different requirements (percentage/processing/testing) compared to HMA? Please specify in the comment box below.

Q.13 was directed to investigate the utilization of RAP (Reclaimed Asphalt Pavement) or RAS (Reclaimed Asphalt Shingles) in WMA, and whether there are different requirements as compared to HMA for their usage in terms of percentage, processing, and testing. As illustrated in FIGURE 4.13, for both RAP and RAS, the majority of responses indicated no need for any modifications. However, only two agencies answered with YES for modifications regarding RAP and RAS.

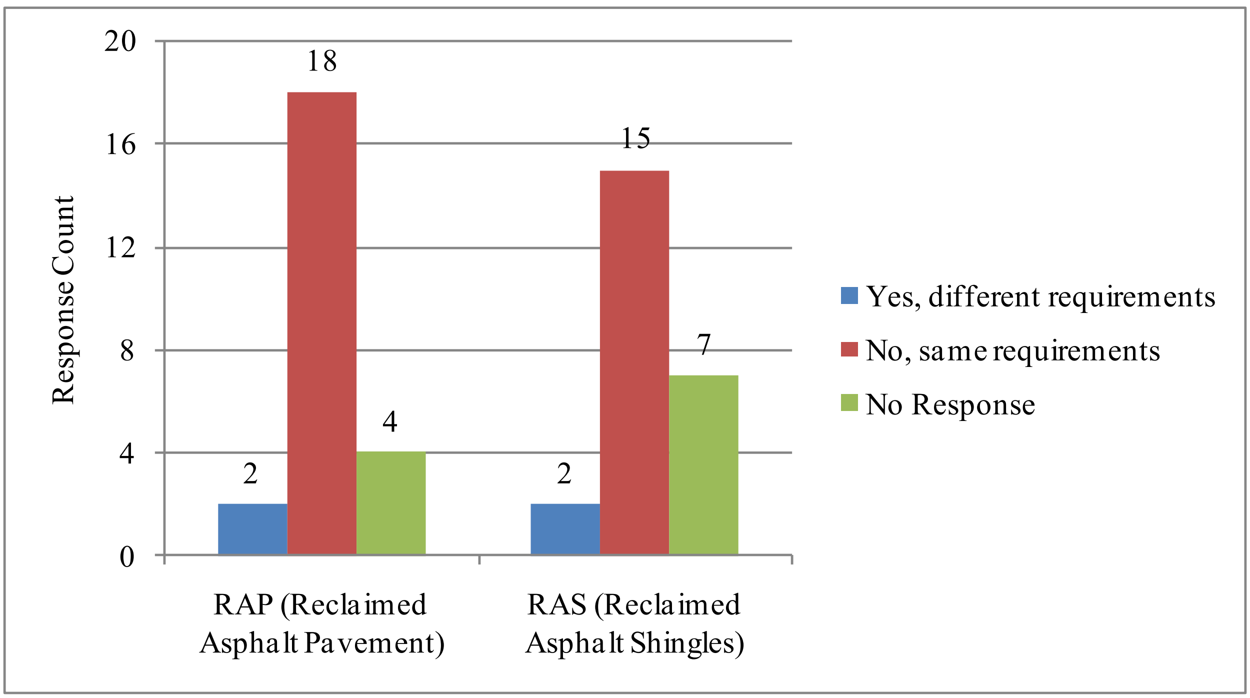

FIGURE 4.13 WMA requirements on RAP and RAS compared to HMA

4.14 Question 14 - Mix Design - WMA Mix Design Dependence on WMA Technology

Q.14 If Modifications are made, does the design for WMA depend on the WMA technology used? (if yes, please explain how)

In Q.14, discussion of the dependence of the WMA mix design on the WMA technology used is elaborated. As can be seen from FIGURE 4.14, nine of the respondents elaborated that no modification is needed. On the other hand, four of the respondents choose (YES) for the need of modification in mix design for the different WMA technologies utilized.

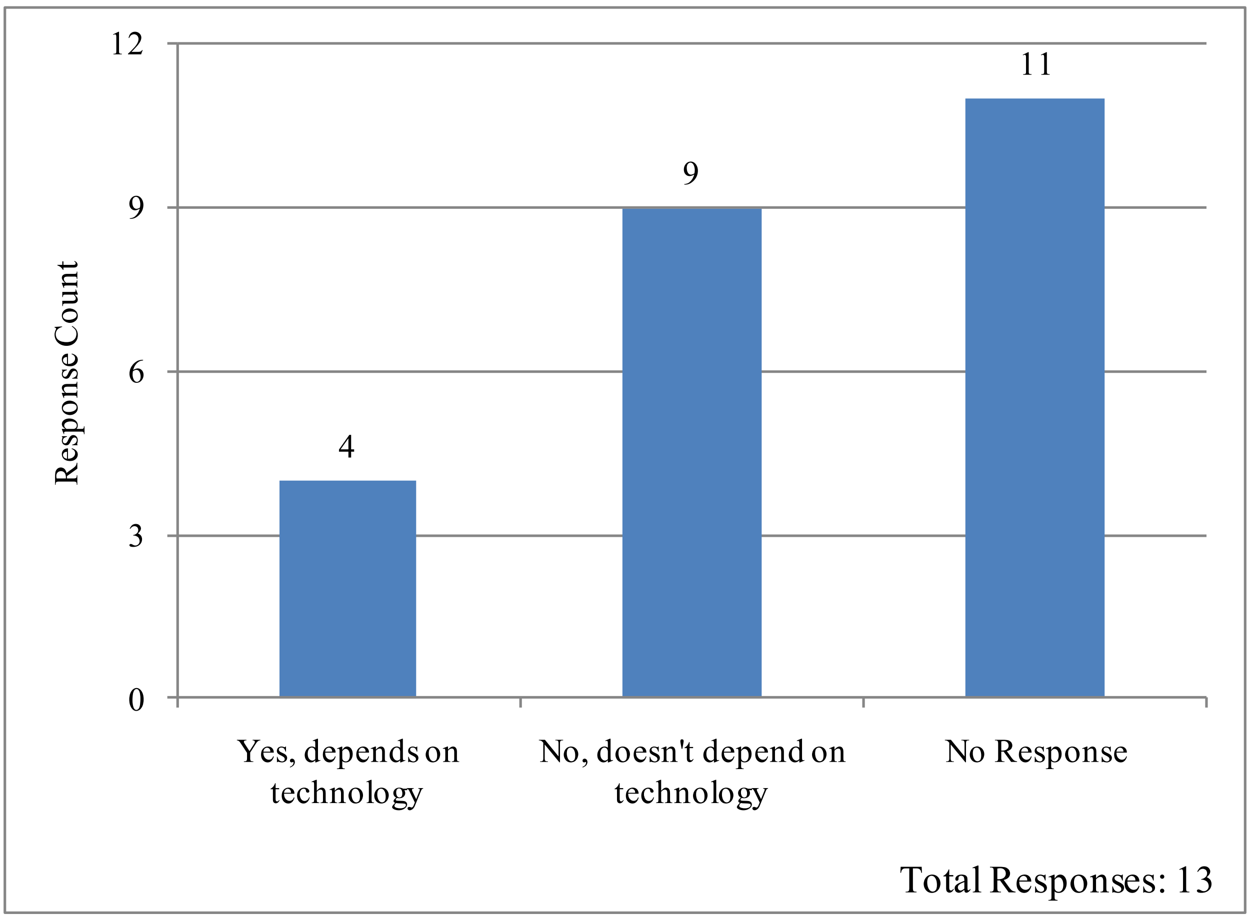

FIGURE 4.14 WMA design dependence on the technology employed

In the specification category, mechanisms for developing warm mix asphalt in agencies as well as the methods for development of specification or approval procedure for WMA within agencies are discussed.

4.15 Question 15 - Specifications - Agencies Mechanisms for WMA Development

Q.15 What are the mechanisms for developing warm mix asphalt in your agency? In the comment box, please provide your most recent documents/web links for each of the items below. (Either copy the web link(s) or email us the document)

In Q.15, it was requested to provide the mechanisms for developing WMA in the agencies and whether it is done through following; separate specification developed for WMA, approved list of processes, or an approval process for non-listed processes proposed. FIGURE 4.15 illustrates the response percent for this question. Montana (Helena), Minnesota (Maplewood), New York (Albany), Maine (Augusta), South Dakota (Pierre), Nebraska (Lincoln), and Iowa (Ames) all choose to have separate specification developed for WMA. Idaho (Boise), New Hampshire (Concord), New York (Albany), Colorado (Denver), Nebraska (Lincoln), and Kansas (Topeka) choose having an approved list of processes as the mechanisms for developing WMA. The third choice (approval process for non-listed processes proposed) was picked by the following agencies; Idaho (Boise), New York (Albany), Colorado (Denver), Nebraska (Lincoln), Manitoba, Canada (Winnipeg), and Kansas (Topeka), to be the mechanisms for developing WMA.

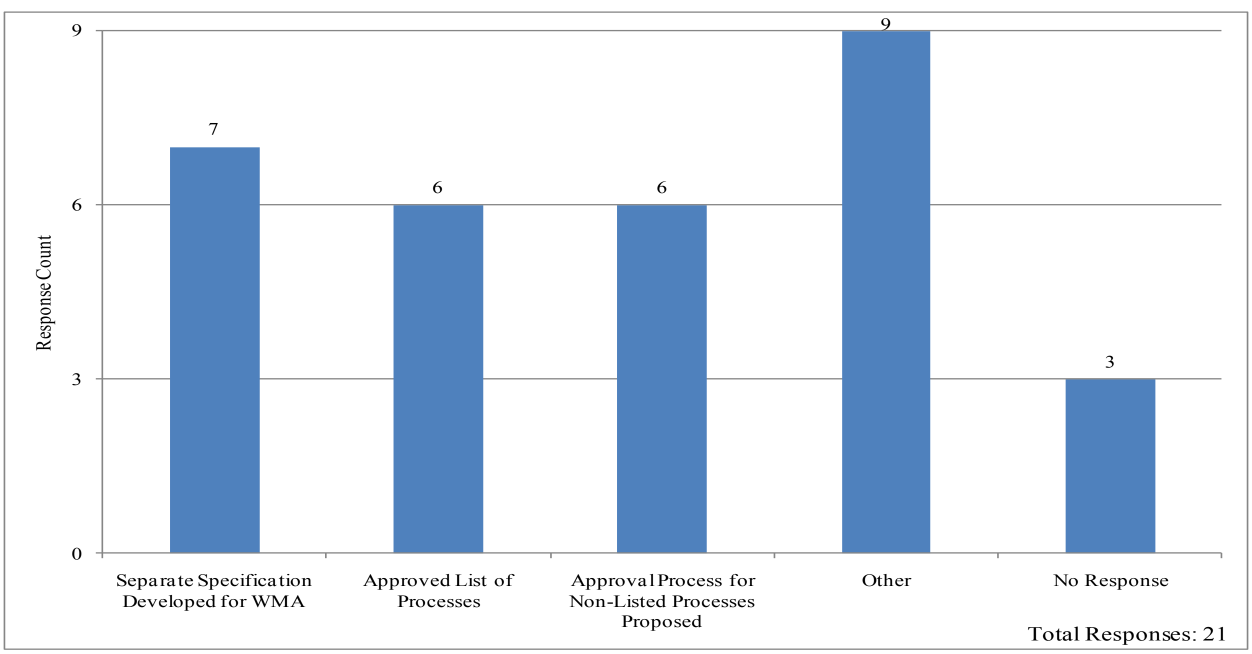

FIGURE 4.15 Mechanisms for developing warm mix asphalt in agencies

4.16 Question 16 - Specifications - Specifications or Approval Procedures Development

Q.16 How did you develop your agency specification or approval procedure? (in the comment box please specify the reference your agency used for the first two choices)

Q.16 discussed the methods for development of agencies specification or approval procedures. The respondents had to choose whether they developed their specifications or approval procedures based on national studies/guidelines (such as NCHRP reports), based on other DOTs specifications, or they developed them by their own. The response percent for this question is illustrated in FIGURE 4.16. Montana (Helena), Idaho (Boise), Minnesota (Maplewood), South Dakota (Pierre), Colorado (Denver), and Iowa (Ames) all choose to have their specifications developed based on national studies/guidelines (such as NCHRP reports). Montana (Helena), New Hampshire (Concord), Minnesota (Maplewood), South Dakota (Pierre), Nebraska (Lincoln) and Kansas (Topeka) choose developing WMA specification or approval procedures based on other DOTs specifications.

The following state agencies; Vermont (Montpelier), Washington (Olympia), Indiana (Indianapolis), Idaho (Boise), Minnesota (Maplewood), New York (Albany), Main (Augusta), South Dakota (Pierre city), Missouri (Jefferson City), Michigan (Lansing), Colorado (Denver), Nebraska (Lincoln), Manitoba (Winnipeg)-Canada, Utah (Salt Lake), Iowa (Ames), and Ohio (Columbus), all choose to have developed their WMA specifications or approval procedures by their own.

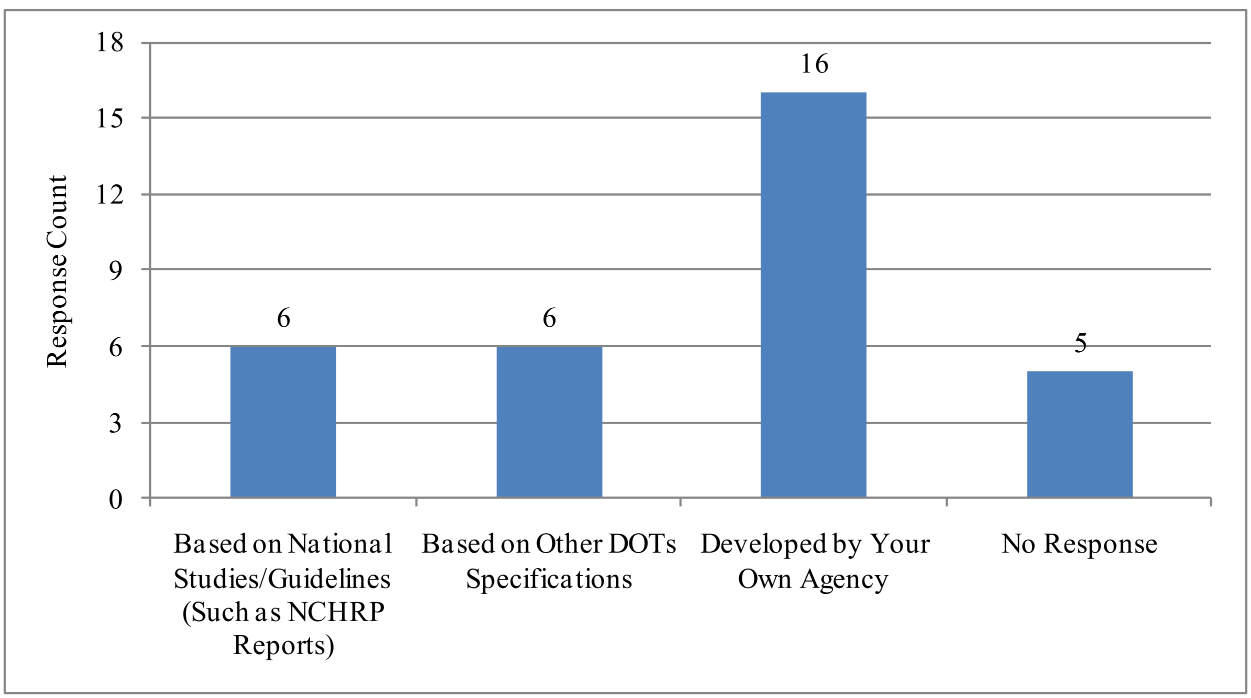

FIGURE 4.16 Development methods for specification or approval procedure in agencies

4.17 Question 17 - Specifications - WMA Non-Permitted Technologies or Additives

Q.17 Do you have a list of NOT PERMITTED (WMA technologies, additives, etc...) in any section of your specification? (If yes, please list the Not Permitted items in the comment box below)

The last question in the specifications category, Q17, was about having a list of not permitted (WMA technologies, additives, etc...) in any section of the agency specification. FIGURE 4.17 illustrates the response count for this question. As can be seen from FIGURE 4.17, all the respondents had no list of non-permitted WMA technologies, additives.

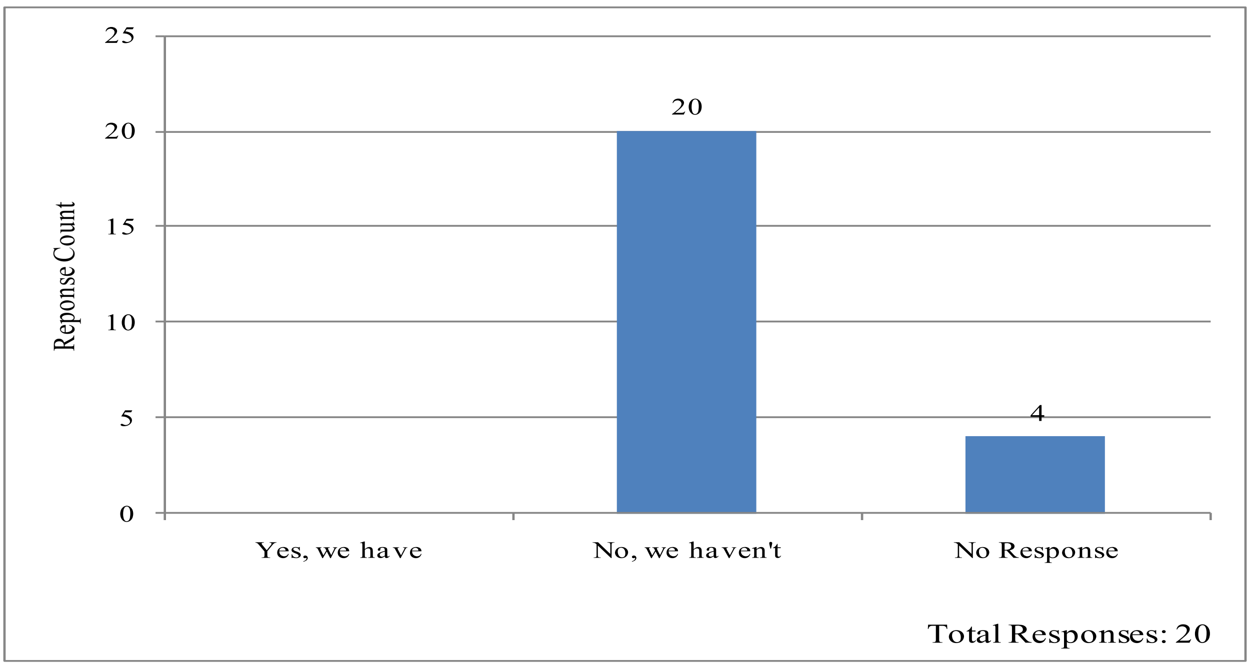

FIGURE 4.17 Agencies having any NOT-PERMITTED list in their specification

Under the acceptance plan category, questions concerning modifications in WMA acceptance plan components, temperature monitoring, sampling schedule for quality assurance, lab assurance testing, and quality control plan are covered.

4.18 Question 18 - Acceptance plan - WMA Acceptance Plan Modifications

Q.18 Compared to HMA, for which of the WMA acceptance plan components do you have modifications? Please explain in the comment box. Also, could you provide us with your agency acceptance plan for WMA (through web link, email, or hard copy).

Q.18 covers the WMA acceptance plan components modifications in terms of acceptance sampling type, quality characteristics, specification limits, quality level goals, risk, and pay factors as compared to HMA. As illustrated in FIGURE 4.18, no modifications were required by agencies for WMA acceptance sampling type, quality level goals, and risk as compared to HMA. Minor response count (one) was given for modifications in quality characteristics, specification limits, and pay-factors for WMA when compared to HMA.

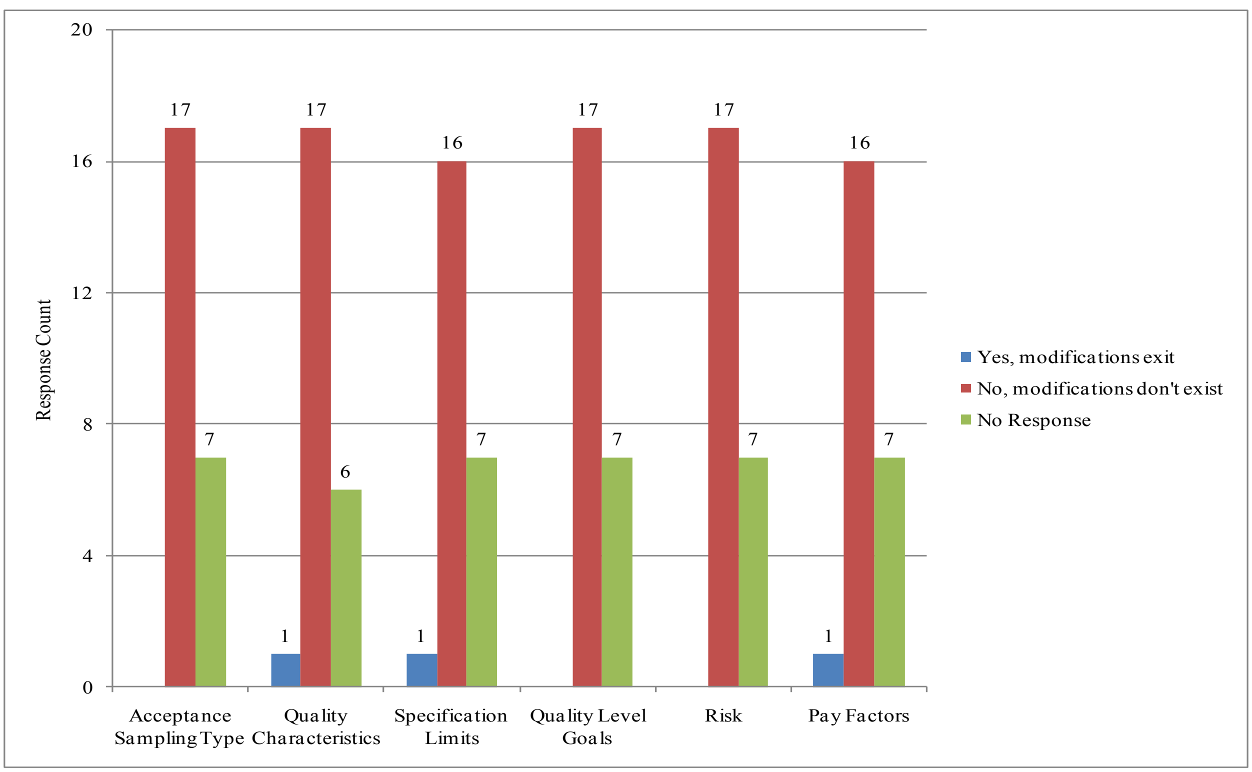

FIGURE 4.18 Modifications in WMA acceptance plan components compared to HMA

4.19 Question 19 - Acceptance Plan - WMA Modifications in Temperature Monitoring

Q.19 Compared to HMA, in which of the following do you have modifications in temperature monitoring for WMA? Please specify in the comment box.

In Q.19, modifications in temperature monitoring for WMA as compared to HMA in terms of mixing and construction or compaction were discussed. FIGURE 4.19 illustrates the response percent for Q.19. The majority of correspondents (11) identified no modification in temperature monitoring for WMA as compared to HMA for both mixing and construction or compaction. In terms of modifications in mixing temperatures, a response count of seven was calculated out of the respondents. On the other hand, a total response count of eight was calculated the respondents for choosing construction or compaction temperature monitoring modifications for WMA as compared to HMA.

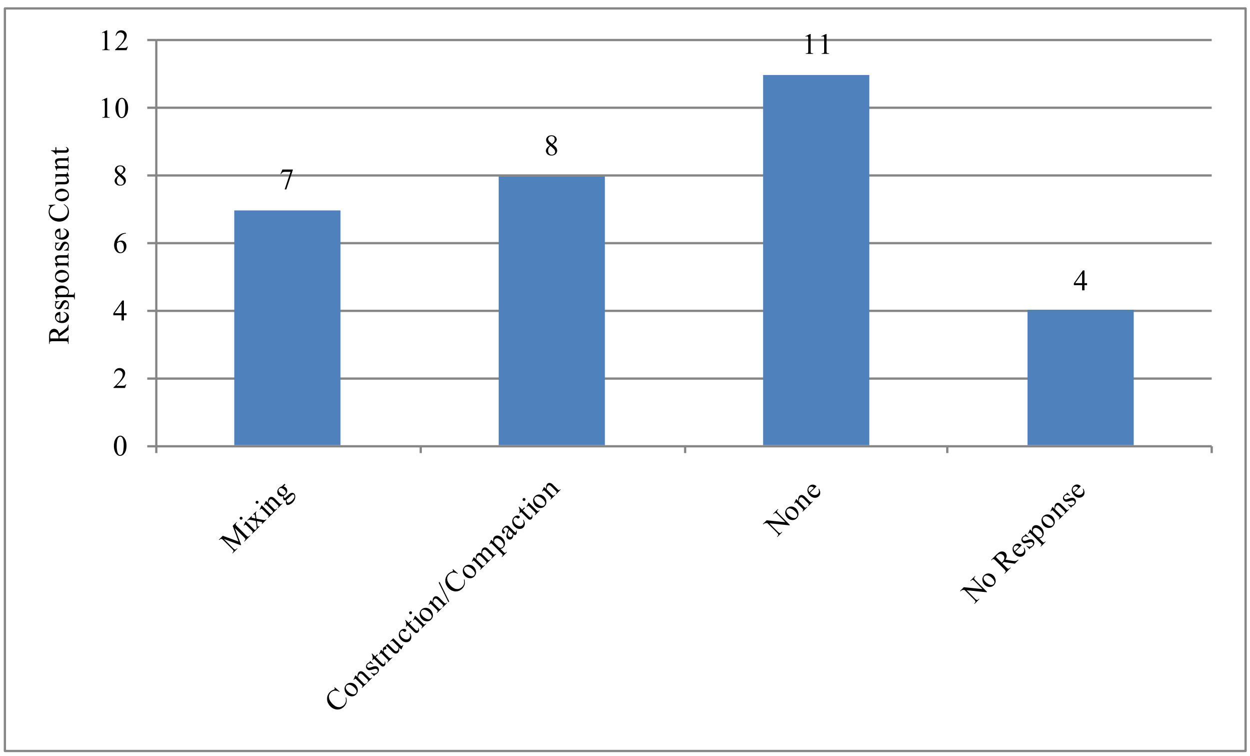

FIGURE 4.19 Modifications in temperature monitoring for WMA compared to HMA

4.20 Question 20 - Acceptance Plan - WMA Modifications in QA Sampling Schedule

Q.20 Is the WMA sampling schedule for quality assurance different from HMA? (If yes, please explain in the comment box)

Q.20 investigated whether there is a difference in the WMA sampling schedule for quality assurance as compared to HMA or not. As illustrated in FIGURE 4.20, the majority of correspondents (20) chose no difference in the WMA sampling schedule for quality assurance as compared to HMA. A total response count of one stated that there is a difference in the WMA sampling schedule for quality assurance as compared to HMA.

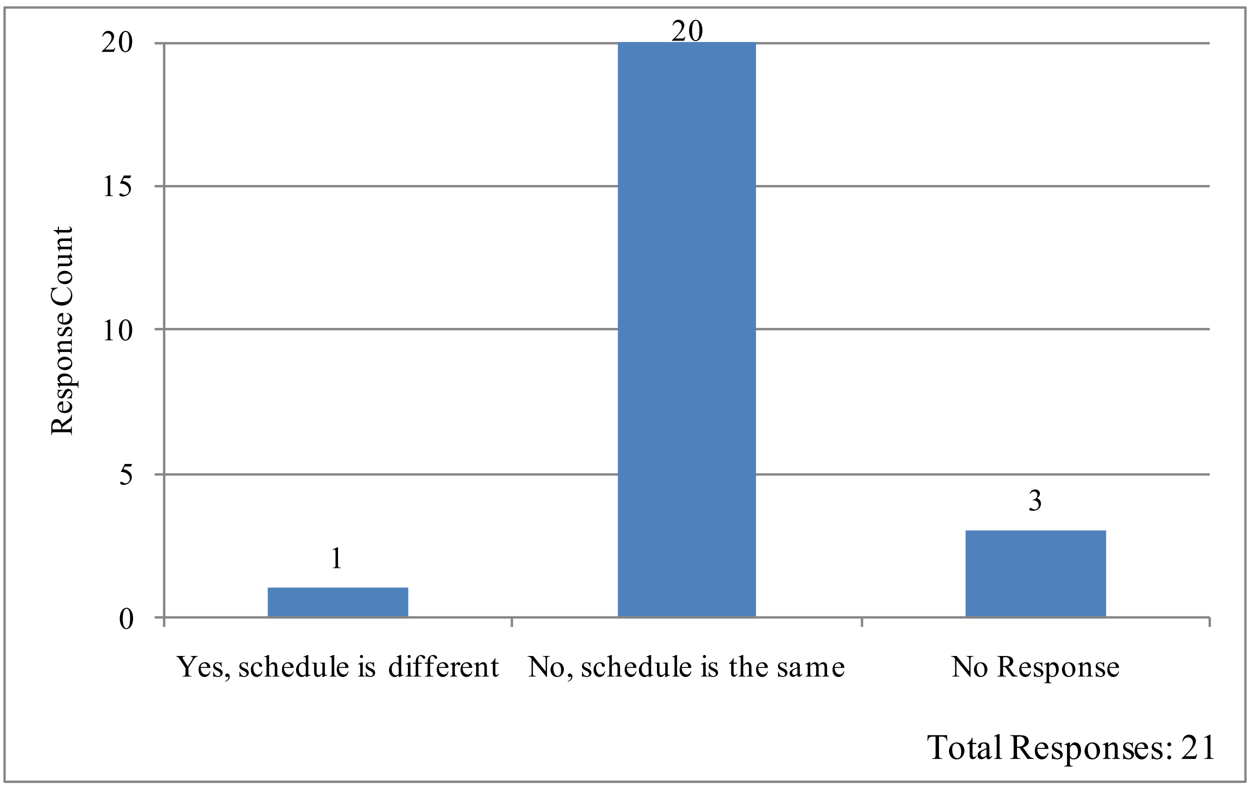

FIGURE 4.20 Changes in WMA quality assurance sampling schedule compared to HMA

4.21 Question 21 - Acceptance Plan - WMA Lab Assurance Testing Modifications

Q.21 For lab assurance testing, in which of the following do you have modifications compared to HMA? Please specify in the comment box.

Q.21 discussed the WMA lab assurance testing modifications as compared to HMA in terms of sample preparation and testing procedure. As shown in FIGURE 4.21, the majority of correspondents (13) identified no modification in WMA lab assurance testing as compared to HMA for both sample preparation and testing procedure. In terms of modifications in sample preparation, a response count of six was calculated out of the respondents. On the other hand, a total response count of three was calculated the respondents for choosing lab assurance testing procedure modifications for WMA as compared to HMA.

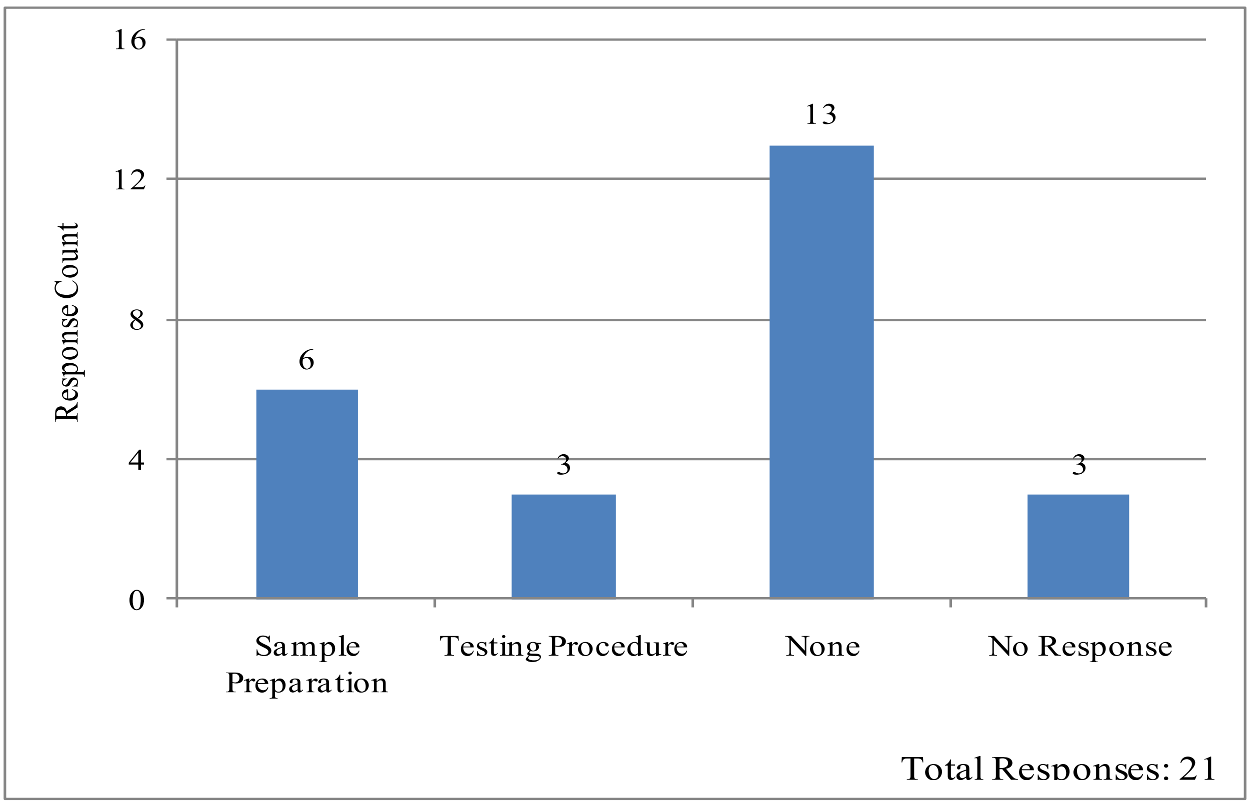

FIGURE 4.21 Modifications in lab assurance testing for WMA compared to HMA

4.22 Question 22 - Acceptance Plan - WMA Modifications for QC Plan

Q.22 Compared to HMA, does your agency have any modifications on Quality Control Plan? If yes, please explain in the comment box.

The modifications on quality control plan for WMA as compared to HMA is discussed in Q.22. FIGURE 4.22 illustrates the response percent of Q.22. The majority of respondents (17) replied that no modifications are required. A total response count of four replied that modifications on WMA quality control plan as compared to HMA is required. From those who replied for the need of modifications, Vermont (Montpelier) stated that it mandates that the quality control plan has a section on the WMA technology to be used, New York (Albany) mandates that the "Production, Testing and Compaction Details" document made by the WMA technology provider be followed by the mixer producer so as to ensure that everyone is utilizing the technology properly, Maine (Augusta) requests that the contractor has to determine the technology-specific production and placement temperature range, and finally, Missouri (Jefferson City) requests that the WMA temperature for mixing and compaction be specified.

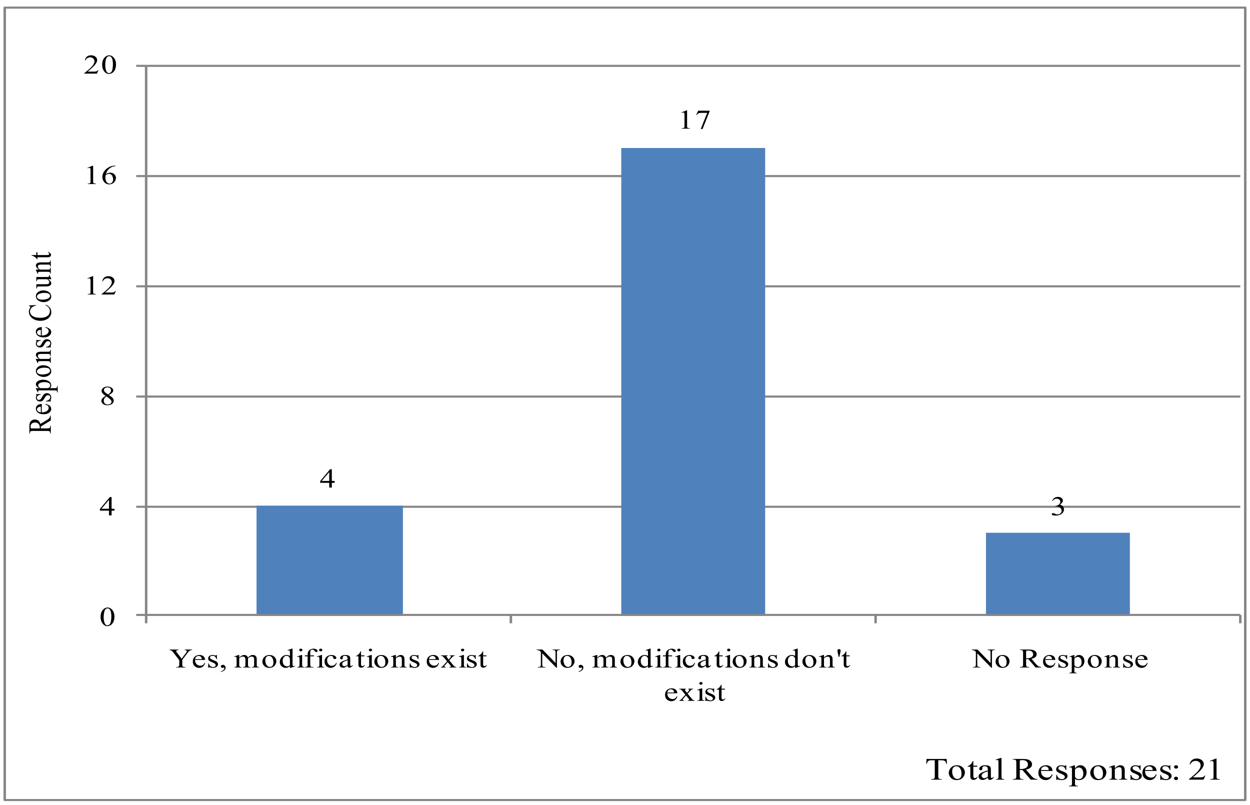

FIGURE 4.22 Modifications in WMA quality control plan compared to HMA

4.23 Question 23 - Acceptance Plan - Evaluation of WMA Construction Performance

Q.23 Do you use test sections to evaluate construction/performance of WMA technologies? If yes, what are the approval process and the tests?

As illustrated in FIGURE 4.23, 14 of the respondents responded by not using test sections for WMA construction/performance evaluation. Six of the respondents replied that they carry out test sections for the evaluation of construction/performance of WMA. From those who replied for the need of test sections for WMA evaluation of construction/performance, Saskatchewan (Saskatoon)-Canada commented that the approval for test sections is conducted on a case by case basis, with the tests including mechanistic testing of lab produced samples, some moisture susceptibility testing, and control sections established on WMA trials. New York (Albany) explained that they do allow trial sections to be built on NYSDOT roadways but do not require it to be limited to the state only. Their approval process allows trial sections to be built in other states, cities, counties, while following up with the project owner on performance and construction of trial section. Maine (Augusta) responded that they use HMA control-strips to compare performance of WMA. Nebraska (Lincoln) stated that they allow the use of both WMA and HMA on a project, requiring at least 1000 tons of each material be placed, and then evaluate the testing as what is done with HMA. They continue to monitor the road by visually evaluating it against HMA section. Manitoba (Winnipeg)-Canada explained that they perform distress survey of each test section for rutting, cracking, and ride quality. Finally, Iowa (Ames) responded that they use test strips for both HMA and WMA. Here, they verify that the density is being achieved with higher specification limits, and if compaction is not achieved, then a change in mix or rolling pattern may be needed.

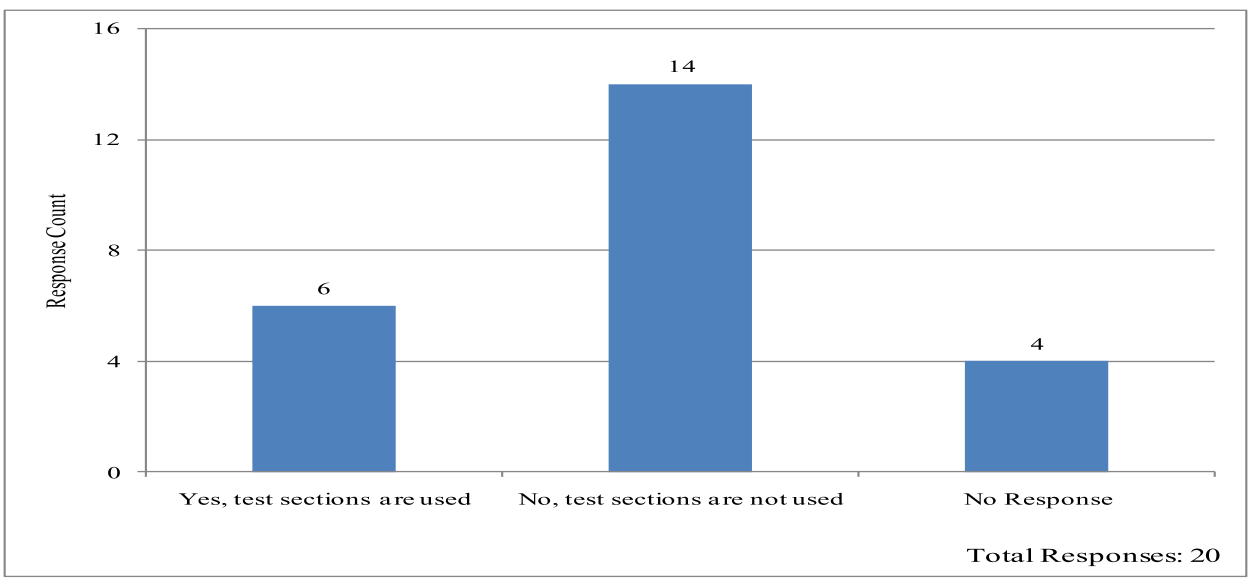

FIGURE 4.23 Use of test section for WMA evaluation

4.24 Question 24 - Acceptance Plan –Use of Non-Approved WMA Technologies

Q.24 In case of using non-approved technologies, additives, or modifiers by the contractor, what would be the agency action? Please explain in the comment box.

Q.24 investigated the measures taken by the agencies if non-approved technologies, additives, or modifiers are used by the contractor. As illustrated in FIGURE 4.24, the majority of respondents replied that they would reject the project (11), whereas only two of the respondents replied that they would accept the project, but with penalty. Six agencies replied by taking other actions.

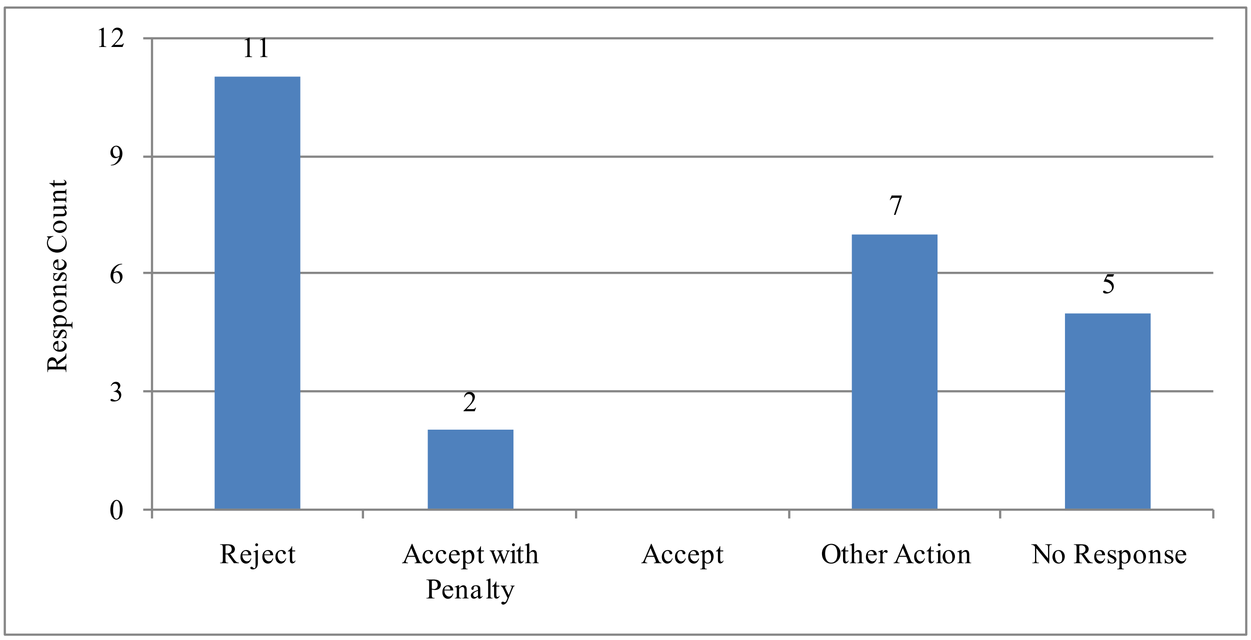

FIGURE 4.24 Agency action in case of using non-approved items by the contractor`

5 SUMMARY AND RECOMMENDATIONS

A main concern in this study was to look at what steps other DOTs have taken in reaching their current status so that NDDOT could also follow the same route. The project conducted literature study and collected data on the materials, construction and performance of WMA in neighboring states to determine the additives and processes that would perform the best on NDDOT projects. Specific changes to current specifications and acceptance plans must follow manufacturer directions, lab testing, and field trials and performance.

5.1 Summary of Survey

In the first category of the survey questions that dealt with the general experience of the agencies with WMA, the increase of WMA additives cost was deemed disadvantageous; however, some agencies identified foaming processes as appealing because they require only the initial cost of installation. The potential added cost of anti-stripping agents associated with WMA technologies, except for Evotherm™, was another disincentive against WMA. On the other hand, reductions in costs associated with fuel and plant wear when utilizing WMA were advantageous. Distresses, such as early rutting as a result of uncertain optimum bitumen ratio and increased moisture sensitivity due to incomplete drying of aggregates, were other disadvantages for WMA. In terms of average yearly production of WMA compared to HMA, WMA yearly production ranged from 20% to 5% of their HMA yearly production for most of the agencies participating in the survey, except for South Dakota (Pierre) and Washington (Olympia). In terms of bidding cost, the agencies responses showed variability in the increase of the bidding cost of WMA as compared to HMA within a range of 5 % to 20%. Such variability could be attributed to the different WMA technologies employed, that either requires additives or modifications to the plant itself. In terms of the agencies' preferred WMA process, foaming and chemical processes were both favored. According to the agencies responses, foaming installation costs are considered as a one-time annualized cost that can be compensated through decreased fuel usage. In addition, water will evaporate out of the mix and leave the asphalt intact with the least potential for changing asphalt properties. This would also be easier for a contractor to install on his hot plant, while providing increased film thickness and compaction. For chemical processes, it is favored as it can act as adhesion promoter, as well as a compaction aid. In addition, the ability to replicate the chemical process in the lab, which is not possible for the foaming process, is also an advantage. Other advantages of chemical processes include its anti-strip capabilities, and the fact that it allows the utilization of higher percentages of RAP and RAS.

For the technology category in the survey, Evotherm™ was, by far, the most utilized chemical process amongst agencies. Generally, a 40-60ºF temperature reduction was associated with the utilization of WMA chemical processes, and moisture damage was the most significant distress encountered. For foaming processes, the most employed technologies are the Double Barrel® Green, AQUABlack™, and Terex® WMA. However, lower ranges of temperature reduction were achieve for such technologies ranging at about 20-40ºF. In the organic additives, Sasobit® is the most utilized technology. Temperature reduction ranges between 20-40ºF. It is worth mentioning that amongst the three main technologies; chemical, foaming, and organic additives, the foaming processes were the most employed technology in agencies.

In the mix design category, in terms of WMA materials selection, the majority of agencies would treat WMA as HMA. Some modifications; however, would be implemented on the type of anti-stripping agents and the utilization of RAP or RAS. In another approach, the implementation of NCHRP 9-43 (Mix Design Practices for Warm Mix Asphalt) report recommendations, in terms of using proposed compaction temperature in the binder grade selection depending on the aging index, were utilized. In terms of modifications for the WMA binder selection, generally, no modifications were applied by agencies, except for adjusting the binder content for reduced absorption. In terms of WMA design aggregate structure, no modifications were recorded for any agency. As for the WMA lab performance tests, the only modifications were for the case of moisture sensitivity's specimen preparation and testing, where some agencies require that the specimens be fabricated with the WMA technology expected to be utilized. In addition, lower compaction temperatures are employed to make the testing samples. For the modifications in the amount of anti-stripping agent, no modifications are required for WMA utilization by most of the agencies. In some agencies, a 1%-1.5% lime is required, regardless of the mixing temperature employed. For the utilization of both RAP and RAS, the requirements for both WMA and HMA are generally the same, except for some agencies where RAP may be permitted for HMA, but not for WMA. Based on most of agencies feedback, WMA mix design does not depend on its technology, with the exception of some agencies that elaborated that, for WMA, all additives need to be included in the specimen fabrication, and mix design needs to be submitted for the specific WMA technology utilized.

For the acceptance plan category, WMA has no modifications as compared to HMA, except in some cases that entail differences on laboratory compaction temperatures, or modifications to mixing and placement temperatures as determined by the manufacturer recommendations. In terms of the modifications in temperature monitoring for WMA, although no changes are associated with the monitoring procedure of temperature as compared to HMA, lower temperatures are employed for cases of WMA. Thus, a threshold temperature is normally set, below which a drop in temperature is not permitted. In terms of WMA sampling schedule, no modifications are required as compared with HMA. IOWA (Ames) exceptionally requests all WMA mixes designed for above three million ESALS be tested under AASHTO T 283 (Resistance of Compacted Asphalt Mixtures to Moisture-Induced Damage), while for HMA it is only a requirement when utilized in interstates and quartzite mixes. For lab assurance testing, modifications in WMA sample preparation and testing procedure are mainly employed towards the utilization of lower compaction temperatures. Generally the WMA mixing and compaction temperatures are recommended by the WMA technology provider.

5.2 Summary of WMA Specifications

5.2.1 Based on Literature

In Colorado, WMA is considered as a Non-Standard Asphalt Mix (NSM) technology. Plant temperatures more than 100°F below existing HMA Superpave mixing temperatures are not allowed for the production of WMA. In case of utilizing more than 20% RAP in WMA mixtures, the plant production temperature must be greater than the documented grade of the "as recovered" RAP binder.

In Idaho, acceptance of test strip requires two additional tests for WMA, namely immersion compression and rutting susceptibility (APA).

In Illinois, modifications employed to WMA can be summarized in terms of Mix Design Verification, Quality Control/Quality Assurance Testing, and Construction Requirements.

In Indiana, WMA, can be employed utilizing water injection foaming devices for ESAL category 1 (<300,000 ESALS), 2 (300,000 to<3,000,000 ESALS), and 3 (3,000,000 to <10,000,000 ESALS) mixtures only.

In Iowa, WMA production temperature should be kept between 215ºF (102ºC) and 280ºF (138ºC) until placed on the grade. WMA mixtures should not be produced at temperatures 10ºF (5ºC) below the target temperature. Compacted WMA field samples should be transported to the laboratory at 240ºF (115ºC). If RAP or RAS are utilized with percentages higher than 20% but less than 30% of the total binder, the designated high temperature binder grade would be intact.

Kansas requires a prequalification process for WMA technologies that the contractor has to pass before using a new technology, otherwise the contractor can select from a pre-approved list of processes which is updated and evaluated based on the field performance.

Michigan has a special provision for water-injection foaming devices, which requires the lab testing temperatures to be based on suppliers' recommended value and a daily asphalt binder sample. The sample should be taken from a point where the water or water foaming additive is added, and the point where the binder is added to mixture.

NYDOT special provision requires the technologies that are used by contractors to be from the approved list of processes developed by them or be approved by the Engineer prior to application. It is mandatory to submit WMA design 14 days prior to construction for verification. Tests results of both the HMA and WMA samples using one of the three methods allowed by the DOT (Asphalt Pavement Analyzer (APA), Hamburg Wheel Track (HWT), and Asphalt Mixture Performance Tester (AMPT)) should be prepared and sent to DOT. The final decision of the WMA is done by the director of Materials Bureau.

In Ohio, a special provision for WMA requires a sampling valve at the injection equipment to sample the binder before spraying for foaming processes. The mixing plants should be pre-approved by the agency.

Oregon has a special provision for WMA, wherein they allow contractors to use WMA in all lifts. The contractors are allowed to choose from a previously approved list of WMA processes, or in case of non-approved processes, their proposed technology should be approved by the Engineer. Recycled asphalt shingles cannot be used in WMA mixes with minimum compaction temperatures less than 260°F.

South Dakota has a special provision to quality control/quality assurance specification for WMA produced for a field trial section. WMA additives shall be added based on the manufacturer's suggestion, and changes in job mix formula shall be verified in writing by the Bituminous Engineer. Modifications are made for air voids, in-place density, and pay factor. For air voids, the modified test temperature is determined based on the production and compaction temperature of the trial section. For density, the field results are compared to the applicable lower specification limits for the class of mix produced. Placement and compaction temperature cannot drop below 140°F (60°C).

According to the Washington specifications, contractor should submit a WMA submittal to the state engineer for approval. The only requirement on the specification for WMA is that the temperature shall not exceed the maximum recommended by the manufacturer.

5.2.2 Based on Survey Responses

In binder content and selection for mix design, only Iowa, Nevada, and South Dakota have modifications compared to HMA in which the emphasis is on adjusting binder content for reduced absorption. In aggregate selection and structure design, none of the agencies have modifications compared to HMA.

Regarding use of anti-stripping agents, none of the agencies have any modifications compared to HMA, except Nebraska. Currently, they require 1.0% lime by weight of virgin aggregate. They require that TST on WMA sample be more than 80%

Considering use of RAP or RAS, most agencies have no difference in their HMA and WMA specifications. In Montana, RAP is allowed in HMA but not WMA. Michigan has also stated that their requirements on RAP and RAS are different, but has not stated how.

Of the studied 21states, none have any modifications to the acceptance plan, as compared to HMA. In sampling for quality assurance, none of the states have any changes compared to HMA except Iowa. They only sample T283 for HMA on interstates and quartzite mixes. However, they sample T283 for all WMA.

In lab testing, of the 21 respondents, 13 had no changes in their lab test (either in "sample preparation" or in "testing procedure"). Of the eight agencies that responded positive to this question, all stated lower compaction temperature (based on the type of WMA technology) in sample preparation as the main modification. Idaho has an additional AASHTO T-165 test done with plant produced material for foamed WMA. Iowa stated that they test all the assurance samples at 240°F, regardless of WMA technology.

In quality control plans, only three agencies stated that they have modification compared to HMA. Maine and Missouri stated that it is up to contractor to determine production and placement procedure specific to the technology they use. New York requires a submission of a "Production, Testing, and Compaction Details" document.

5.3 Recommendations for WMA Implementation in North Dakota

5.3.1 NDDOT WMA Selection or Approval Process

Most DOTs develop their own list of approved WMA technologies. Not all technologies would succeed in ND considering extreme weather conditions as well as different petroleum resources. It is recommended that a short list of approved processes be developed that consists of those processes most frequently used in ND that have had acceptable performance. The list shall be updated on a routine basis. New technologies that have been successful in other states can be evaluated on a limited basis with the assistance of research effort. NAPA has had many pilot studies done in this regard whose publications could be used as a starting point subjected to further evaluation. It is recommended that NDDOT base their selection of approved processes on local evaluation including lab and field testing. Appendix C of the final report provides approved list of processes of all states that have such list.

Additional specification requirements shall be added for each approved technology/additive based on local evaluation. As will be discussed later, the following areas will require testing modifications: temperature acceptance, moisture susceptibility, and binder selection. Further research will indicate the details of needed mix design modifications including lab mixing and compaction temperatures and aging requirements. Considering the fact that new technologies and methods of WMA production are coming out each year, developing an approval procedure for new WMA technologies is recommended. Samples of other states approval process are attached in Appendix C of the report.

The trade-off between cost and performance among different WMA technologies must be based on life-cycle-cost analysis that is based on long-term performance monitoring of different WMA technologies. Added cost of WMA is based on contractors' practices and decisions to use specific technology/equipment. At this time, a suggestion by a contractor to use a specific technology may not be acceptable because NDDOT must first adopt practices and specifications for WMA technologies.

5.3.2 Additives or Processes Appropriate for Use on NDDOT Projects

Most DOTs have had experiences with foamed processes and chemical additives while use of organic additives has been limited. DOTs of North states are at early stages of experimenting WMA and in most cases they have minimum modifications in their WMA specs and testing compared to HMA and are mainly following manufacturer's recommendation. The suggestions of NCHRP 691 study on WMA mix design are mostly directed toward agencies' preferences and implementation based on local testing and experiments. NDDOT experience with foaming technologies will be expanded with future new projects. It is too early to judge which process seems to be more suitable.

The following recommendations are made based on the survey results: the results of survey show foaming processes are most favored (among which Double Barrel Green is the most widely used) and after that are chemical processes (with Evotherm being mostly used). This could be a good starting point for NDDOT although the importance of local testing and evaluation in the actual climatic condition cannot be neglected; the advantage of using the Double Barrel and Evotherm is that as long as other DOTs are years ahead in laying down their WMA sections, updates of the performance of other projects could be of use for NDDOT.

5.3.3 Specification Changes to Account for Differences in Production and/or Placement of WMA as Compared to Hot-Mix-Asphalt

This study provides details current WMA specifications and documents experience of other states in implementing WMA technologies. Following the survey conclusions that most states do not require additional testing for WMA projects as compared to HMA project, no immediate changes to current acceptance testing are recommended. But specific concerns are considered for future WMA implementation. The main items of concern of WMA future specifications that must be evaluated based on local conditions are: (1) temperature control, (2) moisture sensitivity, and (3) selection of binder grade. A key element in WMA future implementation is testing applicability for production and acceptance quality. Special effort should be directed to the verification of the applicability of current HMA testing on WMA mixes. There is also the possibility of conducting local testing to verify characteristics of new technologies and requirements for new specifications.

Specific changes to current specifications and acceptance plans must follow manufacturer directions, lab testing, and field trials and performance. Research at the early stages of WMA implementation would evaluate the steps and practices by other DOTs in using manufacturer's recommendation in mix design and construction. Lab studies on mix design and evaluation at lowered temperatures will help evaluate different technologies and additives. Comparisons of mix performance of different additives, for example moisture susceptibility, in the lab will help verify/develop special requirements and specifications for WMA as compared to HMA specifications. Testing equipment shall not be altered or changed as long as all DOTs are using the same testing equipment they use for HMA. The same note is advised in NCHRP 691, but some of the requirements could be modified such as TSR acceptance values.

Based on the survey results and the review of current research, selection of WMA binder grades may need revisions, particularly for softer binders that will not be aged enough during the mix production and construction stages. Moisture susceptibility testing and acceptance criteria will be close to that of HMA but more restrictive. NCHRP study also showed that HMA and WMA performance were similar and not much modification is required. What is inevitable is the construction of test sections and the running of lab experiments on selected WMA technologies that are to be implemented. Projects with high traffic are more likely to have modified binder grading but considering current knowledge there is not enough information to recommend changes related to moisture testing requirements. The survey suggests that anti stripping or lime is being used by most agencies.

It is recommended to take one step at a time and not to rush into using RAP and RAS as long as full performance of WMA using conventional ingredients is not fully understood. Although RAP use shall not be neglected in pavement projects due to environmental and sustainability concerns, it is not beneficial to add another element to our experiment that increases the complexity. It is also recommended that NDDOT sponsor well designed experiments and extensive lab research on the performance of WMA constructed using local aggregates and laid in ND climate.

Appendix H provides additional recommendations based on the NCHRP 691 study that can help in future WMA implementation in North Dakota.

5.4 Recommendations for Future Research

The widespread demand for Warm Mix Asphalt in North America requires more in-depth information on materials, additives, testing plans, and mix design considerations. As discussed earlier, additional testing requirements are recommended in the following areas: temperature acceptance, moisture susceptibility, and binder selection. Further research will indicate the details of needed mix design modifications including lab mixing and compaction temperatures and aging requirements. Additional studies are recommended in the following areas:

5.4.1 Applicability of HMA Testing on Warm Mix Asphalt

The objective of the proposed study is to examine the applicability of current hot mix testing, including Superpave testing, on warm mixes and the potential to characterize moisture susceptibility accurately. Laboratory study to evaluate the moisture susceptibility of plant-produced warm mix asphalt (WMA) is proposed. WMA mixture samples will be obtained at asphalt plant and compared to hot-mix asphalt (HMA) samples through laboratory performance tests. In addition to traditional AASHTO T283 freeze and thaw (F-T) and tensile strength ratio (TSR), Superpave indirect tension (IDT) tests, dynamic modulus test, Asphalt Pavement Analyzer (APA), and Hamburg wheel tracking test are recommended to evaluate asphalt mixtures subjected to F-T moisture conditioning.

5.4.2 Comparison of Moisture Susceptibility of Warm-Mix Asphalt Technologies

The objective of this study is to compare the moisture susceptibility of the two widely used warm-mix asphalt (WMA) approaches: foaming and emulsion technologies. It is recommended that the study evaluates the constructability of both technologies through monitoring trial pavement sections of the two WMA technologies and their hot-mix asphalt (HMA) counterpart. Plant-mixed loose mixtures from the field will be collected at the time of paving and will be evaluated in the laboratories by conducting various experimental evaluations of the individual mixtures. Recommended testing includes AASHTO T283 freeze and thaw (F-T) and tensile strength ratio (TSR), Superpave indirect tension (IDT) tests, dynamic modulus test, Asphalt Pavement Analyzer (APA), and Hamburg wheel tracking test. The testing will be focused on susceptibility of WMA to moisture conditioning as compared to the HMA controls. Early-stage field performance data will be collected for years after placement to confirm rutting and cracking performance from both the WMA and HMA sections, and that field data agree with laboratory evaluations.

5.4.3 Laboratory Evaluation of Warm Mix Asphalt containing High Percentages of RAP

The objective of this study is to evaluate the rutting resistance, moisture susceptibility, and fatigue resistance of warm-mix asphalt (WMA) mixtures containing high percentages of reclaimed asphalt pavement (RAP) through laboratory performance tests. WMA mixtures can be plant produced, with selected foaming technologies in the US. RAP content will range from 0 to 60%. Laboratory performance tests include asphalt pavement analyzer (APA) rutting test, Hamburg wheel tracking test, tensile strength ratio (TSR) test, Superpave indirect tension (IDT) tests, and possibly, beam fatigue test. WMA mixtures will be compared to HMA mixtures containing same RAP contents.

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APPENDIX A - SURVEY FORM

Warm Mix Asphalt Survey for North Dakota

Introduction, Contact Details and Legal Notice

The purpose of this questionnaire is to gather information from DOTs regarding their experiences with WMA and the specifications they use for WMA projects. The result of this questionnaire will help the research group in development of a guideline for process approval and specification for WMA projects in North Dakota.

Introduction

The use of Warm Mix Asphalt (WMA) allows savings in energy usage. This is achieved through foamed asphalt or through the use of additives to reduce asphalt apparent viscosity at the low mixing temperature and to improve the workability of the mixture, so that asphalt coats aggregate efficiently. WMA has the potential of efficient compaction, reduced thermal segregation, and extended service life. However, concerns related to the mixing processes and additives used in the WMA production exist. For example, the potential for moisture damage and early rutting may be higher because aggregate may not be sufficiently dried. To fully understand WMA, many research projects are under investigation. At the same time, the experience obtained from actual projects is of great importance and could lead to valuable insight to performance of WMA, which is the aim of this study.

Contact Details

NDSU research group would be more than happy to receive your emails or calls if you have any questions or would like to submit any documents or information related to the survey.

NDSU Contact
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Email: m.abdelrahman@ndsu.edu

Legal Notice

By participating in this survey you are giving permission to the research group to use your questionnaire results in their analysis and publish the results. The information obtained from this survey is considered as NDDOT property and can be published or re-produced in any format and in any media.

Page 1

Warm Mix Asphalt Survey for North Dakota

General Observation

1. Compare WMA to HMA in the following categories based on your agency experience. Please explain your choices in the comment box.

	Advantageous	Same	Disadvantageous
Bidding	○	○	○
Contractor's Willingness	○	○	○
Constructability	○	○	○
Performance	○	○	○
Maintenance	○	○	○
Cost	○	○	○

Comments

2. How much was the WMA and HMA approximate production (tonnage/year) based on the average of last 5 years?

3. How is WMA bidding cost compared to HMA?

	%	More/Same/Less
WMA bidding cost is		

4. What is the approximate range of additional costs ($/ton) for WMA production at:

4.1 Cost of Additives

Refinery

Field Location

4.2 Total Cost Including Processing

Refinery

Field Location

Page 1

Warm Mix Asphalt Survey for North Dakota

5. Is it possible to provide information/data/documentation for some of your agency projects/experiences with WMA? (please provide it through web link, email, or post)

6. If you had to pick one WMA process, what would it be? Please explain why.

Warm Mix Asphalt Survey for North Dakota

Technologies

7. For each of the three main processes below please specify the followings:

In how many of your agency projects was the technology implemented?

How much reduction in mixing temperature could you achieve compared to HMA projects?

Have you observed moisture damage and/or rutting on your warm mix projects? If yes, in how many projects did you observe them? If there were other distresses, please list them in the comment box.

7.1 ~~~ CHEMICAL PROCESSES ~~~

	Number of Constructed Projects	Mixing Temperature Reduction Achieved (F)	Number of Projects with Moisture Damage	Number of Projects with Rutting
CECABASE® RT				
Evotherm ™				
HyperTherm™/QualiTherm				
Rediset™WMX				

Please list other technologies and/or other distresses not listed above

Page 4

Warm Mix Asphalt Survey for North Dakota

7.2 ~~~ FOAMING PROCESSES ~~~

	Number of Constructed Projects	Mixing Temperature Reduction Achieved (F)	Number of Projects with Moisture Damage	Number of Projects with Rutting
Accu-Shear™				
Advera® WMA				
AQUABlack™ WMA System				
AquaFoam				
Aspha-Min®				
Double Barrel® Green				
Eco-Foam II				
LEA (Low Emission Asphalt)				
Meeker Warm Mix				
Terex® WMA System				
Tri-Mix Warm Mix Injection System				
Ultrafoam GX2™ System				
WAM Foam				

Please list other technologies and/or other distresses not listed above

7.3 ~~~ ORGANIC ADDITIVES ~~~

	Number of Constructed Projects	Mixing Temperature Reduction Achieved (F)	Number of Projects with Moisture Damage	Number of Projects with Rutting
Asltech PER®				
Sasobit®				
SonneWarmix™				
Thiopave™				
TLA-X™ Warm Mix				

Please list other technologies and/or other distresses not listed above

Page 5

Mix Design

8. In your WMA Material Selection, which of the items below has been modified compared to HMA mix design? (please explain in the comment box)

- [ ] Binder Selection
- [ ] Aggregate Properties
- [ ] Volumetric Parameters (VMA & VFA)
- [ ] Recycled Asphalt Pavement (content/gradation)
- [ ] Additives (types/percentage)
- [ ] No Modifications of Any Items

Comments

9. In your WMA Binder Selection, which of the items below has been modified compared to HMA mix design? (please explain in the comment box)

- [ ] Binder Content
- [ ] Binder Grade
- [ ] Binder Preparation/Testing
- [ ] No Modifications of Any Items

Comments

Warm Mix Asphalt Survey for North Dakota

10. In your WMA Design Aggregate Structure, which of the items below has been modified compared to HMA mix design? (please explain in the comment box)

Add "Aggregate Sources" and "Other Aggregate Properties, Please specify in the space below"
Remove "Aggregate Patching, Aggregate Mixing, Aggregate Conditioning, Volumetric Parameters"

- ☐ Aggregate Sources
- ☐ Nominal Maximum Aggregate Size
- ☐ Trial Gradations
- ☐ Aggregate Compaction
- ☐ No Modifications of Any Items

Other Aggregate Properties. Please specify in the space below

11. In your WMA Lab Performance Tests, which of the testing below has been modified compared to HMA mix design? (please explain in the comment box)

	Specimen Preparation	Testing and Procedure
Rutting	☐	☐
Thermal Cracking	☐	☐
Fatigue	☐	☐
Moisture Sensitivity	☐	☐
No Modifications of Any Items	☐	☐

Comments

Warm Mix Asphalt Survey for North Dakota

12. Compared to HMA, does your agency require to modify the amount of anti-stripping agent used for WMA? If yes, please specify how? Also if any other type of additives are required for WMA, please specify in the comment box.

- ◯ Yes
- ◯ No

Comments

13. For which of the following does your agency have different requirements (percentage/processing/testing) compared to HMA? Please specify in the comment box below.

	Yes	No
RAP (Reclaimed Asphalt Pavement)	◯	◯
RAS (Reclaimed Asphalt Shingles)	◯	◯

Comments

14. If Modifications are made, does the design for WMA depend on the WMA technology used? (if yes, please explain how)

- ◯ Yes
- ◯ No

Comments

-

Warm Mix Asphalt Survey for North Dakota

Specification

15. What are the mechanisms for developing warm mix asphalt in your agency? In the comment box, please provide your most recent documents/web links for each of the items below. (either copy the web link(s) or email us the document)

- ☐ Separate specification developed for WMA
- ☐ Approved list of processes
- ☐ Approval process for non-listed processes proposed

Other (please specify)

16. How did you develop your agency specification or approval procedure? (In the comment box please specify the reference your agency used for the first two choices)

- ☐ Based on national studies/guidelines (such as NCHRP reports)
- ☐ Based on other DOTs specifications
- ☐ Developed by your own agency

Comments

17. Do you have a list of NOT PERMITTED (WMA technologies, additives, etc...) in any section of your specification? (If yes, please list the Not Permitted items in the comment box below)

- ◯ Yes
- ◯ No

Comments

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Warm Mix Asphalt Survey for North Dakota

Acceptance Plan

18 Compared to HMA, for which of the WMA acceptance plan components do you have modifications? Please explain in the comment box. Also, could you provide us with your agency acceptance plan for WMA (through web link, email, or hard copy).

	Yes	No
Acceptance sampling type	◯	◯
Quality characteristics	◯	◯
Specification limits	◯	◯
Quality level goals	◯	◯
Risk	◯	◯
Pay factors	◯	◯

Comments (links or other information)

19. Compared to HMA, in which of the following do you have modifications in temperature monitoring for WMA? Please specify in the comment box.

- ☐ Mixing
- ☐ Construction/Compaction
- ☐ None

Comments

20. Is the WMA sampling schedule for quality assurance different from HMA? (If yes, please explain in the comment box)

- ◯ Yes
- ◯ No

Comments

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Warm Mix Asphalt Survey for North Dakota

21. For lab assurance testing, in which of the following do you have modifications compared to HMA? Please specify in the comment box.

- [ ] Sample preparation
- [ ] Testing procedure
- [ ] None

Comments

22. Compared to HMA, does your agency have any modifications on Quality Control Plan? If yes, please explain in the comment box.

- ( ) Yes
- ( ) No

Comments

23. Do you use test sections to evaluate construction/performance of WMA technologies? If yes, what are the approval process and the tests?

- ( ) Yes
- ( ) No

Comments

Warm Mix Asphalt Survey for North Dakota

24. In case of using non-approved technologies, additives, or modifiers by the contractor, what would be the agency action? Please explain in the comment box.

- [ ] Reject
- [ ] Accept with penalty
- [ ] Accept

Other (please specify)

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Warm Mix Asphalt Survey for North Dakota

Contact Information for Submitting Supplemental Information/Documents

NDSU research group would be more than happy to receive your emails or calls if you have any questions or would like to submit any documents or information related to the survey.

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Tel. (701) 231-7249
Fax. (701) 231-6185
Email: m.abdelrahman@ndsu.edu

Please provide us with the additional information below

Years of Experience

Position

Email

Telephone

City

State

Note:

If you prefer to submit the survey again using the link provided, please clear your browsing history and cookies to remove any saved preferences.

APPENDIX B - RESPONSES TO THE SURVEY

B1. General - Comparison between WMA and HMA

State	Bidding	Contractor's Willingness	Constructability	Performance	Maintenance	Cost
Colorado						
Idaho	Same	Same	Advantageous	Disadvantageous	Disadvantageous	Same
Indiana	Same	Same	Advantageous	Same	Same	Same
Iowa	Disadvantageous	Advantageous	Advantageous	Same	Same	Disadvantageous
Kansas	Same	Same	Same	Same	Same	Same
Maine	Same	Same	Same	Same	Same	Disadvantageous
Manitoba, Canada	Advantageous	Advantageous	Advantageous	Same	Same	Same
Michigan	Same	Same	Same	Same	Same	Same
Minnesota	Same	Same	Advantageous	Same	Same	Disadvantageous
Missouri	Same	Same	Advantageous	Advantageous	Same	Same
Montana(1)	Same	Same	Same			Disadvantageous
Montana(2)		Disadvantageous	Advantageous			
Nebraska	Disadvantageous	Same	Same	Same	Same	Disadvantageous
Nevada(1)	Same	Same	Disadvantageous	Disadvantageous	Same	Same
Nevada(2)						
New Hampshire		Advantageous	Advantageous	Advantageous		
New York	Same	Same	Same			Disadvantageous
Ohio	Advantageous	Advantageous	Same	Same	Same	Advantageous
Oregon						
Saskatchewan			Disadvantageous			
South Dakota	Same	Disadvantageous	Same	Disadvantageous	Disadvantageous	Advantageous
Utah	Same	Disadvantageous	Same	Same	Same	Same
Vermont	Disadvantageous	Same	Same	Same	Same	Disadvantageous
Washington	Same	Advantageous	Same	Same	Same	Same

Table B1 Comments section

State	Comments
Colorado	This is the first construction season that CDOT is allowing WMA processes in construction. We have no information on Q1 at this time.
Idaho	Performance is still an unknown. There may be the potential to strip and moisture susceptibility.
Indiana	WMA has permitted extending the time available to compact the HMA.
Iowa	In Iowa the cost of additives is about $2.25/mix ton for Evotherm and $4/ton for Sasobit, which is an increase to HMA. The water injection technology is only an initial investment cost; however, we require all WMA mixtures to undergo AASHTO T283 testing to satisfy a minimum 80% TSR. We do not require this on all HMA mixes, which leads to a potential added cost of an anti-stripping agent for all WMA technologies except Evotherm.
Kansas	We have WMA down for only one year and so far the performance has been the same. We don't specify that WMA must be used it is the contractor's option, and we have not seen a difference in bidding between the contractors that use WMA and contractors that use HMA.
Maine	Currently contractors are bidding HMA and utilizing warm-mix technologies as compaction aid (not lowering production temperatures). Projects bid with warm-mix technology are slightly more expensive than those with conventional HMA.
Manitoba, Canada	Manitoba Infrastructure and Transportation has constructed 2 WMA projects to date (with a 3rd scheduled for this season using water injection). We hosted a number of informational sessions for MIT staff Contractors prior to advertising our first WMA project; to educate all parties and address any concerns. We felt we recieved competitive bids for the first project, as it was used as part of a bigger reserach project. The second project was proposed by the Contractor to test the benefits of long haul (2 hours). Although the pavement has not been in service for very long, MIT was happy with the constructibility and performance thus far.
Michigan	We plan on taking an apporach where WMA is allowable at the contractor's option, therefore everything is considered the same.

Table B1 Comments section continued

State	Comments
Montana(1)	Montana DOT has only let 5 projects to date requiring WMA, to date only 3 of those jobs have been paved. These were paved within the last year so no information is available for performance and maintenance. The data base for cost comparison is pretty small. Several contractors have purchased equipment for WMA foaming application.
Montana(2)	We are still in the beginning phases of WMA ourselves. So far there has been both reluctance to use WMA and proactive requests to use WMA from our contracting community. Some of the larger contractors have purchased new hot plants in anticipation of wider use of WMA but we have only spec'ed it on 6 jobs so far. 3 last year and 3 this year so performance/maintenance data is not there yet. Compaction is aided on the road but older retrofitted plants have a hard time working at the reduced temperatures. I can't speak to any cost or bidding related issues.
Nebraska	Contractors seem interested in WMA, but there needs to be more innovation in finding cost effective solutions for many of the additives. At the moment, this seems to be one of the bigger hinderances for widespread use in Nebraska.
Nevada(1)	The main concerns that NDOT has with Warm Mix is early rutting due to uncertain optimum bitumen ratio and increased moisture sensitivity due to incomplete drying of aggregates.
Nevada(2)	We have not bid WMA in Nevada.
New Hampshire	Questions not responded to due to lack of data.
New York	Performance and Maintenance of WMA vs. HMA - We don't have enough history yet, hoiwever we do not expect to see the same or better. Cost - Our current WMA specification requires extra testing not normally done with our HMA mixtures, and our production quality incentives/disincentives do not apply to the WMA mixtures. These factors cause the current bid prices to be slightly higher ($1 - $5 per mix ton).
Ohio	Not enough information on performance yet. Since a new set of construction issues arise I rate constructability the same.
Oregon	Can't really address these as we have done only a couple of Warm Mix projects and most have been by a no cost change order.
Saskatchewan	Warm mix was found to have created more tender mixes, which is not a benefit in Saskatchewan as our mixes are already tender. As well, when used for blade patching, crews found it more difficult to work with. However, increased haul distances were an advantage.

Table B1 Comments section continued

State	Comments
Utah	UDOT's approach is to allow WMA but not require it. This allows the contractor to use the technology as it benefits them.
Vermont	We have not required WMA or bid it as an alternate but our specification would allow WMA useage. Contractors have not proposed WMA because of increased costs.
Washington	Use of WMA is optional to the Contractors but must be proposed and approved by WSDOT. Since WMA has only been used for a couple of years it is difficult to provide an accurate assessment of performance and maintenance.

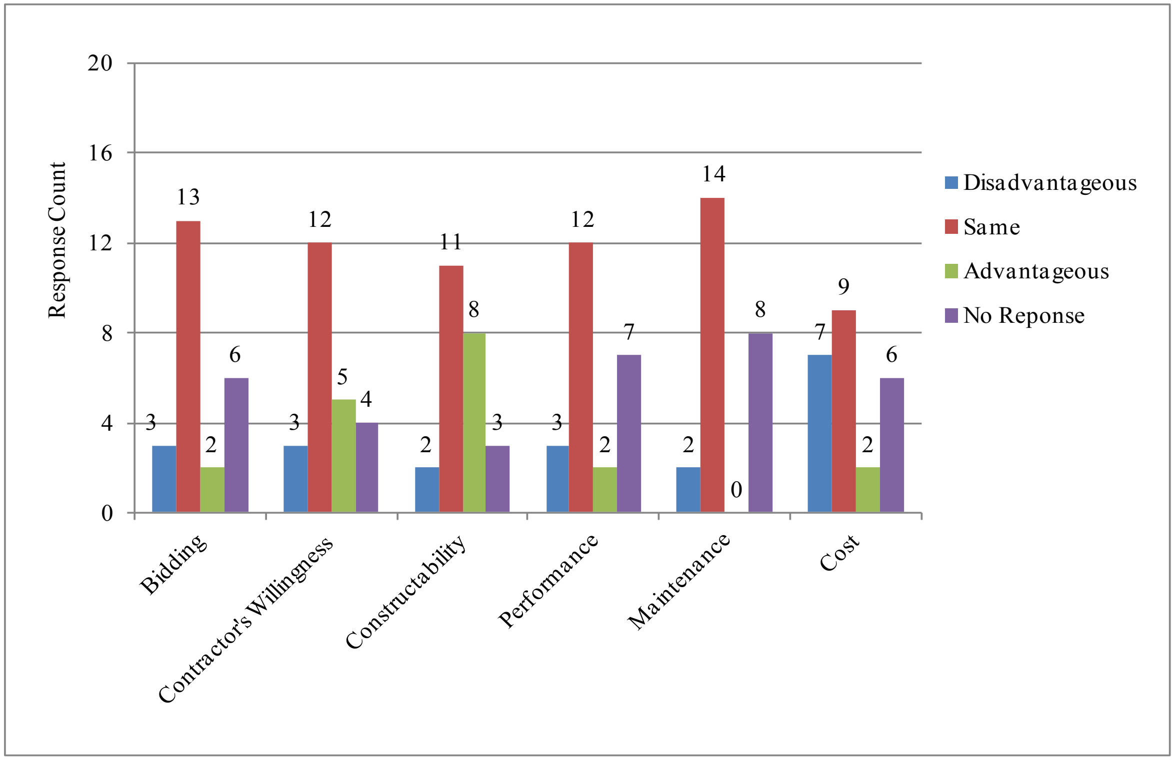

FIGURE B1.a Comparison between WMA and HMA based on agencies' experience

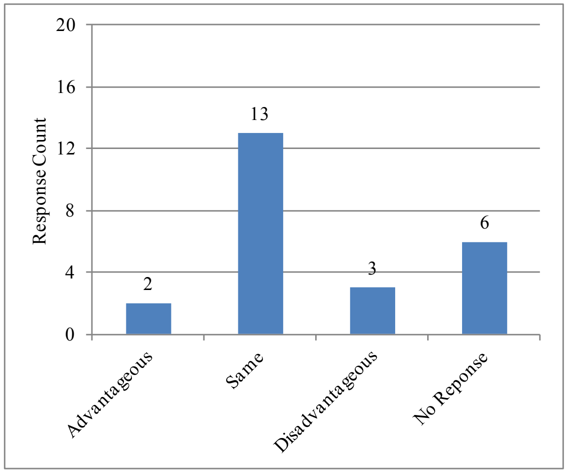

FIGURE B1.b WMA bidding compared to HMA

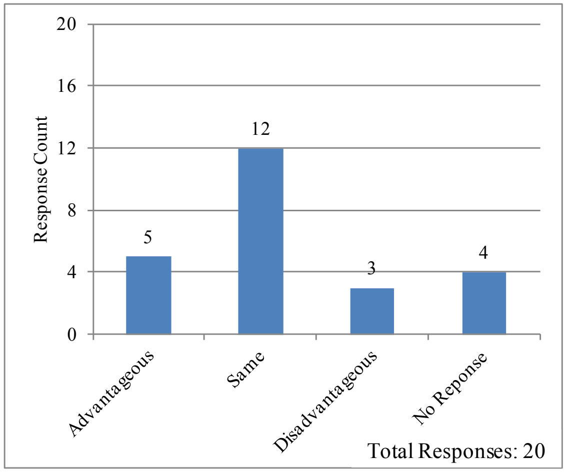

FIGURE B1.c WMA contractor's willingness compared to HMA

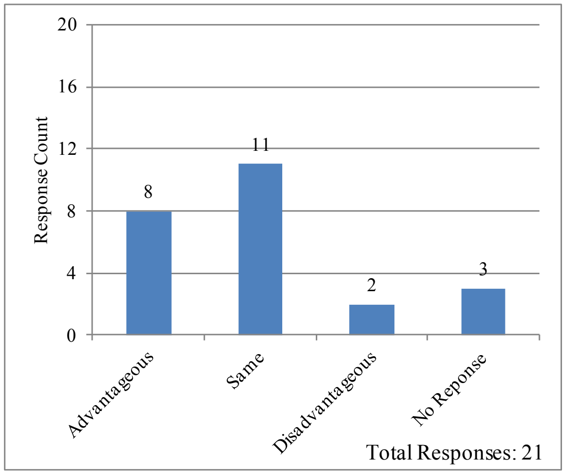

FIGURE B1.d WMA constructability compared to HMA

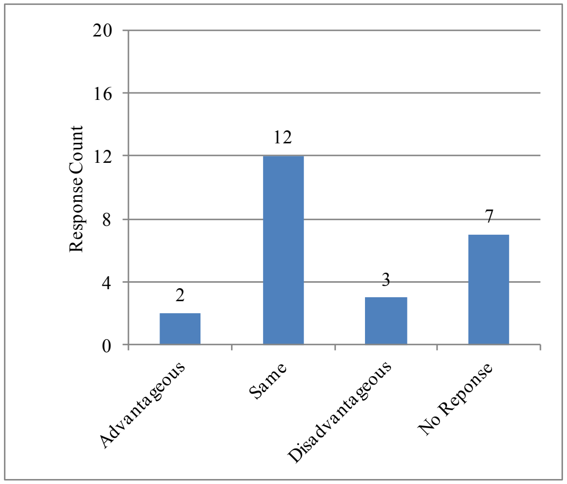

FIGURE B1.e WMA performance compared to HMA

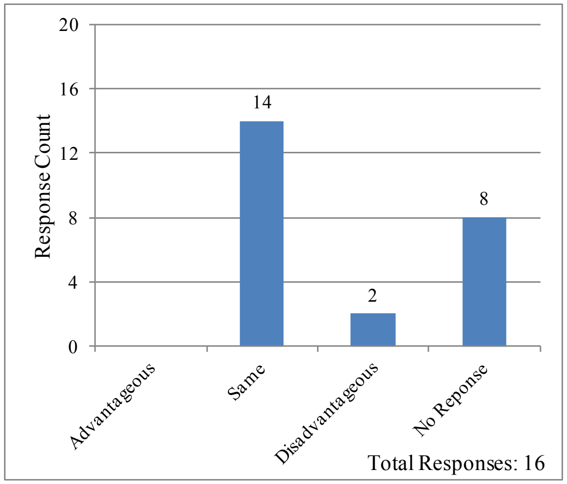

FIGURE B1.f WMA maintenance compared to WMA

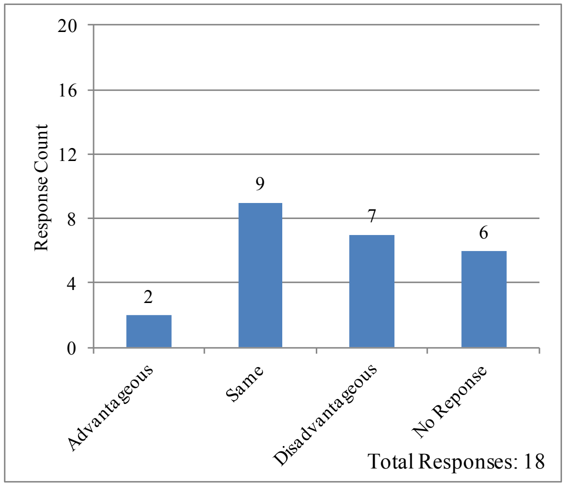

FIGURE B1.g WMA cost compared to HMA

B2. General – Approximate Agencies' Yearly Production of WMA and HMA

Table B2 How much was the WMA and HMA approximate production (tonnage/year) based on the average of last 5 years?

State	Comments
Colorado	Aside from small test sections 3 years ago, we have yet to complete a construction year with WMA projects.
Idaho	WMA avg over last 5 years 6,000 ton/yr. HMA avg over last 5 years 500,000 ton/yr.
Indiana	Indiana has had a permissive specification for the past three years. Annual HMA production could be estimated at 4 million tons with an average of 15 out of 100 plants equipped with foaming equipment. WMA production would therefore be in the realm of 500,000 tons or higher...we do not track WMA production tonnage.
Iowa	We are not permissive yet, so the WMA tonnage is limited and not representative of the true desire of WMA from the contractor's perspective. Iowa did 125,000 tons in 2010 which was about 4%. We expect this to increase when we are permissive in 2012.
Kansas	Last year was the first year we placed WMA and there were approximately 110,000 tons of WMA placed and around 1,100,000 tons of HMA placed.
Maine	Average Production: WMA - 50k Ton HMA - 750k Ton
Manitoba, Canada	Project advertised in 2009: 31,400 tonnes total project (23,550 was WMA) Project contstructed 2011: 81,000 tonnes total project (40,500 will be foamed WMA)
Michigan	0 tons of WMA. A contractor placed WMA on a project at their choice but I wouldn't consider it in answering this question.
Minnesota	50,000 WMA per year 1 million HMA per year
Missouri	In the last 5 years WMA has gone from almost 0% to 20% of the total production or almost 1 million tons. That should increase considerably for 2011 with more contractors using WMA.
Montana(1)	WMA - 25,600 tons based on 5 projects let. HMA - 25,800 tons based on average of 5 years. Although these averages are very close the individual project tonnages vary widely.
Montana(2)	
Nebraska	Around 2 Million Tons per year
Nevada(1)	Zero for State contracts.
Nevada(2)	WMA - 0 HMA - 600,000 tons
New Hampshire	This is the first paving season it is being utilized
New York	HMA - approx. tonnange per year - 3 million WMA - we are still in a experimental trial stages, but we have done approx. 225,000 tons of WMA in the last 5 years.
Ohio	In 2010 we produced 1.9 million WMA tons and almost 6 million total tons. Prior to that we ahd about 5.5 million total tons with WMA phasing in from 0 to 1.9 million tons in about 3 years.
Oregon	We have only done two WMA projects to date with a total tonage of about 10,000 ton. We average about 1,500,000 Tons of HMA
Saskatchewan	WMA production has been limited to trials in 2010. Some has been used for blade patching, some has been used on a thin lift overlay, a trial in which two additives will be evaluated was constructed, and one contractor was allowed to use WMA on paving job when work was occuring in December. Costs have been borne by the contractor/and or supplier at this point, so no information is available regarding bidding/costs.
South Dakota	only test sections of warm mix approx. 20,000 tons of 8 million tonns
Utah	5000
Vermont	HMA - 400,000 T/year WMA - 0
Washington	WMA approximately 75,000 tons. HMA approximately 4,800,000 tons.

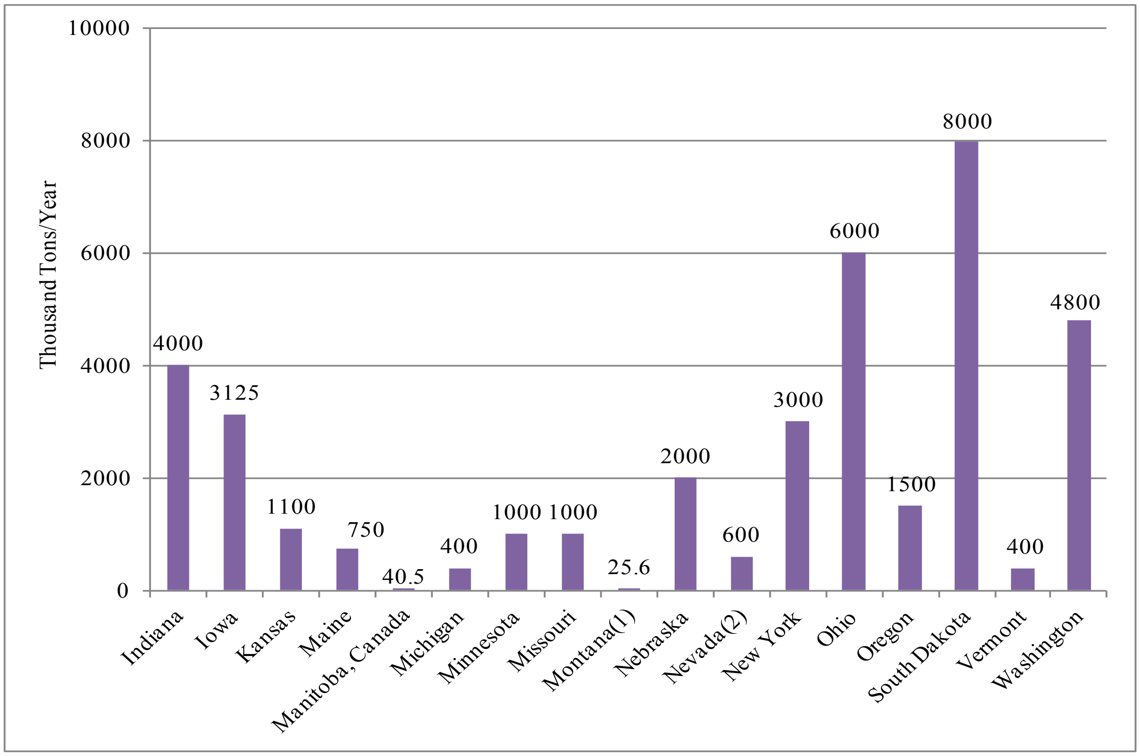

FIGURE B2.a Approximate HMA production (average of last 5 years)

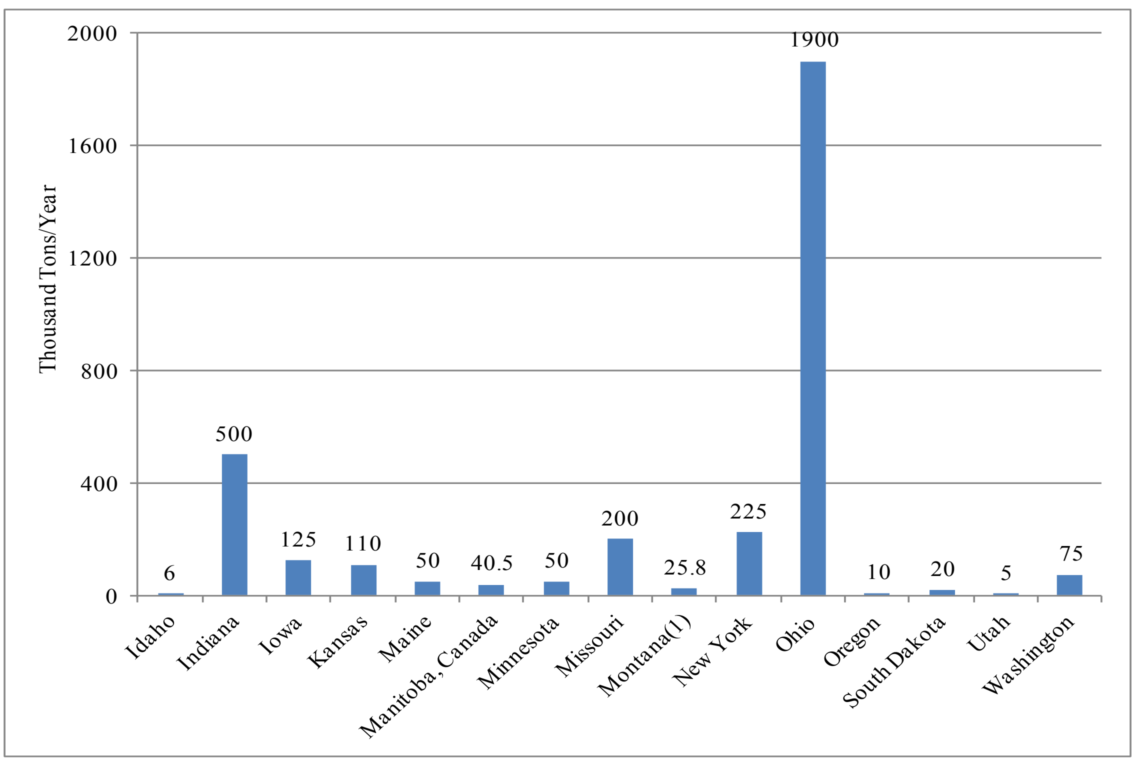

FIGURE B2.b Approximate WMA production (average of last 5 years)

B3. General – HMA and WMA Bidding Cost Comparison

Table B3. How is WMA bidding cost compared to HMA?

State	WMA bidding cost compared to HMA is	
Colorado		
Idaho		Same
Indiana		Same
Iowa	1 to 5 % Higher	More
Kansas		Same
Maine	6 to 10% Higher	More
Manitoba, Canada		
Michigan		Same
Minnesota	6 to 10% Higher	More
Missouri		Same
Montana(1)	6 to 10% Higher	More
Montana(2)		
Nebraska	15 to 20 % Higher	More
Nevada(1)	1 to 5 % Higher	Same
Nevada(2)		
New Hampshire		
New York	1 to 5 % Higher	More
Ohio	1 to 5 % Higher	
Oregon		
Saskatchewan		
South Dakota		
Utah		Same
Vermont		More
Washington		Same

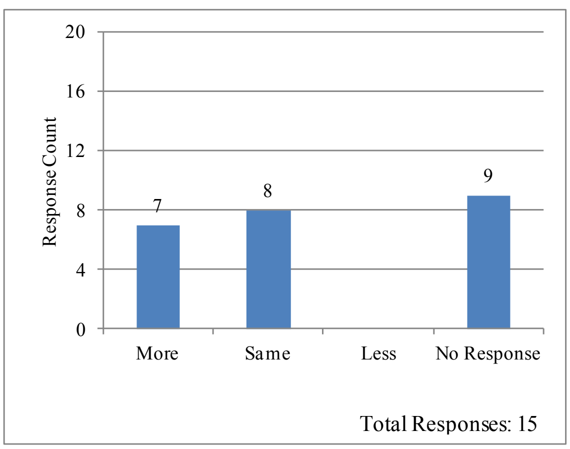

FIGURE B3.a WMA bidding cost compared to HMA

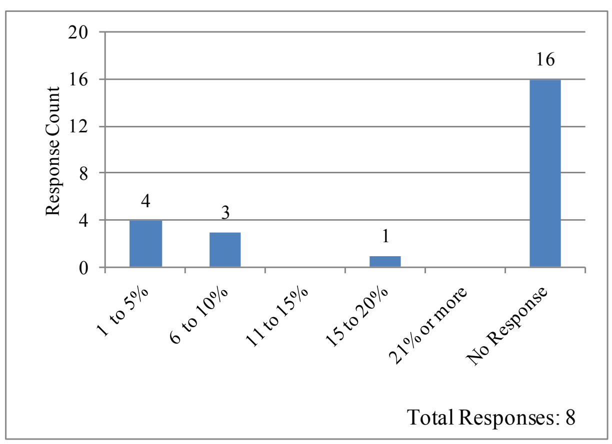

FIGURE B3.b Increase of WMA bidding cost compared to HMA

B4. General – Cost Issues

B4.1. General – WMA Additional Cost of Additives

Table B4.1 What is the approximate range of additional costs ($/ton) for WMA production in terms of Cost of additives

State	Refinery	Field Location
Colorado		
Idaho	Unknown	
Indiana		
Iowa	we use foaming only.	0.00
Kansas		
Maine	n/a	n/a
Manitoba, Canada	unknown	
Michigan		
Minnesota		
Missouri	0.00	0 - except for initial equipment installation
Montana(1)		
Montana(2)	n/a	n/a
Nebraska		
Nevada(1)	depends on additive	depends on additive
Nevada(2)		
New Hampshire		
New York	$3-6/Liquid Ton	$8/Liquid Ton
Ohio		
Oregon		
Saskatchewan		
South Dakota		
Utah		
Vermont	Unknown	Unknown
Washington	N/A	N/A

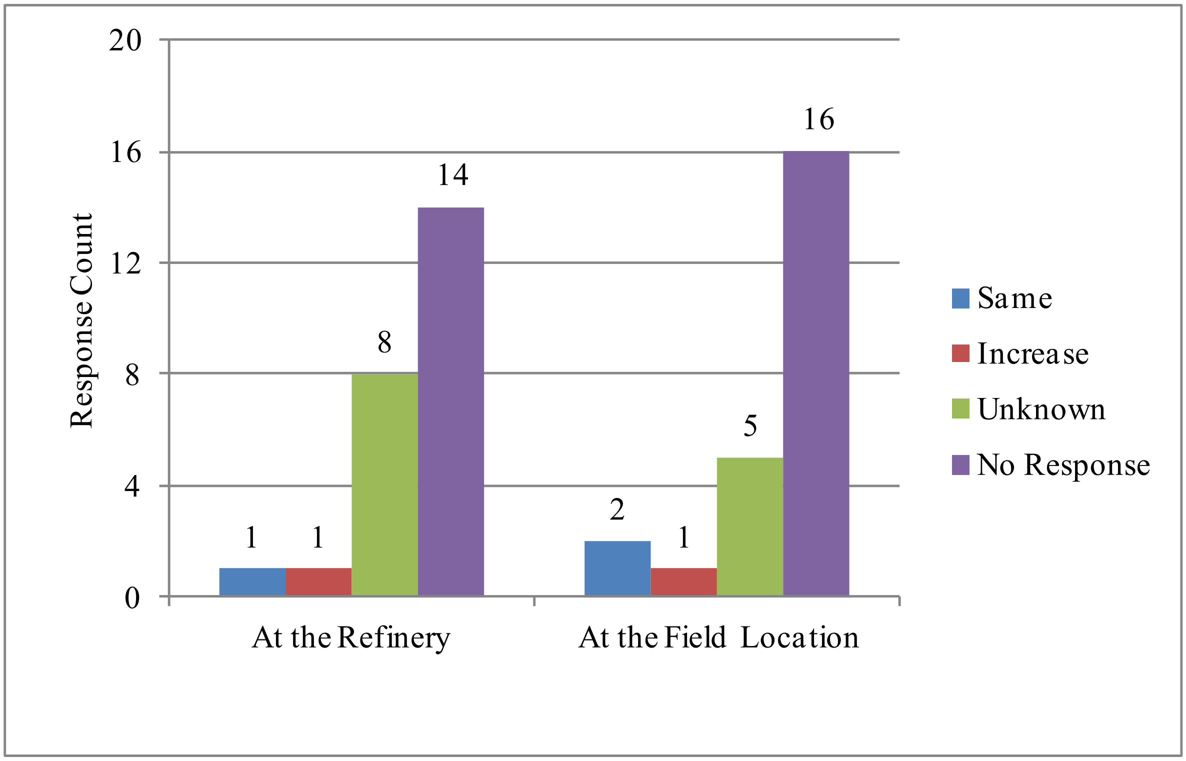

FIGURE 4.1 Additional costs for WMA production in terms of cost of additives

B4.2. General - WMA Additional Total Cost

Table B4.2 What is the approximate range of additional costs ($/ton) for WMA production in terms of Total Cost Including Processing

State	Refinery	Field Location
Colorado		
Idaho		
Indiana	N/A	N/A
Iowa	2-4$/mix ton	
Kansas		
Maine	Unknown/Bid Specific	Unknown/Bid Specific
Manitoba, Canada		
Michigan	0	0- except for initial equpment installation
Minnesota	2	1.75
Missouri		
Montana(1)		
Montana(2)		
Nebraska		
Nevada(1)	n/a	n/a
Nevada(2)		
New Hampshire	unknown	
New York		
Ohio	0	0
Oregon		
Saskatchewan		
South Dakota		
Utah	unknown	
Vermont	$1-2 per ton	$1-2 per ton
Washington	Unknown	$25,000 - $50,000

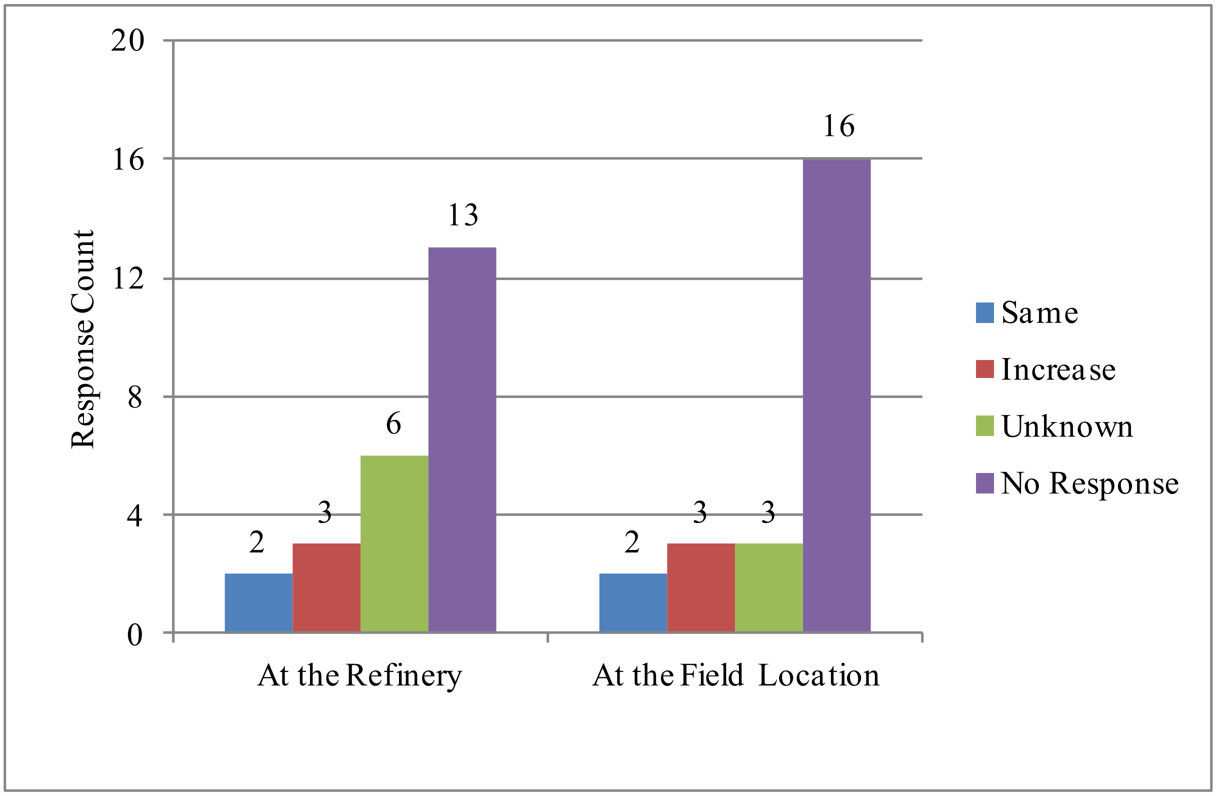

FIGURE B4.2 Additional costs for WMA production in terms of total cost including processing

B5. General – Agencies' WMA Experiences

Table B5 Is it possible to provide information/data/documentation for some of your agency projects/experiences with WMA? (Please provide it through web link, email, or post)

State	Response Text
Colorado	
Idaho	Nothing of great value. We have only limited information on one job. It was bid as HMA and Change Ordered to WMA at contractors request at no cost CO. Did meet all original HMA Superpave specifications and had reasonably good Pay factors based on Volumetrics and density. Spec for density is 91 to 96 percent (Correlated Nuke Gauge). Project completed 2010 mid summer in hot weather.
Indiana	Indiana is permissive with foaming asphalt only. We have not permitted any solid modifiers and have not been pressured by our Contractors to use them because of the substantial cost increase per ton of mixture.
Iowa	http://www.iowadot.gov/operationsresearch/reports/reports_pdf/hr_and_tr/reports/TR-599%20Final%20Report.pdf
Kansas	I will email some of the project results from our WMA projects.
Maine	Yes, however, projects have yet to be completed.
Manitoba, Canada	Contact: tara.liske@gov.mb.ca
Michigan	NA
Minnesota	http://www.dot.state.mn.us/mnroad/WMA/WMA%20Index.html
Missouri	Our first project is documented as part of NCHRP 09-47A and NCAT Report No. 10-02.
Montana(1)	deroberts@mt.gov
Montana(2)	
Nebraska	Yes, will email the information
Nevada(1)	None available at this time.
Nevada(2)	
New Hampshire	Not at this time. First paving season using this technology
New York	Yes, some info/data can be made available. We have various projects with various WMA technologies. Contact me with the type of information you are interested in.
Ohio	Emaililng a reprot from trials in 2008.
Oregon	
Saskatchewan	A paper will be published in the Canadian Technical Asphalt Association Proceedings, and a presentation will be given at the CSCE annual meeting.
South Dakota	No
Utah	
Vermont	No data to date. First projects to be bid this year.
Washington	http://www.wsdot.wa.gov/Research/Reports/700/723.1.htm

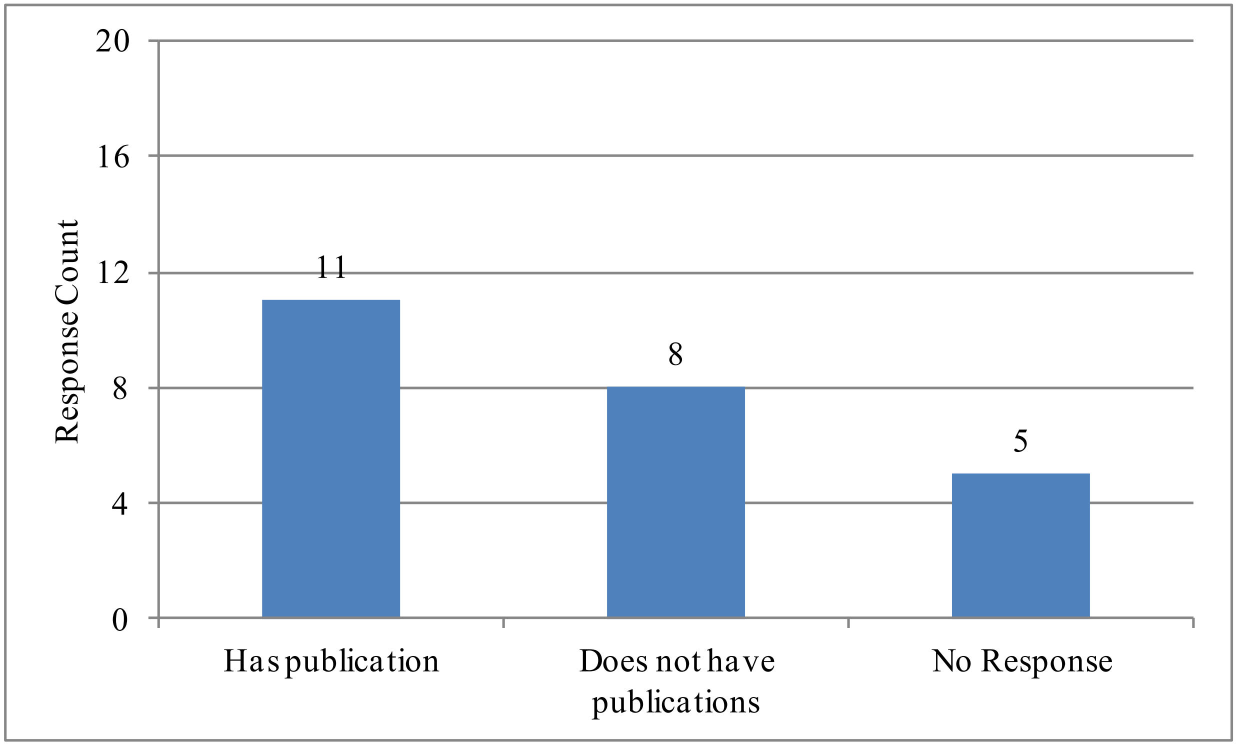

FIGURE B5 Agencies that have WMA publications

B6. General – Agencies' Preferred WMA Process

Table B6 If you had to pick one WMA process, what would it be? Please explain why.

State	Response Text
Colorado	Chemical additive like Advera. CDOT is wary of foaming processes because of the lack of long-term, field performance information.
Idaho	Idaho's only WMA experience is with foaming asphalt (plant modification) Double Barrel Green.
Indiana	Indiana is permissive with foaming asphalt only. The equipment installation costs are considered a one-time annualized cost with pay-back to the contractor in the form of decreased fuel usage. The fuel savings have not approached the nationally reported value of 14% as many variables play into that number.
Iowa	As an owner I would choose Evotherm because it acts as an adhesion promoter as well as a compaction aid. A contractor would prefer water injection due to the one-time initial cost.
Kansas	Chemical Process. At this point we can't replicate the foaming process in the lab and we would be able to replicate the chemical process in the lab. Also the temperature drop can be more substantial with chemical processes, at this point with the foaming processes the contractors aren't really seeing a substantial savings in fuel costs.
Maine	For quality purposes, we feel that the synthetic wax WMA technologies are the best. However, we have only utilized EvoTherm and Water technologies in the State of Maine.
Manitoba, Canada	We only have experience with WMA additives: Sasobit, Evotherm and Advera. We will be constructed a foamed WMA project this season.
Michigan	Foaming/water injection. Least costly.
Minnesota	Evotherm, lower mixing temperatures, adhesion promoters, and anti-strip capabilities
Missouri	Experience has shown that chemical admixtures (Evotherm) provide the largest temperature reduction in addition to antistrip qualities and allowing higher percentages of RAP and RAS.
Montana(1)	foaming technology, water will evaporate out of the mix and leave the asphalt intact with the least potential for changine asphalt properties.
Montana(2)	
Nebraska	If a process could prove itself to lower the cost to produce asphalt while not losing anything in quality, that would be our choice. There is no clearcut leader in that, although the water injection methods may be the frontrunner.
Nevada(1)	Uncertain as of this date.
Nevada(2)	Foaming, easier for a contractor to install on his hot plant.
New Hampshire	At this point it would be the foaming method. No added cost, increased film thickness and compaction.

Table B6 Comments section continued

State	Response Text
New York	NYSDOT does not favor any process over the other(s). NYSDOT has an approval process for each technology to follow in order for them to be put on our Approved List of WMA Technologies. Technologies that have been Approved are allowed to be used on entire WMA projects. Technologies that have not been Approved are limited to trial sections of 1000 tons or less.
Ohio	Foaming, no extra cost, significant emissions reduction.
Oregon	
Saskatchewan	Not enough information at this time.
South Dakota	chemical additives
Utah	unknown
Vermont	Probably waxes (Sasobit/Sonnewarm) because they can be added to the binder either at the HMA plant or at the refinery/terminal.
Washington	N/A

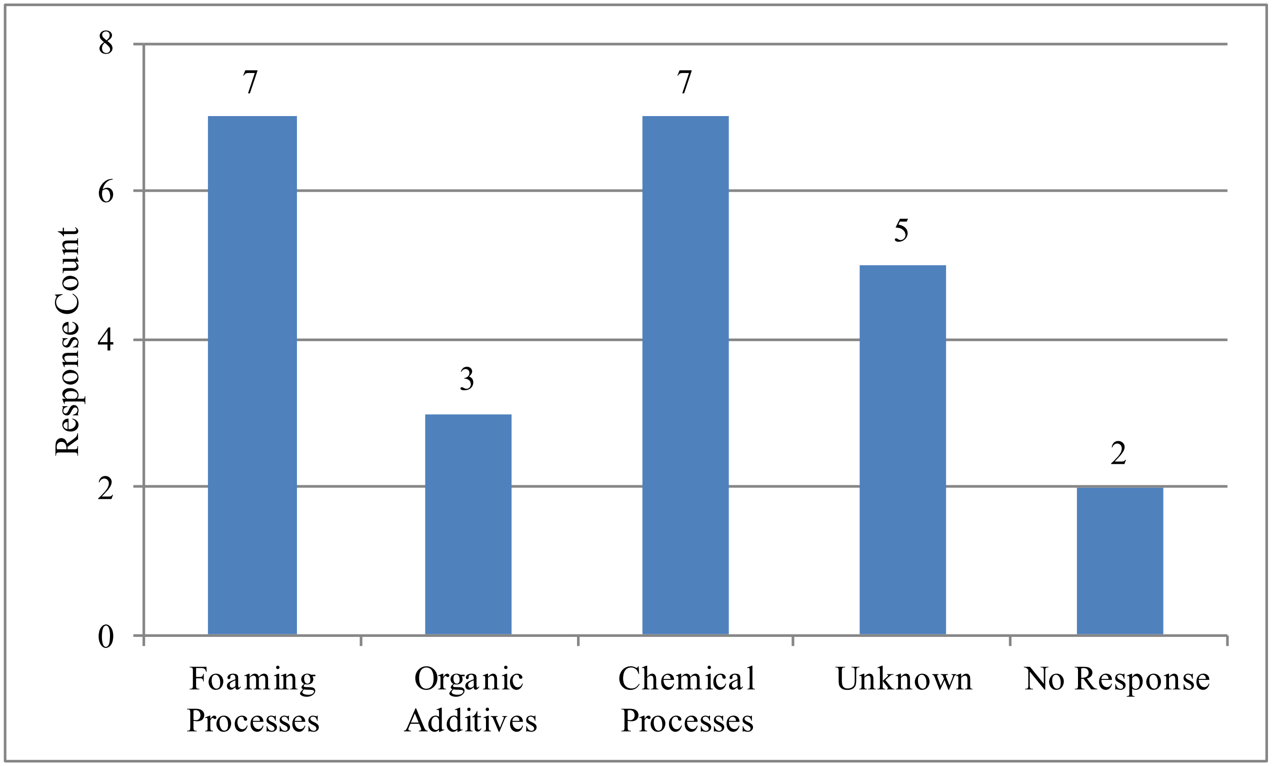

FIGURE B6 Distribution of WMA type preference

B7. Technology – Evaluation of Processes

B7.1. Technology – Chemical Processes

Table B7.1 For each of the three main processes below please specify the followings: In how many of your agency projects was the technology implemented? How much reduction in mixing temperature could you achieve compared to HMA projects? Have you observed moisture damage and/or rutting on your warm mix projects? If yes, in how many projects did you observe them? If there were other distresses, please list them in the comment box.

State	Number of Constructed Projects CECABASE® RT	Mixing Temperature Reduction Achieved (°F) CECABASE® RT	Number of Projects with Moisture Damage CECABASE® RT	Number of Projects with Rutting CECABASE® RT
Colorado				
Idaho				
Indiana				
Iowa				
Kansas				
Maine				
Manitoba, Canada				
Michigan				
Minnesota				
Missouri				
Montana(1)				
Montana(2)				
Nebraska				
Nevada(1)				
Nevada(2)				
New Hampshire				
New York	1	40-60		
Ohio				
Oregon				
Saskatchewan	1			
South Dakota				
Utah				
Vermont				
Washington				

Table B7.1 Continued

State	Number of Constructed Projects Evotherm ™	Mixing Temperature Reduction Achieved (°F) Evotherm ™	Number of Projects with Moisture Damage Evotherm ™	Number of Projects with Rutting Evotherm ™
Colorado	1	20-40		
Idaho				
Indiana				
Iowa	6	40-60		
Kansas	4			
Maine	3	20-40		1
Manitoba, Canada	2	40-60		
Michigan				
Minnesota	3	40-60		
Missouri	15	40-60		
Montana(1)	1			
Montana(2)				
Nebraska	1	40-60		
Nevada(1)				
Nevada(2)				
New Hampshire	2	40-60		
New York	7	40-60		
Ohio	2	40-60		
Oregon				
Saskatchewan	3	20-40		
South Dakota	3	40-60		12
Utah	1	40-60		
Vermont				
Washington				

Table B7.1 Continued

State	Number of Constructed Projects HyperTherm™ /QualiTherm	Mixing Temperature Reduction Achieved (°F) HyperTherm™ /QualiTherm	Number of Projects with Moisture Damage HyperTherm™ /QualiTherm	Number of Projects with Rutting HyperTherm™ /QualiTherm
Colorado				
Idaho				
Indiana				
Iowa				
Kansas				
Maine				
Manitoba, Canada				
Michigan				
Minnesota				
Missouri				
Montana(1)				
Montana(2)				
Nebraska				
Nevada(1)				
Nevada(2)				
New Hampshire				
New York	1	40-60		
Ohio				
Oregon				
Saskatchewan				
South Dakota				
Utah				
Vermont				
Washington				

Table B7.1 Continued

State	Number of Constructed Projects Rediset™WMX	Mixing Temperature Reduction Achieved (°F) Rediset™WMX	Number of Projects with Moisture Damage Rediset™WMX	Number of Projects with Rutting Rediset™WMX
Colorado				
Idaho				
Indiana				
Iowa				
Kansas				
Maine				
Manitoba, Canada				
Michigan				
Minnesota				
Missouri				
Montana(1)				
Montana(2)				
Nebraska				
Nevada(1)				
Nevada(2)				
New Hampshire				
New York				
Ohio				
Oregon				
Saskatchewan				
South Dakota				
Utah				
Vermont				
Washington				

Table B7.1 Continued

State	Please list other technologies and/or other distresses not listed above
Colorado	
Idaho	Foaming Asphalt - Double Barrel Green
Indiana	Chemical processes are not currently permitted.
Iowa	
Kansas	
Maine	Moisture damage to the WMA projects is unknown to the date.
Manitoba, Canada	
Michigan	
Minnesota	
Missouri	
Montana(1)	
Montana(2)	
Nebraska	
Nevada(1)	
Nevada(2)	None.
New Hampshire	
New York	LEA - Lite - 4 Projects with approx 50 degree F temperature reduction. No damage to date.
Ohio	
Oregon	
Saskatchewan	No data regarding moisture damage/rutting is available at this time. Temperature reduction is based off of the trial
South Dakota	
Utah	
Vermont	None of these technologies have been used.
Washington	

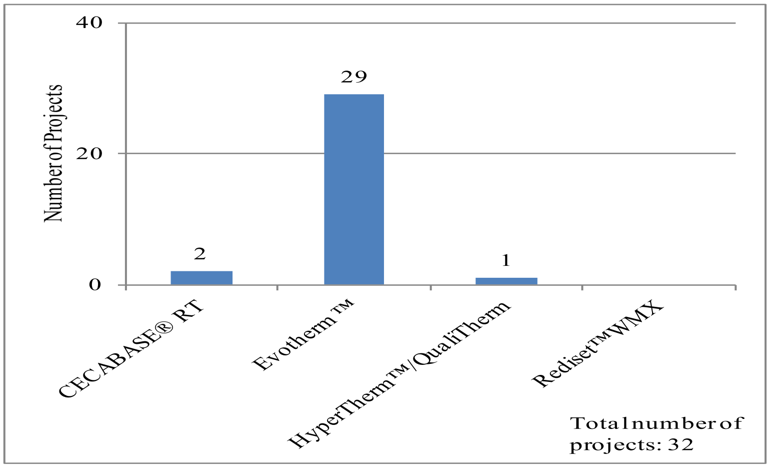

FIGURE B7.1.a Number of constructed projects for each chemical process

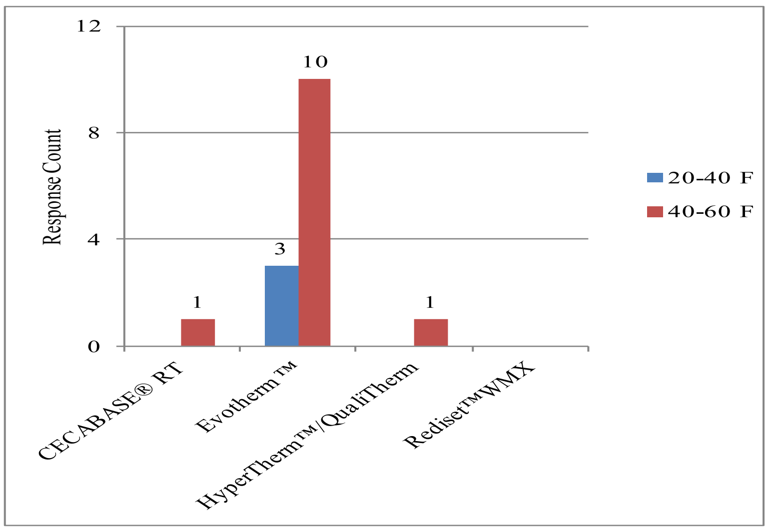

FIGURE B7.1.b Mixing temperature reduction (F) achieved for each chemical process

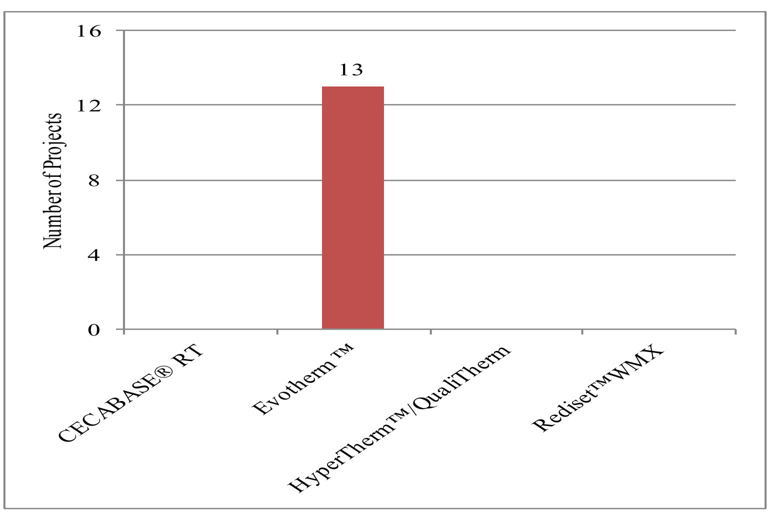

FIGURE B7.1.c Number of projects with moisture damage for each chemical process

B7.2. Technology - Foaming Processes

Table B7.2 For each of the three main processes below please specify the followings: In how many of your agency projects was the technology implemented? How much reduction in mixing temperature could you achieve compared to HMA projects? Have you observed moisture damage and/or rutting on your warm mix projects? If yes, in how many projects did you observe them? If there were other distresses, please list them in the comment box.

State	Number of Constructed Projects Accu-Shear™	Mixing Temperature Reduction Achieved (°F) Accu-Shear™	Number of Projects with Moisture Damage Accu-Shear™	Number of Projects with Rutting Accu-Shear™
Colorado				
Idaho				
Indiana				
Iowa				
Kansas				
Maine				
Manitoba, Canada				
Michigan				
Minnesota				
Missouri				
Montana(1)				
Montana(2)				
Nebraska	1	20-40		
Nevada(1)				
Nevada(2)				
New Hampshire				
New York				
Ohio				
Oregon				
Saskatchewan				
South Dakota				
Utah				
Vermont				
Washington				

Table B7.2 Continued

State	Number of Constructed Projects Advera® WMA	Mixing Temperature Reduction Achieved (°F) Advera® WMA	Number of Projects with Moisture Damage Advera® WMA	Number of Projects with Rutting Advera® WMA
Colorado	1	20-40		
Idaho				
Indiana				
Iowa				
Kansas				
Maine				
Manitoba, Canada	1	40-60		
Michigan				
Minnesota				
Missouri	1	20-40		
Montana(1)				
Montana(2)				
Nebraska	1	40-60		
Nevada(1)				
Nevada(2)				
New Hampshire				
New York				
Ohio	3	40-60		
Oregon				
Saskatchewan	1	20-40		
South Dakota				
Utah				
Vermont				
Washington				

Table B7.2 Continued

State	Number of Constructed Projects AQUABlack ™ WMA System	Mixing Temperature Reduction Achieved (°F) AQUABlack ™ WMA System	Number of Projects with Moisture Damage AQUABlack ™ WMA System	Number of Projects with Rutting AQUABlack ™ WMA System
Colorado				
Idaho				
Indiana				
Iowa				
Kansas	15	20-40		
Maine				
Manitoba, Canada				
Michigan				
Minnesota	10	20-40		
Missouri	6	20-40		
Montana(1)	1			
Montana(2)				
Nebraska				
Nevada(1)				
Nevada(2)				
New Hampshire				
New York				
Ohio				
Oregon				
Saskatchewan				
South Dakota				
Utah				
Vermont				
Washington	1	20-40		

Table B7.2 Continued

State	Number of Constructed Projects AquaFoam	Mixing Temperature Reduction Achieved (°F) AquaFoam	Number of Projects with Moisture Damage AquaFoam	Number of Projects with Rutting AquaFoam
Colorado				
Idaho				
Indiana				
Iowa				
Kansas				
Maine				
Manitoba, Canada				
Michigan				
Minnesota				
Missouri				
Montana(1)				
Montana(2)				
Nebraska				
Nevada(1)				
Nevada(2)				
New Hampshire				
New York				
Ohio				
Oregon				
Saskatchewan				
South Dakota	2			
Utah				
Vermont				
Washington	1	20-40		

Table B7.2 Continued

State	Number of Constructed Projects Aspha-Min®	Mixing Temperature Reduction Achieved (°F) Aspha-Min®	Number of Projects with Moisture Damage Aspha-Min®	Number of Projects with Rutting Aspha-Min®
Colorado				
Idaho				
Indiana				
Iowa				
Kansas				
Maine				
Manitoba, Canada				
Michigan				
Minnesota				
Missouri	1	20-40		
Montana(1)				
Montana(2)				
Nebraska				
Nevada(1)				
Nevada(2)				
New Hampshire				
New York				
Ohio				
Oregon				
Saskatchewan				
South Dakota				
Utah				
Vermont				
Washington				

Table B7.2 Continued

State	Number of Constructed Projects Double Barrel® Green	Mixing Temperature Reduction Achieved (°F) Double Barrel® Green	Number of Projects with Moisture Damage Double Barrel® Green	Number of Projects with Rutting Double Barrel® Green
Colorado				
Idaho	1	20-40		
Indiana				
Iowa	5	20-40		
Kansas				
Maine	12	20-40		
Manitoba, Canada				
Michigan				
Minnesota				
Missouri	15	20-40		
Montana(1)				
Montana(2)				
Nebraska				
Nevada(1)				
Nevada(2)				
New Hampshire	8	20-40		
New York				
Ohio				
Oregon				
Saskatchewan				
South Dakota	1			
Utah	1	20-40		
Vermont				
Washington	1	20-40		

Table B7.2 Continued

State	Number of Constructed Projects Eco-Foam II	Mixing Temperature Reduction Achieved (°F) Eco-Foam II	Number of Projects with Moisture Damage Eco-Foam II	Number of Projects with Rutting Eco-Foam II
Colorado				
Idaho				
Indiana				
Iowa				
Kansas				
Maine				
Manitoba, Canada				
Michigan				
Minnesota				
Missouri				
Montana(1)				
Montana(2)				
Nebraska				
Nevada(1)				
Nevada(2)				
New Hampshire				
New York				
Ohio				
Oregon				
Saskatchewan				
South Dakota				
Utah				
Vermont				
Washington				

Table B7.2 Continued

State	Number of Constructed Projects LEA (Low Emission Asphalt)	Mixing Temperature Reduction Achieved (°F) LEA (Low Emission Asphalt)	Number of Projects with Moisture Damage LEA (Low Emission Asphalt)	Number of Projects with Rutting LEA (Low Emission Asphalt)
Colorado				
Idaho				
Indiana				
Iowa				
Kansas				
Maine				
Manitoba, Canada				
Michigan				
Minnesota				
Missouri				
Montana(1)				
Montana(2)				
Nebraska				
Nevada(1)				
Nevada(2)				
New Hampshire				
New York	12	80-100		
Ohio				
Oregon				
Saskatchewan				
South Dakota				
Utah				
Vermont				
Washington				

Table B7.2 Continued

State	Number of Constructed Projects Meeker Warm Mix	Mixing Temperature Reduction Achieved (°F) Meeker Warm Mix	Number of Projects with Moisture Damage Meeker Warm Mix	Number of Projects with Rutting Meeker Warm Mix
Colorado				
Idaho				
Indiana				
Iowa				
Kansas				
Maine				
Manitoba, Canada				
Michigan				
Minnesota				
Missouri				
Montana(1)				
Montana(2)				
Nebraska				
Nevada(1)				
Nevada(2)				
New Hampshire				
New York				
Ohio				
Oregon				
Saskatchewan				
South Dakota				
Utah				
Vermont				
Washington				

Table B7.2 Continued

State	Number of Constructed Projects Terex® WMA System	Mixing Temperature Reduction Achieved (°F) Terex® WMA System	Number of Projects with Moisture Damage Terex® WMA System	Number of Projects with Rutting Terex® WMA System
Colorado				
Idaho				
Indiana				
Iowa				
Kansas				
Maine				
Manitoba, Canada				
Michigan				
Minnesota				
Missouri	4	20-40		
Montana(1)				
Montana(2)				
Nebraska				
Nevada(1)				
Nevada(2)				
New Hampshire	8	20-40		
New York	3	20-40		
Ohio				
Oregon				
Saskatchewan				
South Dakota	1			
Utah				
Vermont	1	20-40		
Washington				

Table B7.2 Continued

State	Number of Constructed Projects Tri-Mix Warm Mix Injection System	Mixing Temperature Reduction Achieved (°F) Tri-Mix Warm Mix Injection System	Number of Projects with Moisture Damage Tri-Mix Warm Mix Injection System	Number of Projects with Rutting Tri-Mix Warm Mix Injection System
Colorado				
Idaho				
Indiana				
Iowa				
Kansas				
Maine				
Manitoba, Canada				
Michigan				
Minnesota				
Missouri				
Montana(1)				
Montana(2)				
Nebraska				
Nevada(1)				
Nevada(2)				
New Hampshire				
New York				
Ohio				
Oregon				
Saskatchewan				
South Dakota				
Utah				
Vermont				
Washington				

Table B7.2 Continued

State	Number of Constructed Projects Ultrafoam GX2™ System	Mixing Temperature Reduction Achieved (°F) Ultrafoam GX2™ System	Number of Projects with Moisture Damage Ultrafoam GX2™ System	Number of Projects with Rutting Ultrafoam GX2™ System
Colorado				
Idaho				
Indiana				
Iowa				
Kansas				
Maine				
Manitoba, Canada				
Michigan				
Minnesota				
Missouri				
Montana(1)				
Montana(2)				
Nebraska				
Nevada(1)				
Nevada(2)				
New Hampshire				
New York				
Ohio				
Oregon				
Saskatchewan				
South Dakota				
Utah				
Vermont				
Washington	3	20-40		

Table B7.2 Continued

State	Number of Constructed Projects WAM Foam	Mixing Temperature Reduction Achieved (°F) WAM Foam	Number of Projects with Moisture Damage WAM Foam	Number of Projects with Rutting WAM Foam
Colorado				
Idaho				
Indiana				
Iowa				
Kansas				
Maine				
Manitoba, Canada				
Michigan				
Minnesota				
Missouri				
Montana(1)				
Montana(2)				
Nebraska				
Nevada(1)				
Nevada(2)				
New Hampshire				
New York				
Ohio				
Oregon				
Saskatchewan				
South Dakota				
Utah				
Vermont				
Washington				

Table B7.2 Continued

State	Please list other technologies and/or other distresses not listed above
Colorado	I'm pretty sure Advera is a mineral additive, not a foaming process
Idaho	
Indiana	Indiana contractors have primarily focused on purchasing the Double Barrel Green system and the Gencor system for foaming. One contractor to date has purchased the Accu-Shear system and one contractor to date has acquired the AQUABlack system.
Iowa	
Kansas	We have not seen any mositure damage or rutting in any of the WMA projects, though the longest has been down for just a year.
Maine	Moisture damage to the WMA projects is unknown to the date. No rutting observed in these projects to date. All have been thin overlays.
Manitoba, Canada	
Michigan	first official project will be this summer
Minnesota	
Missouri	
Montana(1)	One other project utilized foaming technology but the specific system was not noted.
Montana(2)	
Nebraska	
Nevada(1)	
Nevada(2)	None.
New Hampshire	
New York	
Ohio	Contractors in Ohio use any of the above foaming equipment. I do not currently have a count of each type. Total is about 70 plants. We are not using other foam processes like WAM, LEA etc
Oregon	
Saskatchewan	No data is available on rutting/moisture damage at this time.
South Dakota	
Utah	
Vermont	
Washington	Since WMA has only been used for a couple of years it is difficult to provide an accurate assessment of performance and maintenance.

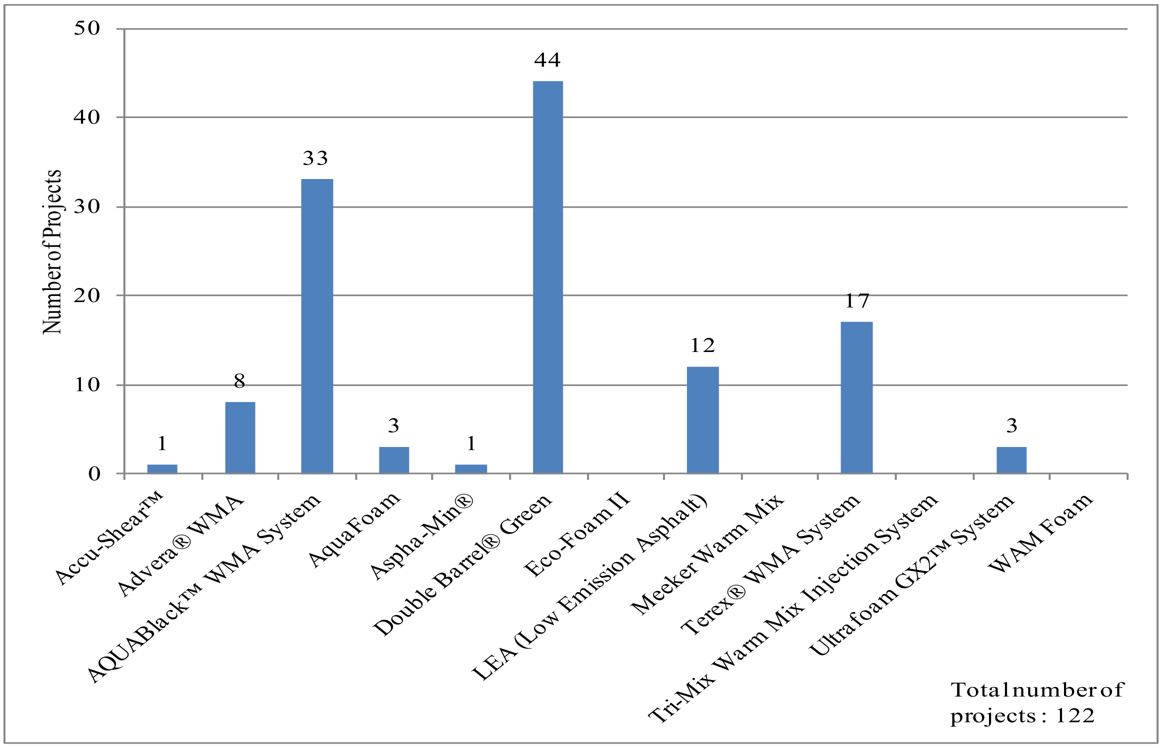

FIGURE B7.2.a Number of constructed projects for each foaming process

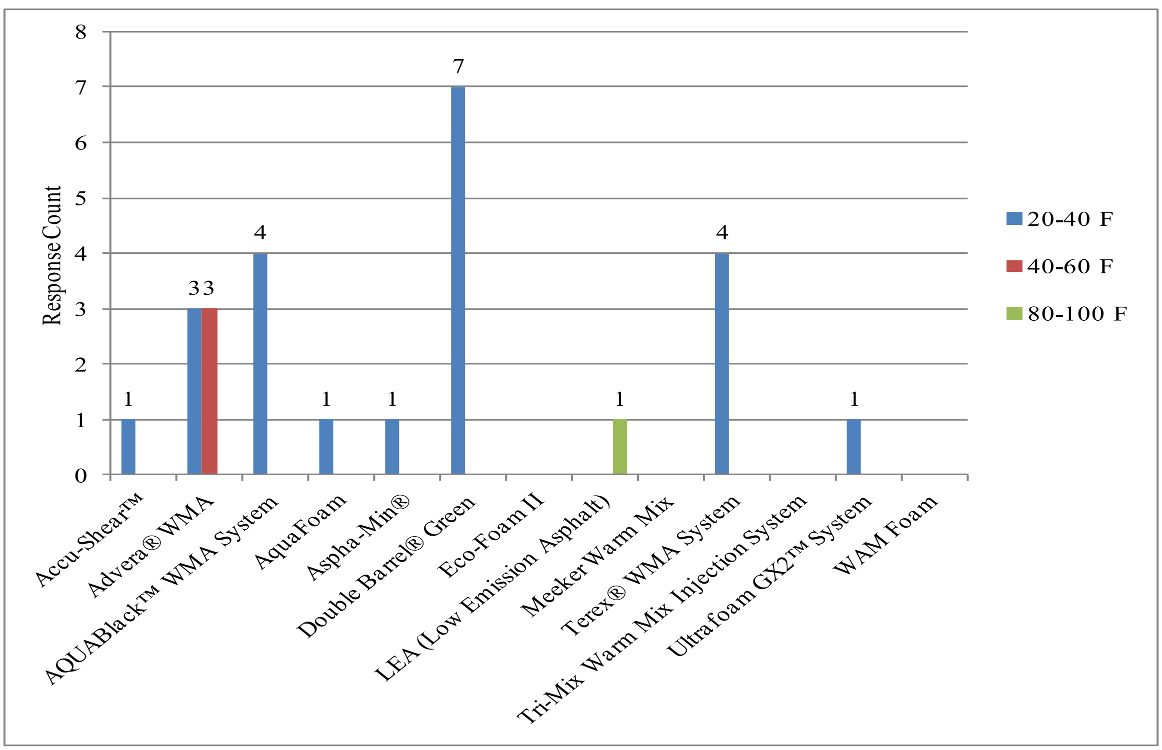

FIGURE B7.2.b Mixing temperature reduction (F) achieved for each foaming process

B7.3. Technology - Organic Additives

Table B7.3 For each of the three main processes below please specify the followings: In how many of your agency projects was the technology implemented? How much reduction in mixing temperature could you achieve compared to HMA projects? Have you observed moisture damage and/or rutting on your warm mix projects? If yes, in how many projects did you observe them? If there were other distresses, please list them in the comment box.

State	Number of Constructed Projects Astech PER®	Mixing Temperature Reduction Achieved (°F) Astech PER®	Number of Projects with Moisture Damage Astech PER®	Number of Projects with Rutting Astech PER®
Colorado				
Idaho				
Indiana				
Iowa				
Kansas				
Maine				
Manitoba, Canada				
Michigan				
Minnesota				
Missouri				
Montana(1)				
Montana(2)				
Nebraska				
Nevada(1)				
Nevada(2)				
New Hampshire				
New York				
Ohio				
Oregon				
Saskatchewan				
South Dakota				
Utah				
Vermont				
Washington				

Table B7.3 Continued

State	Number of Constructed Projects Sasobit®	Mixing Temperature Reduction Achieved (°F) Sasobit®	Number of Projects with Moisture Damage Sasobit®	Number of Projects with Rutting Sasobit®
Colorado	1	20-40		
Idaho				
Indiana				
Iowa	1	20-40		
Kansas				
Maine				
Manitoba, Canada	1	40-60		
Michigan				
Minnesota				
Missouri	8	20-40		
Montana(1)				
Montana(2)				
Nebraska	1	80-100		
Nevada(1)				
Nevada(2)				
New Hampshire				
New York	1	40-60		
Ohio	1	40-60		
Oregon				
Saskatchewan				
South Dakota	1			
Utah				
Vermont				
Washington	1	20-40		

Table B7.3 Continued

State	Number of Constructed Projects SonneWarmix ™	Mixing Temperature Reduction Achieved (°F) SonneWarmix ™	Number of Projects with Moisture Damage SonneWarmix ™	Number of Projects with Rutting SonneWarmix ™
Colorado				
Idaho				
Indiana				
Iowa				
Kansas				
Maine	2	20-40		
Manitoba, Canada				
Michigan				
Minnesota				
Missouri				
Montana(1)				
Montana(2)				
Nebraska				
Nevada(1)				
Nevada(2)				
New Hampshire				
New York				
Ohio				
Oregon				
Saskatchewan				
South Dakota				
Utah				
Vermont				
Washington				

Table B7.3 Continued

State	Number of Constructed Projects Thiopave™	Mixing Temperature Reduction Achieved (°F) Thiopave™	Number of Projects with Moisture Damage Thiopave™	Number of Projects with Rutting Thiopave™
Colorado				
Idaho				
Indiana				
Iowa				
Kansas				
Maine				
Manitoba, Canada				
Michigan				
Minnesota				
Missouri	3	20-40		
Montana(1)				
Montana(2)				
Nebraska				
Nevada(1)				
Nevada(2)				
New Hampshire				
New York				
Ohio				
Oregon				
Saskatchewan				
South Dakota				
Utah				
Vermont				
Washington				

Table B7.3 Continued

State	Number of Constructed Projects TLA-X™ Warm Mix	Mixing Temperature Reduction Achieved (°F) TLA-X™ Warm Mix	Number of Projects with Moisture Damage TLA-X™ Warm Mix	Number of Projects with Rutting TLA-X™ Warm Mix
Colorado				
Idaho				
Indiana				
Iowa				
Kansas				
Maine				
Manitoba, Canada				
Michigan				
Minnesota				
Missouri				
Montana(1)				
Montana(2)				
Nebraska				
Nevada(1)				
Nevada(2)				
New Hampshire				
New York				
Ohio				
Oregon				
Saskatchewan				
South Dakota				
Utah				
Vermont				
Washington				

Table B7.3 Continued

State	Please list other technologies and/or other distresses not listed above
Colorado	
Idaho	
Indiana	Organic additives are not currently permitted.
Iowa	Sasobit (1 project) no performance issues, though the TSR failed on both the WMA and HMA control section.
Kansas	
Maine	Each project less than one year old, no distress observed at this time.
Manitoba, Canada	
Michigan	
Minnesota	Planning on 1 project with Leadcap
Missouri	
Montana(1)	We have an experimental project in place that will begin in about 3 weeks that will utilize Sasobit additive.
Montana(2)	
Nebraska	
Nevada(1)	
Nevada(2)	None
New Hampshire	
New York	
Ohio	
Oregon	
Saskatchewan	
South Dakota	
Utah	
Vermont	
Washington	Since WMA has only been used for a couple of years it is difficult to provide an accurate assessment of performance and maintenance.

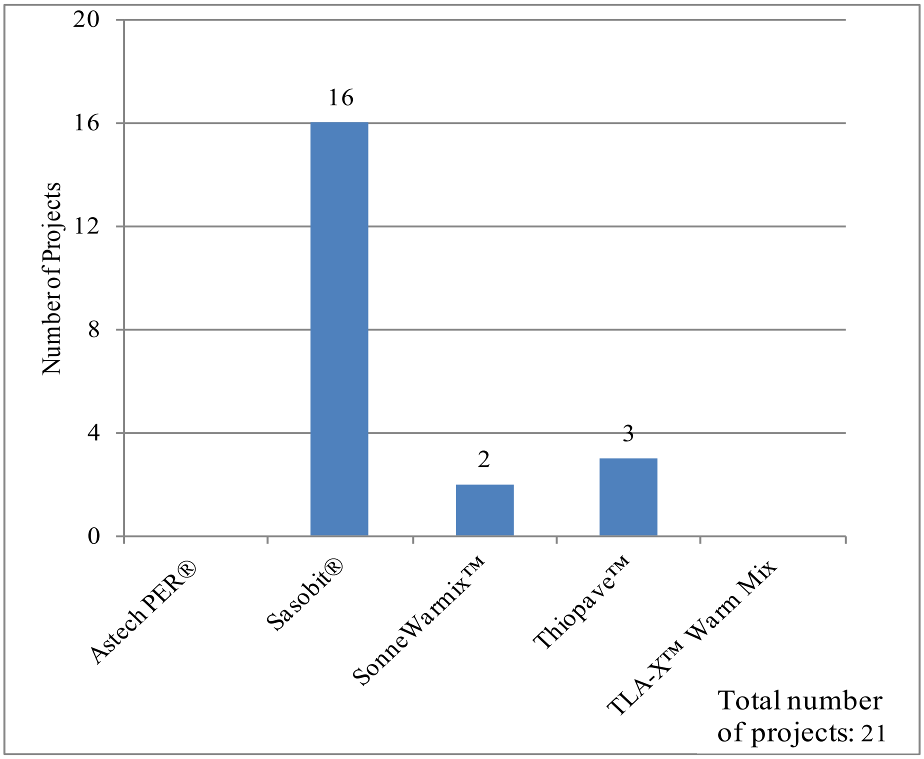

FIGURE B7.3.a Number of constructed projects for each organic additive

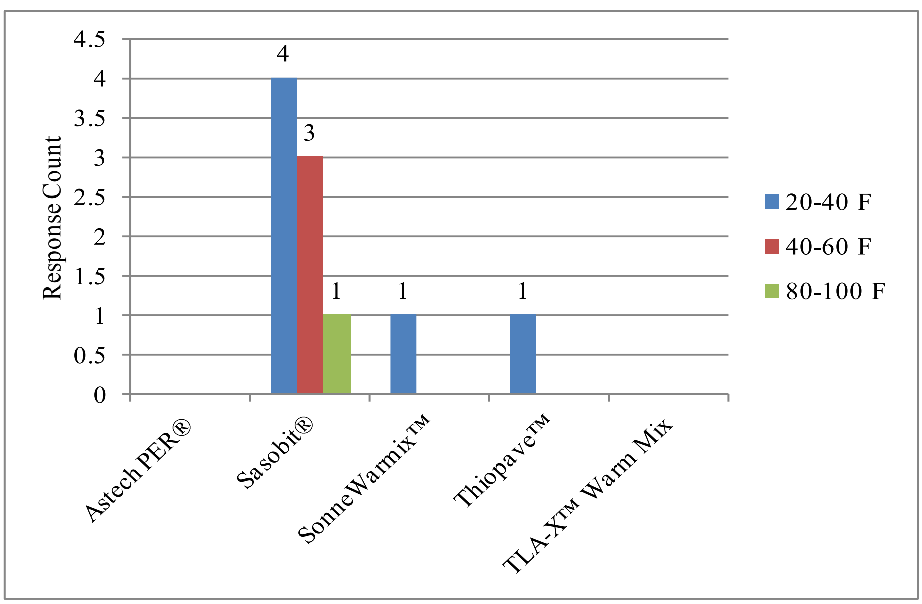

FIGURE B7.3.b Mixing temperature reduction (F) achieved for each organic additive

B8. Mix Design - WMA Material Selection Modifications

Table B8 In your WMA Material Selection, which of the items below has been modified compared to HMA mix design? (please explain in the comment box)

State	Binder Selection	Aggregate Properties	Volumetric Parameters (VMA & VFA)	Recycled Asphalt Pavement (Content/Gradation)	Additives (Types/Percentage)	No Modifications of Any Items
Colorado			Volumetric Parameters (VMA & VFA)			
Idaho						No Modifications of Any Items
Indiana						No Modifications of Any Items
Iowa	Binder Selection					
Kansas						No Modifications of Any Items
Maine						No Modifications of Any Items
Manitoba, Canada						No Modifications of Any Items
Michigan						No Modifications of Any Items
Minnesota						
Missouri						No Modifications of Any Items
Montana(1)				Recycled Asphalt Pavement (content/gradation)		
Montana(2)						
Nebraska					Additives (types/percentage)	No Modifications of Any Items
Nevada(1)	Binder Selection					
Nevada(2)						
New Hampshire						No Modifications of Any Items
New York						No Modifications of Any Items
Ohio						No Modifications of Any Items
Oregon						
Saskatchewan						No Modifications of Any Items
South Dakota						
Utah						No Modifications of Any Items
Vermont						No Modifications of Any Items
Washington						No Modifications of Any Items

Table B8 Comment section

State	Comments
Colorado	Lab volumetrics are run at standard super-pave temperatures; ergo, lab voids are typically below spec levels. We calculate an volumetric offset for each mix design, which is applied to the lab results and accounts for the higher compaction temperatures in the lab.
Idaho	
Indiana	Indiana has treated the foaming process as a drop-in technology. We do not require the contractor to fabricate the mix design or production control specimens at WMA temperatures. All gyratory fabricated specimens, including our acceptance samples, are made at HMA temperatures, which for us means 300F regardless of the production temperature.
Iowa	We have implemented NCHRP 9-43 recommendations to use proposed compaction temperature in the binder grade selection depending on the aging index.
Kansas	
Maine	Warm-mix is being evaluated in the same terms as HMA.
Manitoba, Canada	
Michigan	
Minnesota	Do not allow shingles on some projects.
Missouri	
Montana(1)	Our current warm mix bituminous surfacing specifications do not allow incorporation of recycled asphalt pavement.
Montana(2)	
Nebraska	Modifications may be made to type of antistrip used on the project.
Nevada(1)	
Nevada(2)	
New Hampshire	
New York	
Ohio	
Oregon	
Saskatchewan	No modifications have taken place at this time as WMA is in the early trial stages.
South Dakota	used manufacturers recommendations mix design and field volumetrics will be areas that need work
Utah	
Vermont	
Washington	

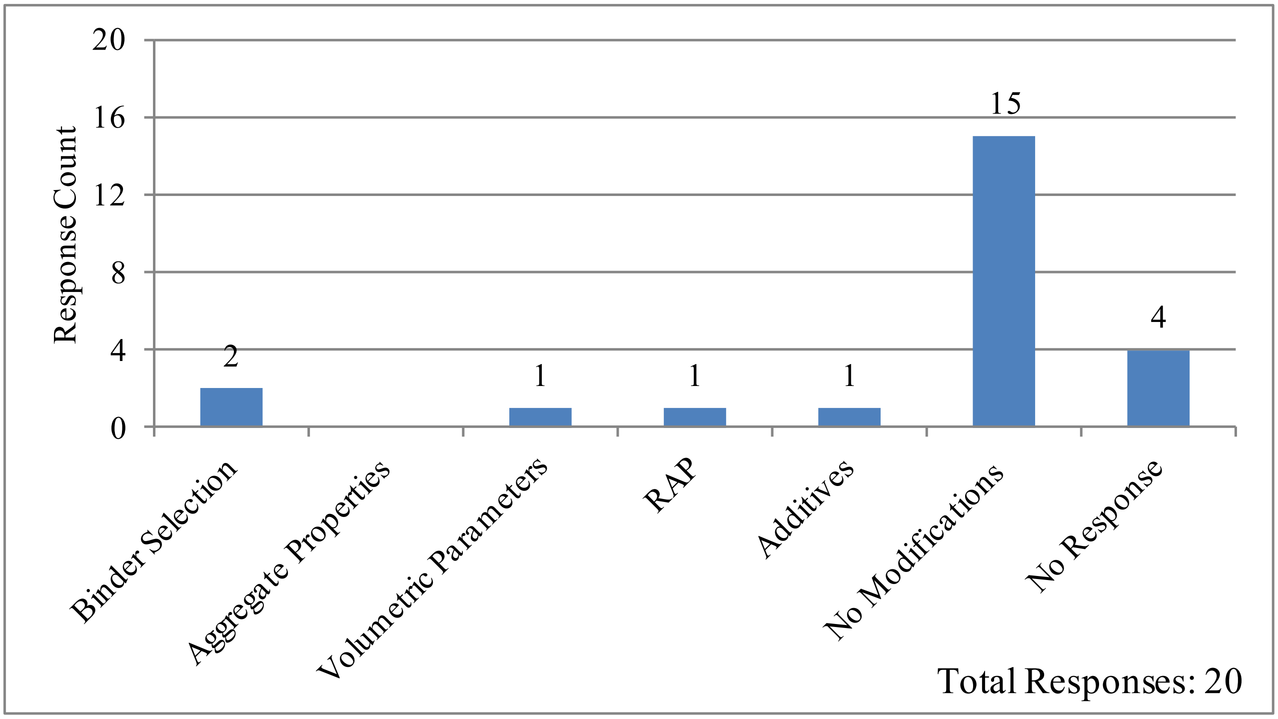

FIGURE B8 Modifications in WMA material selections items compared to HMA

B9. Mix Design - WMA Binder Selection Modifications

Table B9 In your WMA Binder Selection, which of the items below has been modified compared to HMA mix design? (please explain in the comment box)

State	Binder Content	Binder Grade	Binder Preparation/Testing	No Modifications of Any Items	Comments
Colorado				No Modifications of Any Items	
Idaho				No Modifications of Any Items	
Indiana				No Modifications of Any Items	
Iowa		Binder Grade			We suspect 0.1-0.2 in optimum binder content when specimens are fabricated using the WMA technology.
Kansas				No Modifications of Any Items	
Maine				No Modifications of Any Items	
Manitoba, Canada				No Modifications of Any Items	
Michigan				No Modifications of Any Items	
Minnesota				No Modifications of Any Items	
Missouri				No Modifications of Any Items	
Montana(1)				No Modifications of Any Items	
Montana(2)					
Nebraska				No Modifications of Any Items	
Nevada(1)	Binder Content				Adjusted for reduced absorption.
Nevada(2)					
New Hampshire				No Modifications of Any Items	
New York				No Modifications of Any Items	
Ohio				No Modifications of Any Items	
Oregon					
Saskatchewan				No Modifications of Any Items	No modifications have taken place at this time as WMA is in the early trial stages.
South Dakota	Binder Content		Binder Preparation/Testing		
Utah				No Modifications of Any Items	
Vermont				No Modifications of Any Items	
Washington				No Modifications of Any Items	

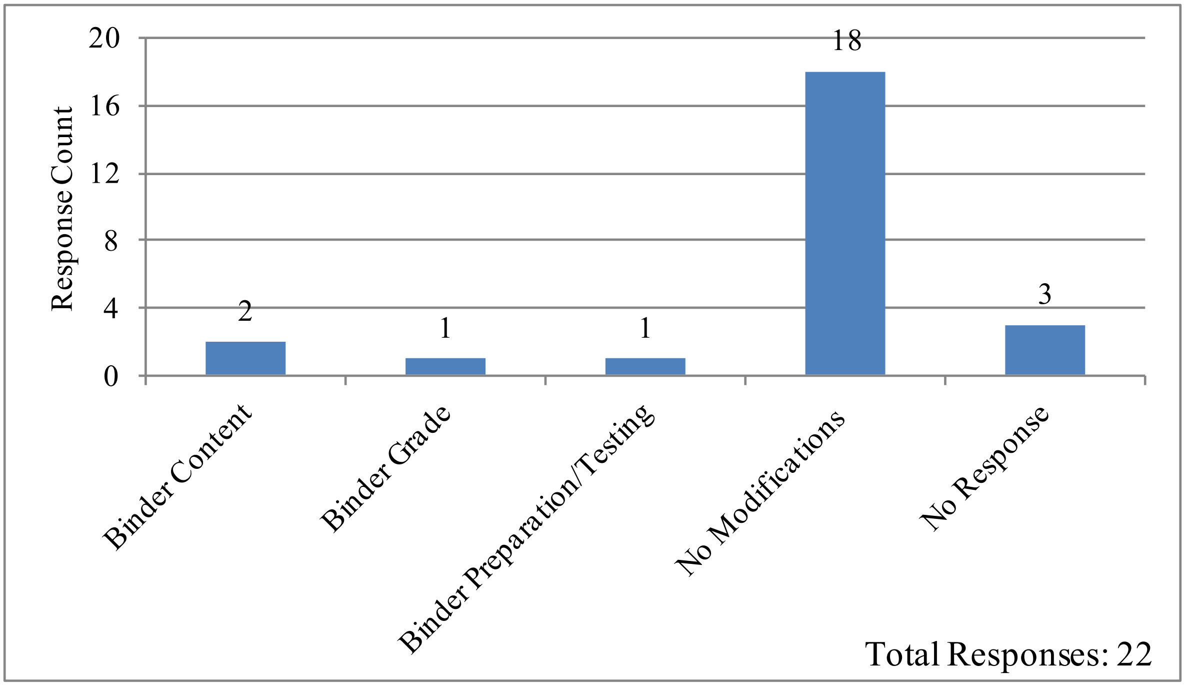

FIGURE B9 Modifications in WMA binder selection items compared to HMA

B10. Mix Design - WMA Design Aggregate Structure Modifications

Table B10 In your WMA Design Aggregate Structure, which of the items below has been modified compared to HMA mix design? (Please explain in the comment box)

State	Aggregate Sources	Nominal Maximum Aggregate Size	Trial Gradations	Aggregate Compaction	No Modifications of Any Items	Other Aggregate Properties
Colorado					No Modifications of Any Items	
Idaho					No Modifications of Any Items	
Indiana					No Modifications of Any Items	
Iowa						
Kansas					No Modifications of Any Items	
Maine					No Modifications of Any Items	
Manitoba, Canada					No Modifications of Any Items	
Michigan					No Modifications of Any Items	
Minnesota					No Modifications of Any Items	
Missouri					No Modifications of Any Items	
Montana(1)					No Modifications of Any Items	
Montana(2)						
Nebraska					No Modifications of Any Items	
Nevada(1)					No Modifications of Any Items	
Nevada(2)						
New Hampshire					No Modifications of Any Items	
New York					No Modifications of Any Items	
Ohio					No Modifications of Any Items	
Oregon						
Saskatchewan					No Modifications of Any Items	No modifications have taken place at this time as WMA is in the early trial stages.
South Dakota						
Utah					No Modifications of Any Items	
Vermont					No Modifications of Any Items	
Washington					No Modifications of Any Items	

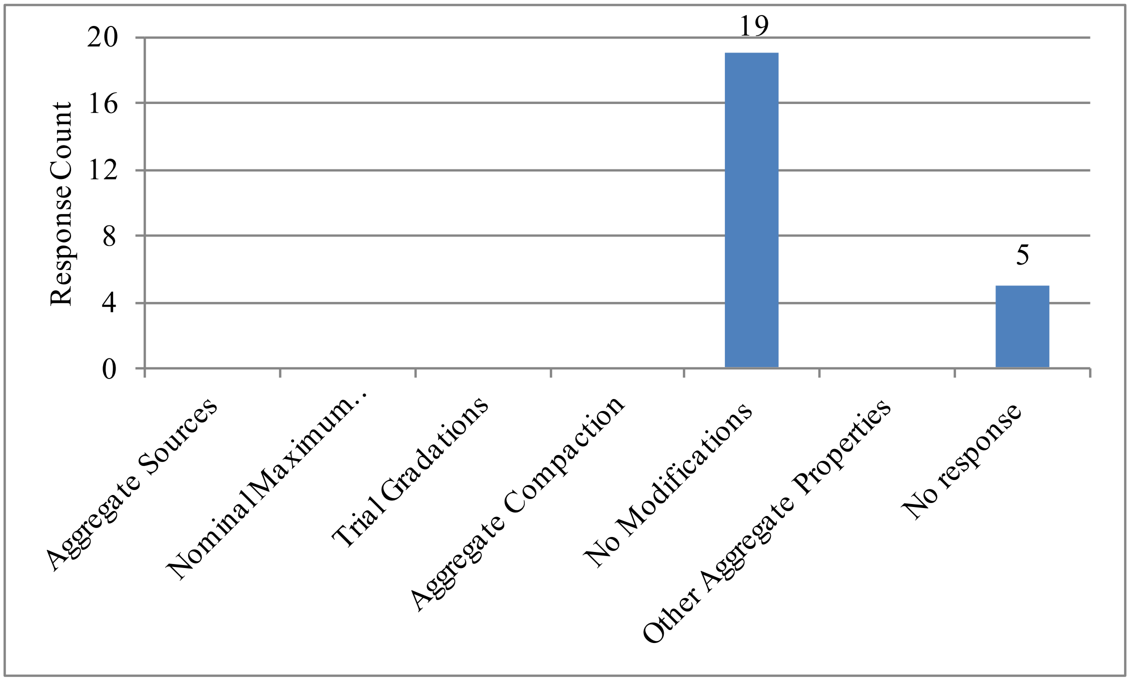

FIGURE B10 Modifications in WMA design aggregate structure compared to HMA

B11. Mix Design - WMA Lab Performance Tests Modifications

Table B11 In your WMA Lab Performance Tests, which of the testing below has been modified compared to HMA mix design? (Please explain in the comment box)

State	Rutting-Specimen Preparation	Rutting-Testing and Procedure	Thermal Cracking-Specimen Preparation	Thermal Cracking-Testing and Procedure
Colorado				
Idaho				
Indiana				
Iowa				
Kansas				
Maine				
Manitoba, Canada				
Michigan				
Minnesota				
Missouri				
Montana(1)				
Montana(2)				
Nebraska				
Nevada(1)				
Nevada(2)				
New Hampshire				
New York				
Ohio				
Oregon				
Saskatchewan				
South Dakota				
Utah				
Vermont				
Washington				

Table B11 Continued

State	Fatigue-Specimen Preparation	Fatigue-Testing and Procedure	Moisture Sensitivity-Specimen Preparation	Moisture Sensitivity-Testing and Procedure
Colorado				
Idaho			Specimen Preparation	Testing and Procedure
Indiana				
Iowa			Specimen Preparation	
Kansas				
Maine				
Manitoba, Canada				
Michigan				
Minnesota			Specimen Preparation	
Missouri				
Montana(1)				
Montana(2)				
Nebraska				
Nevada(1)				
Nevada(2)				
New Hampshire				
New York				
Ohio				
Oregon				
Saskatchewan				
South Dakota				
Utah				
Vermont				
Washington				

Table B11 Continued

State	No Modifications of Any Items-Specimen Preparation	No Modifications of Any Items-Testing and Procedure
Colorado	Specimen Preparation	Testing and Procedure
Idaho		
Indiana	Specimen Preparation	Testing and Procedure
Iowa		Testing and Procedure
Kansas	Specimen Preparation	Testing and Procedure
Maine	Specimen Preparation	Testing and Procedure
Manitoba, Canada		
Michigan		
Minnesota		
Missouri	Specimen Preparation	Testing and Procedure
Montana(1)	Specimen Preparation	Testing and Procedure
Montana(2)		
Nebraska	Specimen Preparation	Testing and Procedure
Nevada(1)	Specimen Preparation	Testing and Procedure
Nevada(2)		
New Hampshire	Specimen Preparation	Testing and Procedure
New York	Specimen Preparation	Testing and Procedure
Ohio	Specimen Preparation	Testing and Procedure
Oregon		
Saskatchewan	Specimen Preparation	Testing and Procedure
South Dakota		
Utah	Specimen Preparation	Testing and Procedure
Vermont	Specimen Preparation	Testing and Procedure
Washington		

Table B11 Continued

State	Comments
Colorado	Lab volumetrics are run at standard super-pave temperatures; ergo, lab voids are typically below spec levels. We calculate an volumetric offset for each mix design, which is applied to the lab results and accounts for the higher compaction temperatures in the lab.
Idaho	AASHTO T 165 done at test strip, in addition to being done at design, with plant produced material.
Indiana	
Iowa	We require the specimens are fabricated with the WMA technology (except foaming at this point since no contractor has a foaming table).
Kansas	
Maine	
Manitoba, Canada	MIT does not conduct performance tests as part of our mix design
Michigan	None at this time
Minnesota	Lower compaction temperature.
Missouri	
Montana(1)	
Montana(2)	
Nebraska	
Nevada(1)	We will modify to match proposed field mixing and compacting temps.
Nevada(2)	
New Hampshire	
New York	
Ohio	
Oregon	
Saskatchewan	No modifications have taken place at this time as WMA is in the early trial stages.
South Dakota	
Utah	
Vermont	
Washington	To date only the Sasobit additive was evaluated during mix design analysis, all other WMA technologies have been used during production with no mix design evaluation.

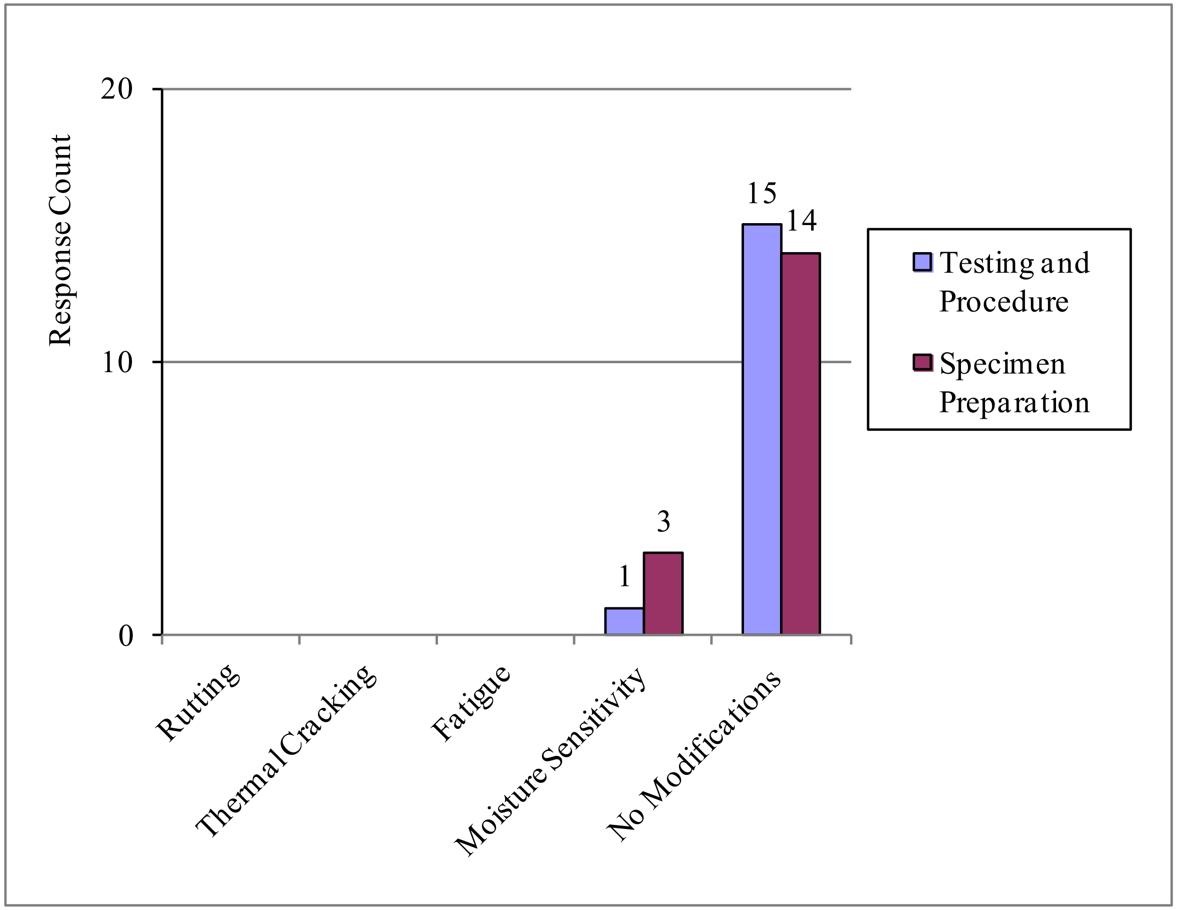

FIGURE B11 WMA lab performance tests modifications compared to HMA

B12. Mix Design – WMA Anti-Stripping Agent Modifications

Table B12 Compared to HMA, does your agency require to modify the amount of anti-stripping agent used for WMA? If yes, please specify how? Also if any other types of additives are required for WMA, please specify in the comment box**.**

State	Does your agency require to modify the amount of anti-stripping agent used for WMA?	Comments
Colorado	No	
Idaho	No	
Indiana	No	Our mix design procedures incorporate AASHTO T-283. We do not conduct stripping tests on production samples. Indiana, overall, does not have stripping sensitive aggregates and overall we see very little use of anti-stripping materials.
Iowa	No	The dosage is not prescribed for neither HMA nor WMA. It is optimized by evaluating TSR over 3 dosage rates.
Kansas	No	
Maine	No	Not at this time. Potential changes in the future.
Manitoba, Canada	No	
Michigan	No	
Minnesota	No	
Missouri	No	
Montana(1)	No	
Montana(2)		
Nebraska	Yes	Yes, currently we require 1.0% lime by weight of virgin aggregate. For evotherm or any other WMA with amine antistrip material no lime is added, but the contractor must find a way to meet 80% or greater on TSR. Most other additives still require 1.0% lime at this time, but this is still preliminary.
Nevada(1)	No	We already require 1.5% lime by 48-hour marination.
Nevada(2)		
New Hampshire		No additives required
New York	No	
Ohio	No	
Oregon		
Saskatchewan	No	1% lime is generally required in all Saskatchewan mixes regardless of mixing temperature.
South Dakota	No	
Utah	No	
Vermont	No	
Washington	No	

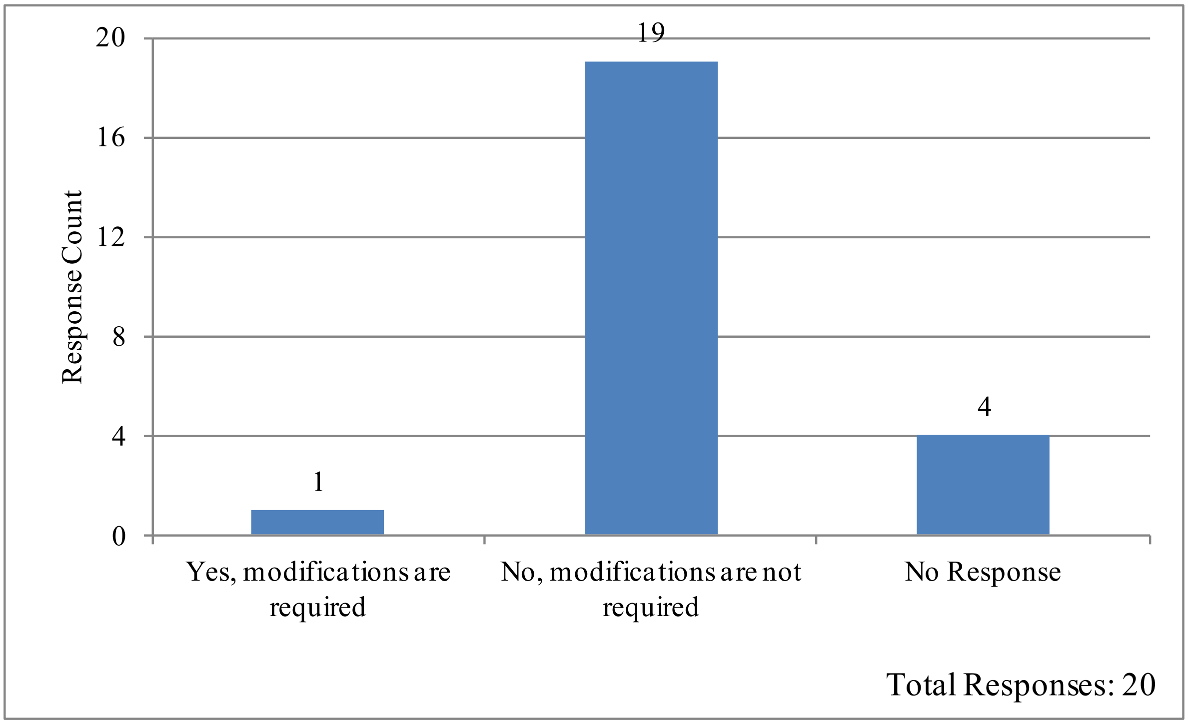

FIGURE B12 WMA requirements on anti-stripping agent compared to HMA

B13. Mix Design - RAP and RAS Utilization in WMA

Table B13 For which of the following does your agency have different requirements (percentage/processing/testing) compared to HMA? Please specify in the comment box below.

State	RAP (Reclaimed Asphalt Pavement)	RAS (Reclaimed Asphalt Shingles)	Comments
Colorado	No	Yes	
Idaho	No	No	
Indiana	No	No	Indiana has one set of standards for using recycled materials.
Iowa	No	No	
Kansas	No	No	
Maine	No	No	
Manitoba, Canada	No		MIT does not use RAS.
Michigan	Yes	Yes	
Minnesota	No	No	
Missouri	No	No	
Montana(1)	Yes	No	Asphalt Shingles are not allowed in either HMA or WMA at this point in time. RAP is allowed in HMA but not allowed in WMA.
Montana(2)			
Nebraska	No	No	
Nevada(1)	No	No	We allow 15% max RAP and do not allow Shingles.
Nevada(2)			
New Hampshire	No	No	
New York	No	No	
Ohio	No	No	
Oregon			
Saskatchewan	No	No	RAS is not used in Saskatchewan
South Dakota	No		
Utah	No		
Vermont	No	No	
Washington			Requirments are the same for use of RAP, WSDOT does not allow the use of RAS under current specifications.

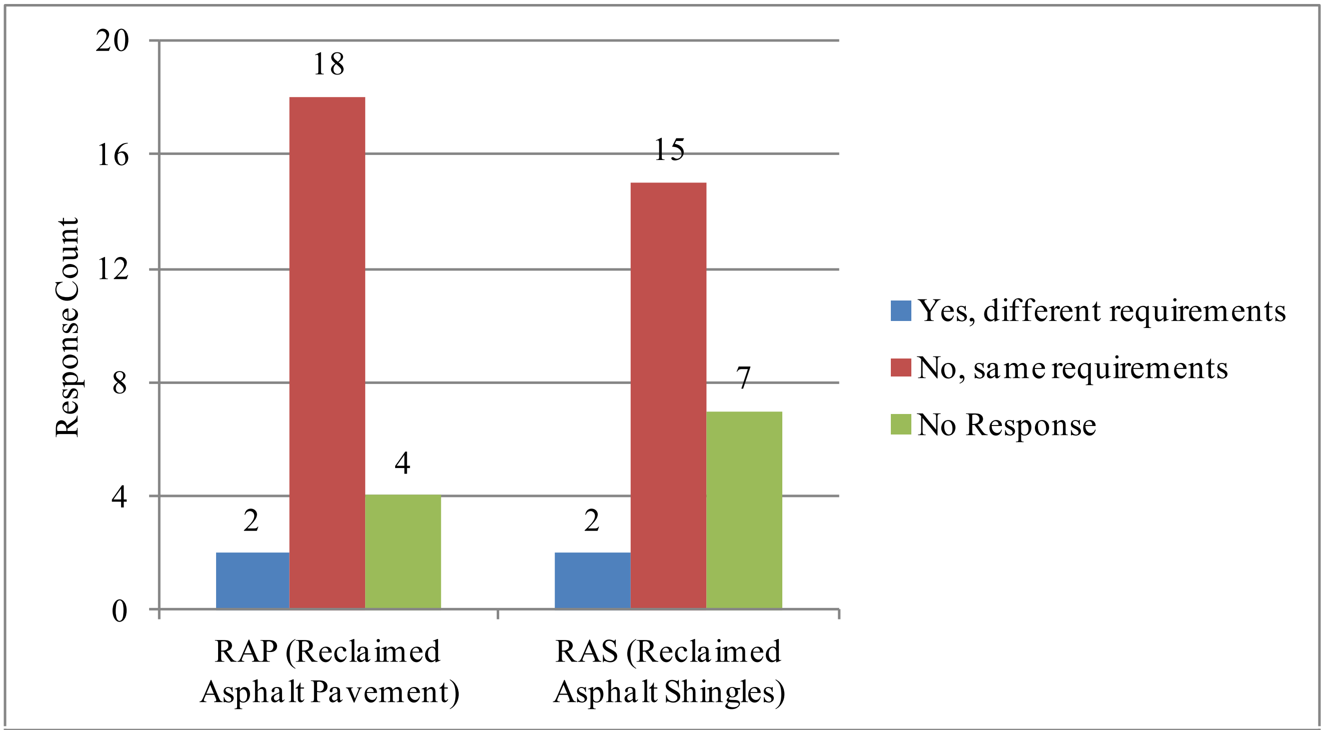

FIGURE B13 WMA requirements on RAP and RAS compared to HMA

B14. Mix Design - WMA Mix Design Dependence on WMA Technology

Table B14 If Modifications are made, does the design for WMA depend on the WMA technology used? (If yes, please explain how)

State	Does the design for WMA depend on the WMA technology used?	Comments
Colorado		
Idaho		
Indiana	No	
Iowa	Yes	All additives need to be included in the specimen fabrication. For the time being, contractors do not need a foaming table to do a foam design. We will require the raw materials be sent to our lab where we will foam the contractor's design and compare air voids. If we see a significant difference between the foamed and HMA designs we will eventually require contractors to foam their designs.
Kansas	No	
Maine	No	
Manitoba, Canada		No modifications have been made to date.
Michigan	No	
Minnesota	No	
Missouri		
Montana(1)	Yes	A mix design needs to be submitted for MDT approval for the specific WMA technology utilized.
Montana(2)		
Nebraska	No	
Nevada(1)	Yes	Depending on proposed mixing and compacting temps.
Nevada(2)		
New Hampshire		No modifications at this time
New York	No	
Ohio		
Oregon		
Saskatchewan		
South Dakota	Yes	
Utah	No	
Vermont	No	
Washington		N/A

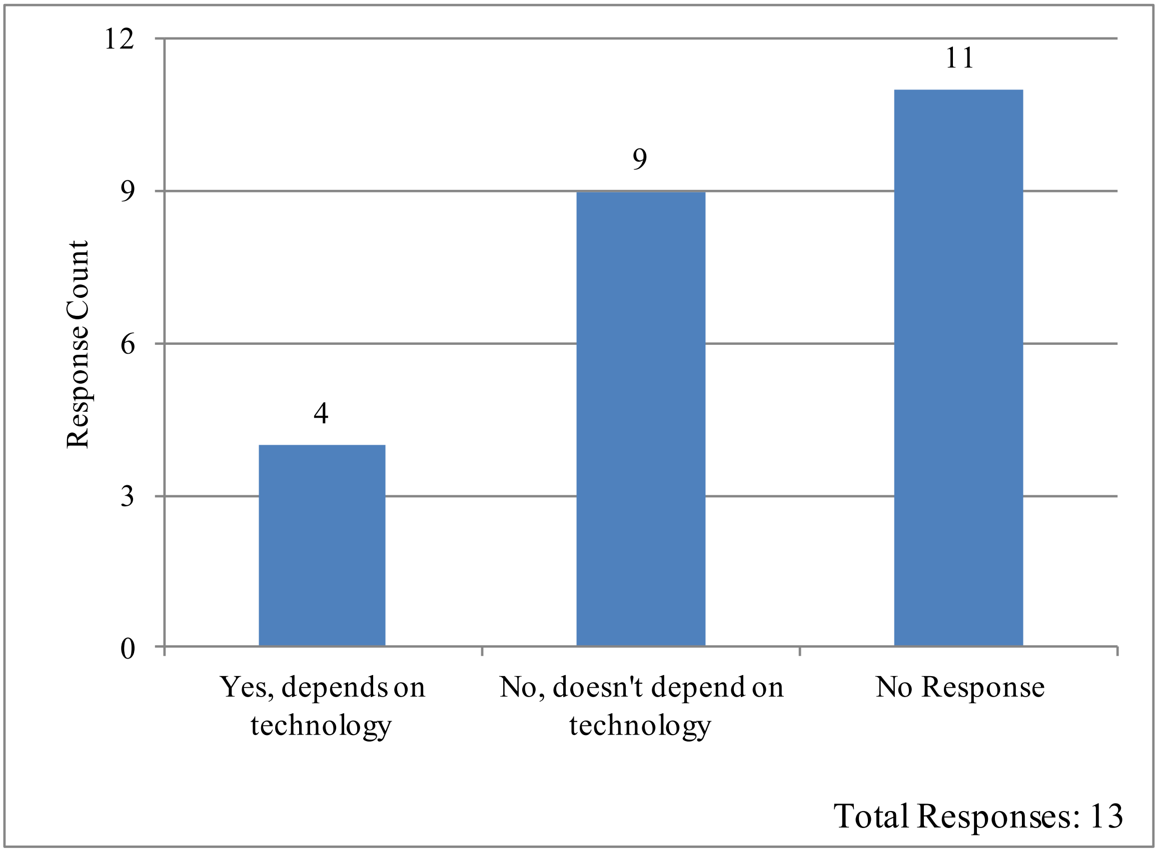

FIGURE B14 WMA design dependence on the technology employed

B15. Specifications - Agencies Mechanisms for WMA Development

Table B15 What are the mechanisms for developing warm mix asphalt in your agency? In the comment box, please provide your most recent documents/web links for each of the items below. (Either copy the web link(s) or email us the document)

State	Separate specification developed for WMA	Approved list of processes	Approval process for non-listed processes proposed	Other (Please Specify)
Colorado		Approved list of processes	Approval process for non-listed processes proposed	
Idaho		Approved list of processes	Approval process for non-listed processes proposed	
Indiana				Indiana has a permissive specification as written into our Standard Specification for foamed asphalt only.
Iowa	Separate specification developed for WMA			No formal approval process. The technology needs to be approved by the Bituminous Engineer. We may eventually adopt an approach similar to Florida (provide results from previous paving histories for new technologies).
Kansas		Approved list of processes	Approval process for non-listed processes proposed	http://www.ksdot.org/burmatrres/pql/pql-04-03.pdf http://www.ksdot.org/burConsMain/specprov/2007/pdf/07-12002.pdf
Maine	Separate specification developed for WMA			Separate special provision developed for Warm-mix technology use.
Manitoba, Canada			Approval process for non-listed processes proposed	
Michigan				Same as HMA
Minnesota	Separate specification developed for WMA			WMA is also allowed under a permissive basis in our standard specification. MnDOT does not have an approved product list.

Table B15 Continued

State	Separate specification developed for WMA	Approved list of processes	Approval process for non-listed processes proposed	Other (please specify)
Missouri				Contractors are choosing the tried and tested processes and tend to shy away from others.
Montana(1)	Separate specification developed for WMA			We have a separate special provision for WMA.
Montana(2)				
Nebraska	Separate specification developed for WMA	Approved list of processes	Approval process for non-listed processes proposed	We are still drafting the specification. Any process may be used, but if it is not on the approved list it will need to go through a trial/research project.
Nevada(1)				We intend to approve specific processes by specific Contractors.
Nevada(2)				
New Hampshire		Approved list of processes		
New York	Separate specification developed for WMA	Approved list of processes	Approval process for non-listed processes proposed	
Ohio				We only allow foaming. HMA Specs allow use of WMA except where restricted in specific mix types. Contractors can propose other processes but so far have not.
Oregon				
Saskatchewan				Nothing at this time.
South Dakota	Separate specification developed for WMA			Research project
Utah				Same as Hot Mix
Vermont				Project Special Provision modifying sections of HMA specification. Currently being developed.
Washington				Use of WMA is optional to the Contractors but must be proposed and approved by WSDOT.

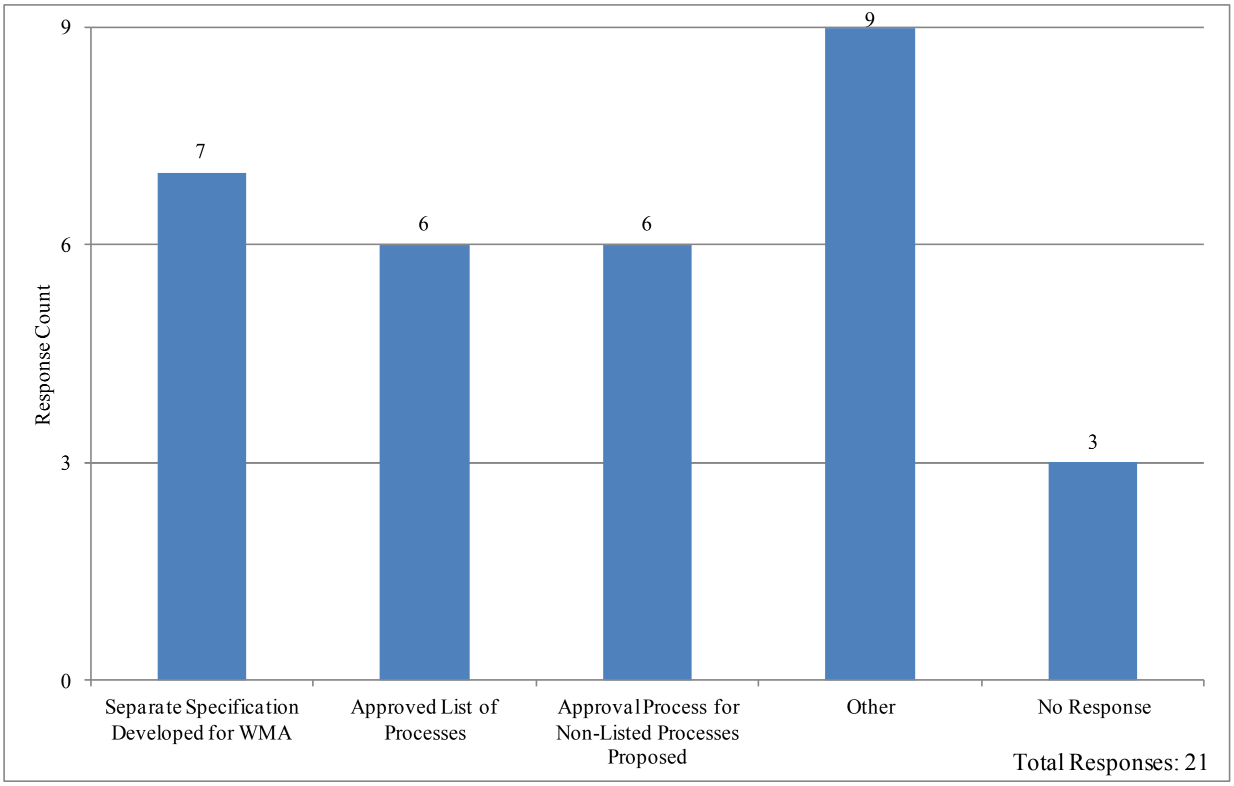

FIGURE B15 Mechanisms for developing warm mix asphalt in agencies

B16. Specifications - Specifications or Approval Procedures Development

Table B16 How did you develop your agency specification or approval procedure? (in the comment box please specify the reference your agency used for the first two choices)

State	Based on National Studies/Guidelines (Such as NCHRP Reports)	Based on Other DOTs Specifications	Developed by Your Own Agency	Comments
Colorado	Based on national studies/guidelines (such as NCHRP reports)		Developed by your own agency	
Idaho	Based on national studies/guidelines (such as NCHRP reports)		Developed by your own agency	NCHRP Report 691 under study for implementation
Indiana			Developed by your own agency	
Iowa	Based on national studies/guidelines (such as NCHRP reports)		Developed by your own agency	
Kansas		Based on other DOTs specifications		For now since our experience with WMA has been limited we have used Texas's experience with WMA. Once we have gathered more of our own information we will re-evaluate the steps to get pre-approved.
Maine			Developed by your own agency	May adopt New England agency guidelines for approval process and approved products list.
Manitoba, Canada			Developed by your own agency	
Michigan			Developed by your own agency	Agency and HMA Industry developed
Minnesota	Based on national studies/guidelines (such as NCHRP reports)	Based on other DOTs specifications	Developed by your own agency	
Missouri			Developed by your own agency	
Montana(1)	Based on national studies/guidelines (such as NCHRP reports)	Based on other DOTs specifications		Also based on MDT research of local Federal Lands projects utilizing WMA.
Montana(2)				
Nebraska		Based on other DOTs specifications	Developed by your own agency	We surveyed other DOT specifications and then for that brought in what was pertinent for our specification and local experiences.
Nevada(1)				Not developed yet.
Nevada(2)				
New Hampshire		Based on other DOTs specifications		
New York			Developed by your own agency	
Ohio			Developed by your own agency	
Oregon				

Table B16 Continued

State	Based on national studies/guidelines (such as NCHRP reports)	Based on other DOTs specifications	Developed by your own agency	Comments
Saskatchewan				No agency spec or approval process at this time. Trials are approved on a case by case basis.
South Dakota	Based on national studies/guidelines (such as NCHRP reports)	Based on other DOTs specifications	Developed by your own agency	will use all three to develop spec for state
Utah			Developed by your own agency	
Vermont			Developed by your own agency	
Washington			Developed by your own agency	Worked with Washington Asphalt Pavement Association to develop review and approval process based on nationally recognized processes.

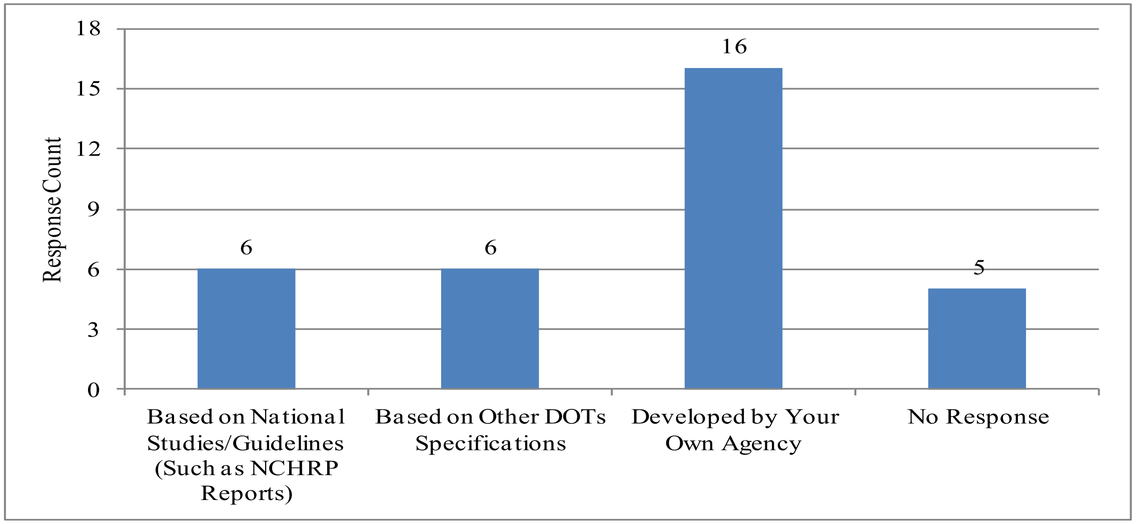

FIGURE B16 Development method for specification or approval procedure in agencies

B17. Specifications - WMA Non-Permitted Technologies or Additives

Table B17 Do you have a list of NOT PERMITTED (WMA technologies, additives, etc...) in any section of your specification? (If yes, please list the Not Permitted items in the comment box below)

State	Do you have a list of NOT PERMITTED (WMA technologies,	Comments
Colorado	No	Currently, some foaming processes are limited to 5,000 tons per project for test sections.
Idaho	No	
Indiana	No	
Iowa	No	Although our lab results with Advera are not encouraging
Kansas	No	
Maine	No	
Manitoba, Canada	No	
Michigan	No	
Minnesota	No	
Missouri	No	
Montana(1)	No	We don't specifically list technologies that we permit, instead we have listed technologies that we do allow.
Montana(2)		
Nebraska	No	
Nevada(1)	No	
Nevada(2)		
New Hampshire	No	
New York	No	If the WMA technology is on our approved list, then it can be used for an entire WMA project. Technologies that have not been put on our Approved List are limited to 1000 ton trial sections.
Ohio	No	
Oregon		
Saskatchewan	No	
South Dakota		not determined at this time
Utah	No	
Vermont	No	
Washington	No	

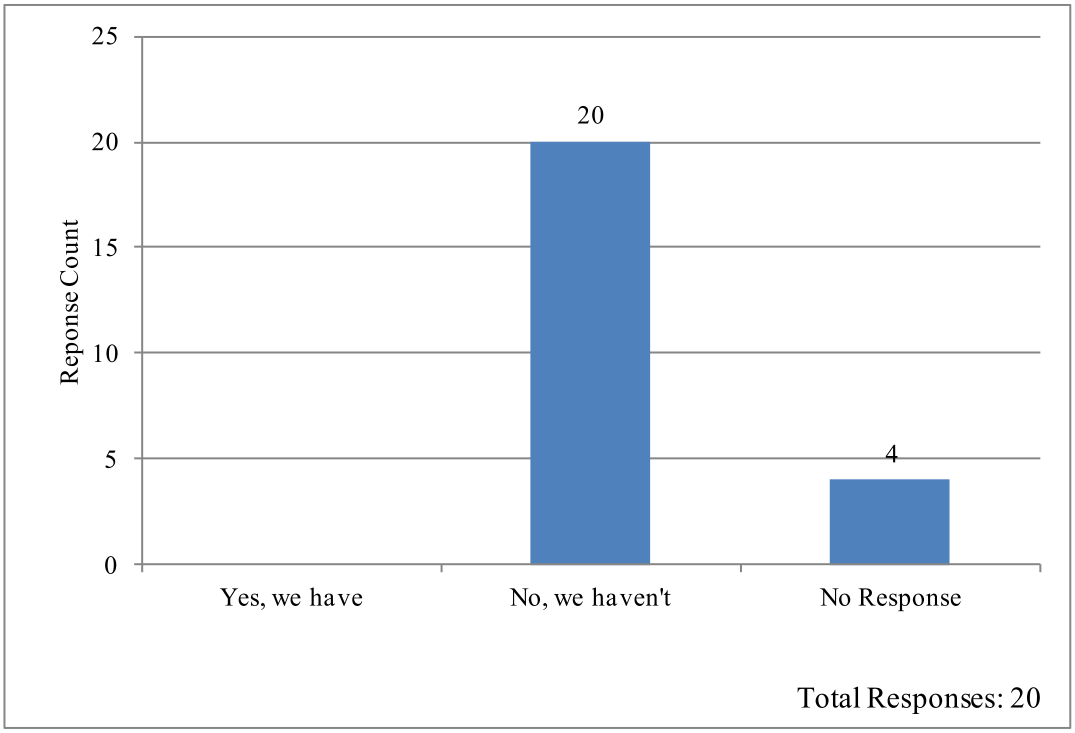

FIGURE B17 Agencies having any NOT-PERMITTED list in their specification

B18. Acceptance plan - WMA Acceptance Plan Modifications

Table B18 Compared to HMA, for which of the WMA acceptance plan components do you have modifications? Please explain in the comment box. Also, could you provide us with your agency acceptance plan for WMA (through web link, email, or hard copy)?

State	Acceptance Sampling Type	Quality Characteristics	Specification Limits	Quality Level Goals	Risk	Pay Factors
Colorado	No	No	No	No	No	No
Idaho		Yes				
Indiana	No	No	No	No	No	No
Iowa	No	No	No	No	No	No
Kansas	No	No	No	No	No	No
Maine	No	No	Yes	No	No	No
Manitoba, Canada						
Michigan	No	No	No	No	No	No
Minnesota	No	No	No	No	No	No
Missouri	No	No	No	No	No	No
Montana(1)	No	No	No	No	No	No
Montana(2)						
Nebraska	No	No	No	No	No	No
Nevada(1)	No	No	No	No	No	No
Nevada(2)						
New Hampshire	No	No	No	No	No	No
New York	No	No	No	No	No	Yes
Ohio	No	No	No	No	No	No
Oregon						
Saskatchewan	No	No	No	No	No	No
South Dakota						
Utah	No	No	No	No	No	No
Vermont	No	No	No	No	No	No
Washington						

Table B18 Comments section

State	Comments (Links or Other Information)
Colorado	
Idaho	
Indiana	Indiana expects all foamed asphalt to meet the HMA criteria.
Iowa	
Kansas	
Maine	Modification to specification limits is for mixing and placement temperatures as determined by the manufacturer recommendations.
Manitoba, Canada	n/a
Michigan	
Minnesota	Only difference is laboratory compaction temperatures.
Missouri	
Montana(1)	
Montana(2)	
Nebraska	
Nevada(1)	
Nevada(2)	
New Hampshire	
New York	Under our current experimetal work plan for WMA, the plant recieves no incentives/disincentives for mixture quality.
Ohio	
Oregon	
Saskatchewan	Acceptance is the same as HMA at this time.
South Dakota	not deermined at this time
Utah	
Vermont	
Washington	No modifications required. http://www.wsdot.wa.gov/biz/construction/word/wmaproposal.docx

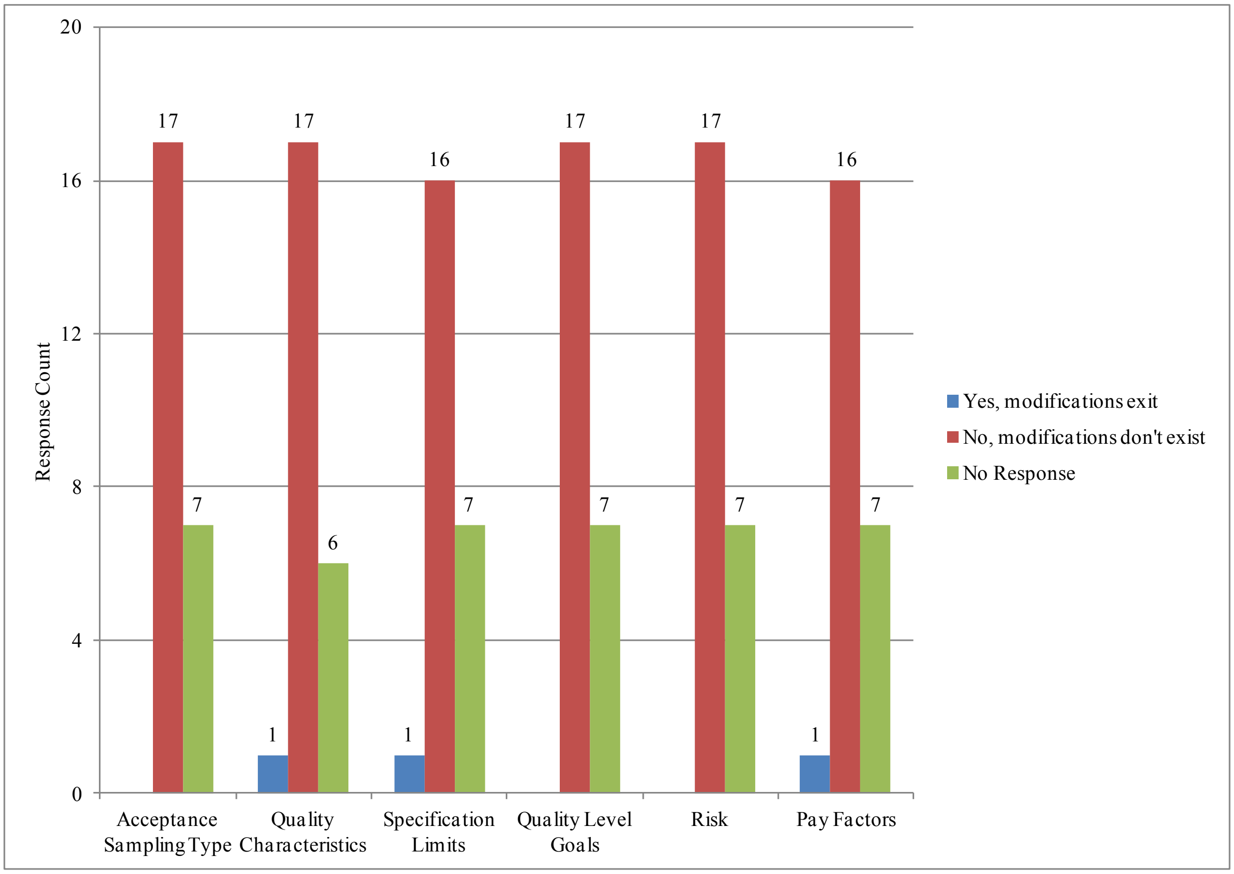

FIGURE B18 Modifications in WMA acceptance plan components compared to HMA

B19. Acceptance Plan - WMA Modifications in Temperature Monitoring

Table B19 Compared to HMA, in which of the following do you have modifications in temperature monitoring for WMA? Please specify in the comment box.

State	Mixing	Construction/Compaction	None	Comments
Colorado			None	
Idaho				
Indiana			None	
Iowa	Mixing	Construction/Compaction		WMA plant temp is proposed as part of the mix design. The design is done at this temperature. Production temp cannot drop more than 10F below the target temp. The max temp for WMA is 280F.
Kansas		Construction/Compaction		For HMA maximum density needs to be achieved by 175 F and for WMA by 165 F.
Maine	Mixing	Construction/Compaction		
Manitoba, Canada	Mixing	Construction/Compaction		
Michigan		Construction/Compaction		
Minnesota			None	
Missouri			None	
Montana(1)			None	
Montana(2)				
Nebraska			None	It is based on manufactures recommendation.
Nevada(1)			None	
Nevada(2)				
New Hampshire			None	
New York	Mixing	Construction/Compaction		Monitoring of the Temperature does not change. The mixing and compaction temperatures are as recommended by the WMA technology provider.
Ohio	Mixing	Construction/Compaction		We compact field specimens at 30 degrees less than the HMA design temp. We target about 30 degrees less at the pavement depending on conditions.
Oregon				
Saskatchewan	Mixing			WMA is mixed at a lower temperature, so plant operators must be aware of this, and adjust temperatures accordingly.
South Dakota	Mixing	Construction/Compaction		
Utah			None	
Vermont			None	Monitoring protocols are the same, only lower temperatures.
Washington			None	

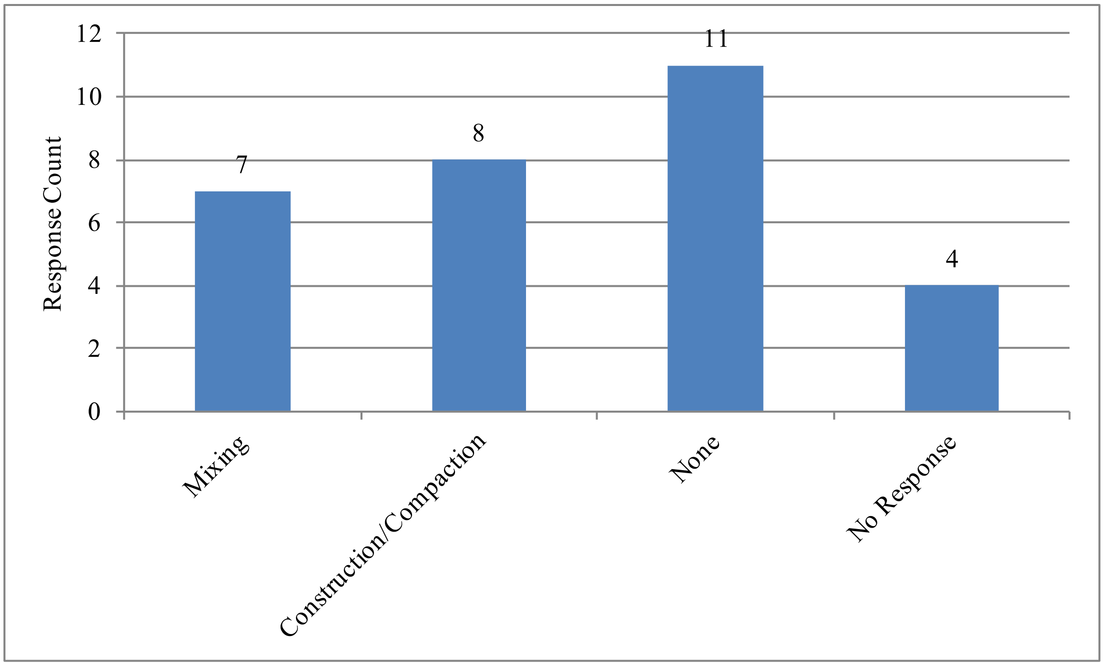

FIGURE B19 Modifications in temperature monitoring for WMA compared to HMA

B20. Acceptance Plan - WMA Modifications in QA Sampling Schedule

Table B20 Is the WMA sampling schedule for quality assurance different from HMA? (If yes, please explain in the comment box)

State	Is the WMA sampling schedule for quality assurance different from HMA?	Comments
Colorado	No	
Idaho	No	
Indiana	No	
Iowa	Yes	Only in the realm of AASHTO T283. We normally only sample T283 for HMA on interstates and quartzite mixes; however, we will sample T283 for all WMA mixes above 3M ESALS.
Kansas	No	
Maine	No	
Manitoba, Canada	No	
Michigan	No	
Minnesota	No	
Missouri	No	
Montana(1)	No	
Montana(2)		
Nebraska	No	
Nevada(1)	No	
Nevada(2)		
New Hampshire	No	
New York	No	
Ohio	No	
Oregon		
Saskatchewan	No	
South Dakota	No	
Utah	No	
Vermont	No	
Washington	No	

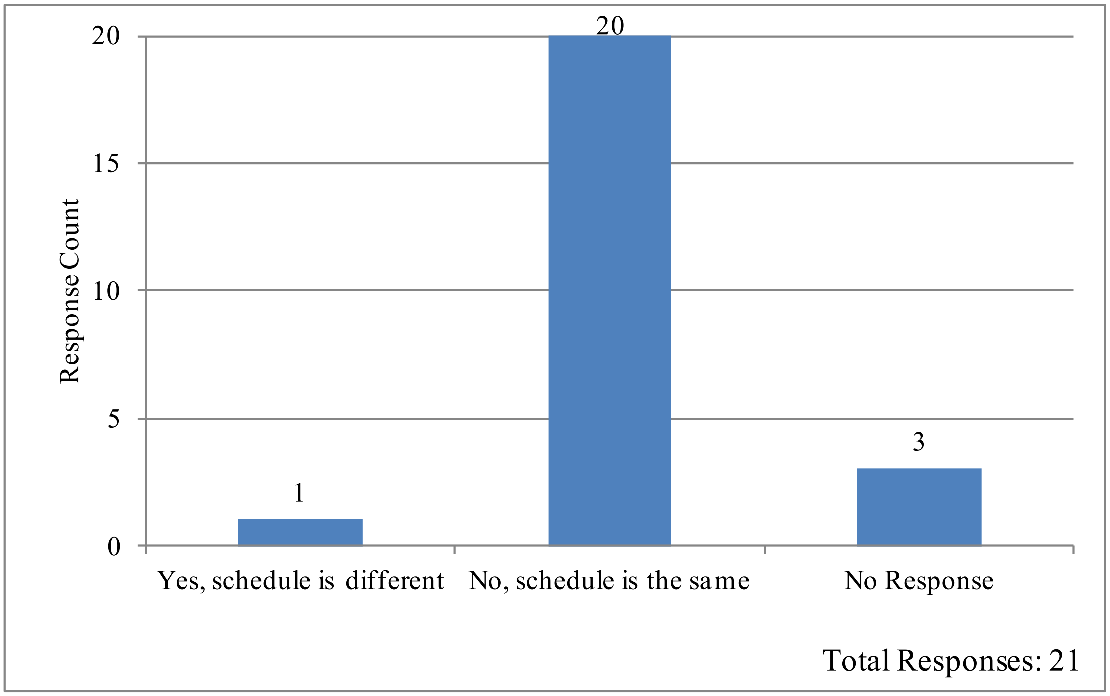

FIGURE B20 Changes in WMA quality assurance sampling schedule compared to HMA

B21. Acceptance Plan - WMA Lab Assurance Testing Modifications

Table B21 For lab assurance testing, in which of the following do you have modifications compared to HMA? Please specify in the comment box.

State	Sample Preparation	Testing Procedure	None	Comments
Colorado			None	Lab volumetrics are run at standard super-pave temperatures; ergo, lab voids are typically below spec levels. We calculate an volumetric offset for each mix design, which is applied to the lab results and accounts for the higher compaction temperatures in the lab.
Idaho		Testing procedure		Foamed WMA Plant produced Material is brought down below 200 F and then brought to HMA temps and tested as HMA. There is an additional AASHTO T-165 test done with plant produced material for foamed WMA.
Indiana			None	
Iowa	Sample preparation			We compact assurance testing to 240F for WMA regardless of technology or compaction temp. (275F for HMA)
Kansas	Sample preparation			The sample preparation will be completed at the warm mix asphalt temperatures if the mateiral is not re-heated. If foaming is used and the material needs to be re-heated then we re-heat the material to HMA temperatures.
Maine			None	
Manitoba, Canada			None	
Michigan			None	
Minnesota	Sample preparation			Lower lab compaction temperatures
Missouri		Testing procedure		Fresh WMA by foaming process is compacted at WMA tempertures. Reheated foamed WMA is compacted at the binder recommeded temperature.
Montana(1)			None	
Montana(2)				
Nebraska			None	
Nevada(1)			None	
Nevada(2)				
New Hampshire			None	

Table B21 Continued

State	Sample preparation	Testing procedure	None	Comments
New Hampshire			None	
New York	Sample preparation			Laboratory samples are compacted at the WMA compaction temperature recommended by the WMA technology provider. One of our Approved technologies recommends conditioning the mixture in an oven prioir to any QC/QA laboratory testing.
Ohio	Sample preparation			30 degrees less compaction temp for WMA.
Oregon				
Saskatchewan			None	
South Dakota	Sample preparation	Testing procedure		
Utah			None	
Vermont			None	
Washington			None	

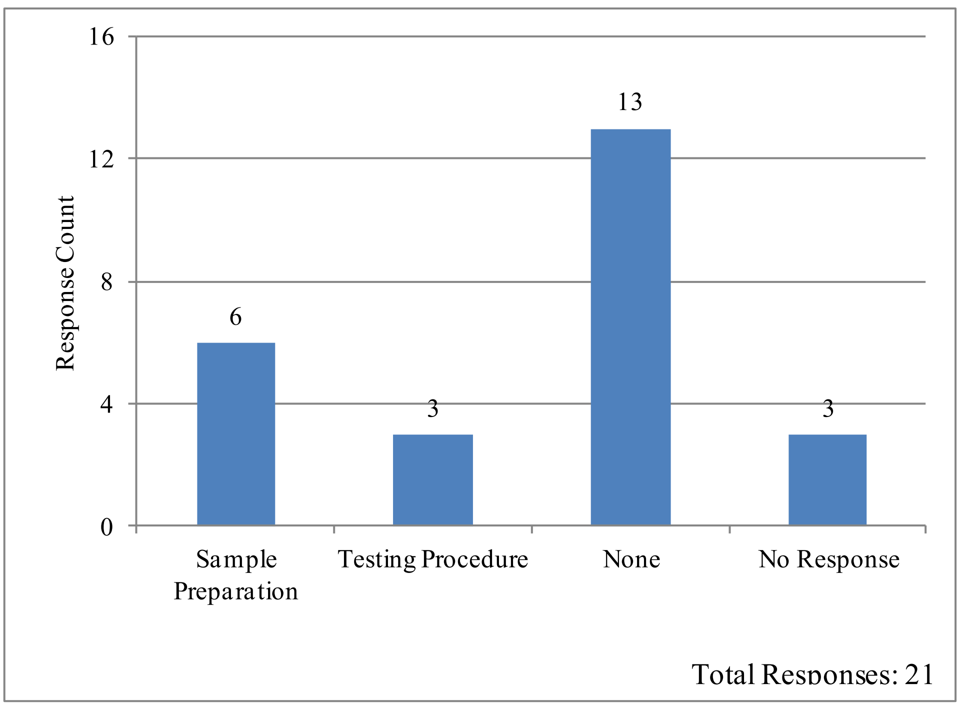

FIGURE B21 Modifications in lab assurance testing for WMA compared to HMA

B22. Acceptance Plan - WMA Modifications for QC Plan

Table B22 Compared to HMA, does your agency have any modifications on Quality Control Plan? If yes, please explain in the comment box.

State	Compared to HMA, does your agency have any modifications on Quality Control Plan?	Comments
Colorado	No	
Idaho	No	
Indiana	No	
Iowa	No	
Kansas	No	
Maine	Yes	Contractor has to determine the technology-specific production and placement temperature range.
Manitoba, Canada	No	
Michigan	No	
Minnesota	No	
Missouri	Yes	Specify WMA temperature for mixing and compaction.
Montana(1)	No	
Montana(2)		
Nebraska	No	
Nevada(1)	No	
Nevada(2)		
New Hampshire	No	
New York	Yes	As part of a WMA technologies approval, the technology must write a "Production, Testing and Compaction Details" document. This document must be followed by the mixture producer to ensure that everyone using this technology is using it in the proper way. We require the mix producers to state in their Quality Control Plans that they will follow the "Details" writen by the technology provider.
Ohio	No	
Oregon		
Saskatchewan	No	
South Dakota	No	
Utah	No	
Vermont	Yes	Need to include section on the WMA technology to be used.
Washington	No	

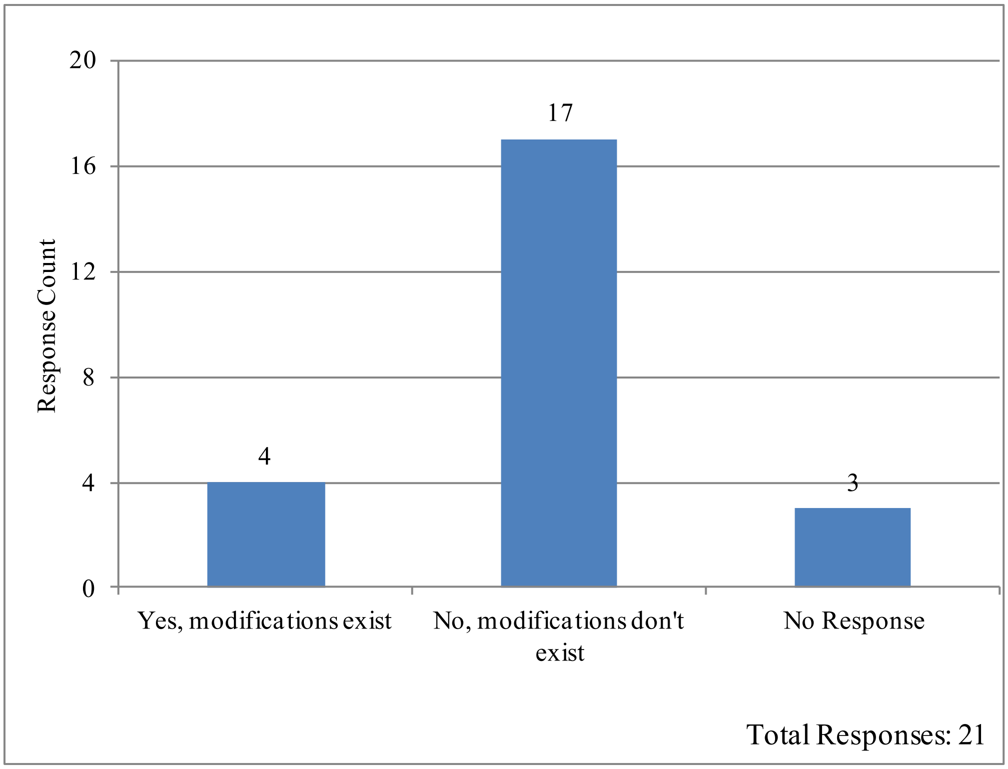

FIGURE B22 Modifications on WMA quality control plan compared HMA

B23. Acceptance Plan - Evaluation of WMA Construction Performance

Table B23 Do you use test sections to evaluate construction/performance of WMA technologies? If yes, what are the approval process and the tests?

State	Do you use test sections to evaluate	Comments
Colorado	No	
Idaho	No	We perform Test Strips on all projects HMA or WMA with no changes to either however we do not place control sections for WMA projects.
Indiana	No	
Iowa	Yes	We use test strips for both HMA and WMA. We verify density is being achieved with higher specification limits. If compaction is not achieved then a change in mix or rolling pattern may be needed.
Kansas	No	
Maine	Yes	Use of HMA control-strips to compare performance of WMA.
Manitoba, Canada	Yes	Distress survey of each test sections (rutting, cracking, ride)
Michigan	No	
Minnesota	No	Some sections at MnROAD
Missouri	No	
Montana(1)	No	Currently we have one research project to be constructed where we have one control paving section utilizing HMA and 3 other WMA technologies that we will be able to compare during construction and compare results following construction.
Montana(2)		
Nebraska	Yes	We allow the use of both WMA and HMA on a project, requiring at least 1000 tons of each material be placed, and then evaluate testing as we do with HMA and continue to monitor the road, visually evaluating it against the HMA and

Table B23 Continued

State	Do you use test sections to evaluate construction/performance of WMA technologies?	Comments
Nevada(1)	No	
Nevada(2)		
New Hampshire	No	
New York	Yes	We do allow trial sections to be built on NYSDOT roadways, but we do not require it. The approval process allows trial sections to be built in other states, cities, counties, etc. We follow up with the project owner on performace, construction, etc.
Ohio	No	We had condcuted trials a few years ago. We not longer construct test sections but may for a new technology.
Oregon		
Saskatchewan	Yes	Approval for test sections is conducted on a case by case basis. Tests at this point have included mechanistic testing of lab produced samples, some moisture susceptibility testing, and control sections established on WMA trials.
South Dakota		
Utah	No	
Vermont	No	
Washington	No	

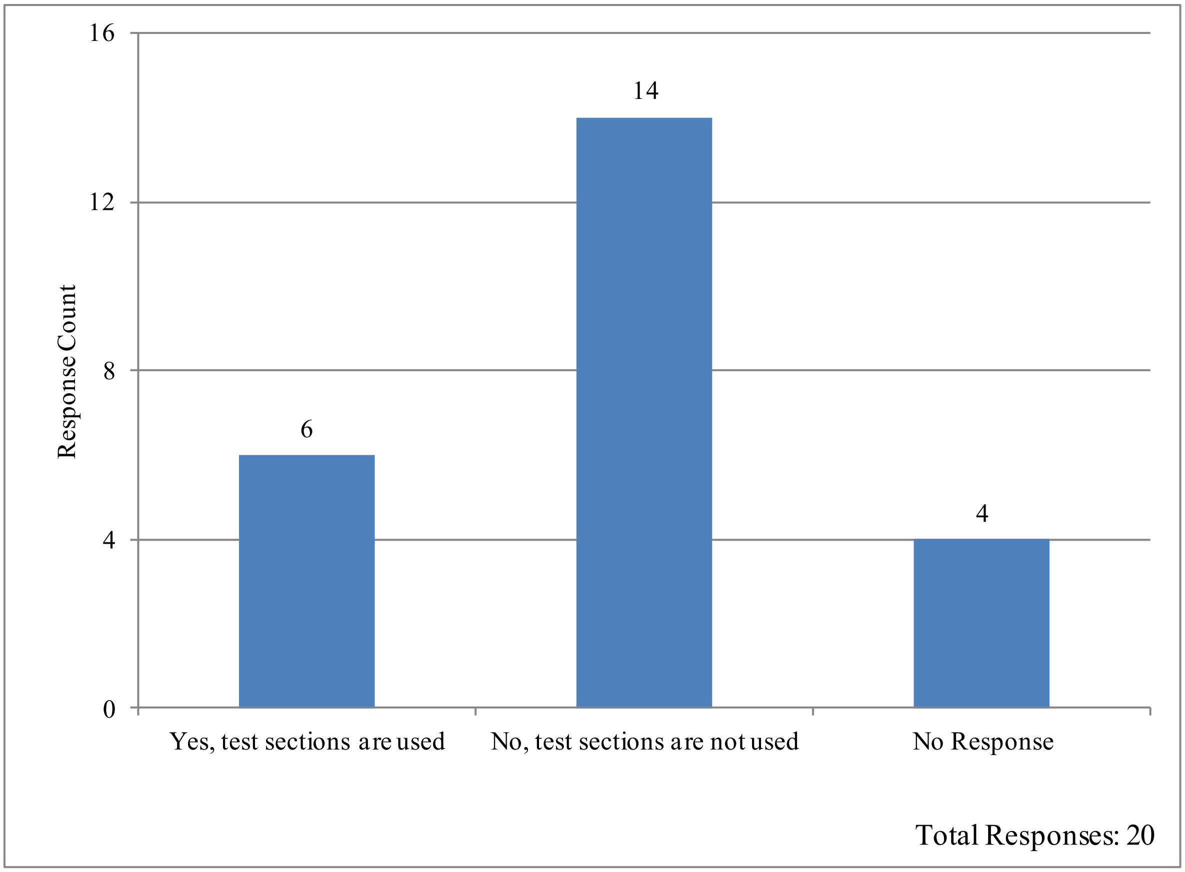

FIGURE B23 Use of test section for WMA evaluation

B24. Acceptance Plan – Use of Non-Approved WMA Technologies

Table B24 In case of using non-approved technologies, additives, or modifiers by the contractor, what would be the agency action? Please explain in the comment box.

State	Reject	Accept with Penalty	Accept	Other (Please Specify)
Colorado	Reject	Accept with penalty		
Idaho	Reject			
Indiana				Cost added per ton of mixture for additives or modifiers has prohibited their use or request for use in Indiana.
Iowa	Reject			
Kansas	Reject			
Maine	Reject			All technologies must be approved prior to use by the contractor.
Manitoba, Canada				We would investigate the product and approve prior to use.
Michigan	Reject			Only allowing foaming/water injection at this time.
Minnesota	Reject			
Missouri				What is "non-approved?" If it is that the contractor used a recognized process without noticification, the mixture would be accepted based on testing and acceptable placement.
Montana(1)	Reject			
Montana(2)				
Nebraska	Reject			
Nevada(1)	Reject			
Nevada(2)				
New Hampshire				Require verification before use.
New York				If a producer seeks prior consent to use a non-approved technology, we are open to limited trials of 1000 tons or less. If a producer uses a non-approved technology without our consent, then the pavement section will be rejected.
Ohio	Reject			
Oregon				
Saskatchewan				At this time, no standard response exists. The ministry is open to new technologies, if the contractor/supplier shares some of the risk. However, it is unlikely a contractor would be allowed to proceed if they switched additives during construction.
South Dakota				
Utah				This issue should be performance based. Mix tests can be used to sort out the major sources of distress. If performance is demonstrated to be poor in labratory testing, penalties should be assessed accordingly. If a mix is executed contrary to design, it should not be accepted.
Vermont		Accept with penalty		Would likely accept with penalty if contractor can demonstrate no significant adverse effect. However, we monitor at the plant and would not allow production to begin if a non-approved used. Technology must be identified in WMA design.
Washington				N/A

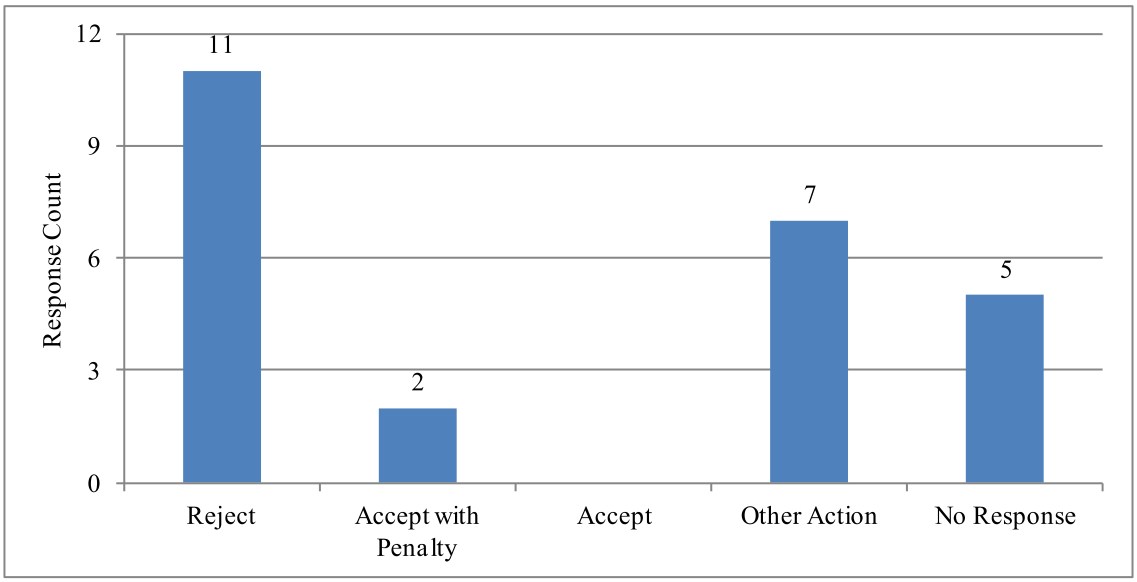

FIGURE B24 Agency action in case of using non-approved items by the contractor

APPENDIX C - SPECIFICATIONS, SPECIAL PROVISIONS AND APPROVED LISTS OF TECHNOLOGIES OF TARGET STATES

C1. WMA Guide Specification by WMA TWG

Warm Mix Asphalt (WMA) Guide Specification for Highway Construction

Division 400 - Asphalt Pavements and Surface Treatments

SECTION 4XX - WARM MIX ASPHALT (WMA) PAVEMENT

Warm mix asphalt (WMA) is the generic term used to describe the reduction in production, paving, and compaction temperatures achieved through the application of one of several WMA technologies.

Some modifications to HMA plants may be necessary to accommodate the WMA technologies as noted in Section 4XX.03 Construction.

Production and paving temperatures may need to be increased for higher reclaimed asphalt pavement (RAP) contents, increased haul distances, decreased ambient temperatures, or other WMA project specific conditions.

All provisions for the production and placement of conventional HMA mixtures as stipulated in [*applicable Agency specification*] are in force except as noted below.

4XX.01 Description

Construct one or more courses of plant produced warm mix asphalt (WMA) pavement on a prepared foundation, using virgin aggregate or a combination of virgin and/or reclaimed aggregate material (RAM) and prescribed manufactured WMA additives and/or WMA plant process modifications. Use of RAP materials, consisting of cold milled, crushed, or processed bituminous asphalt mixture; and reclaimed asphalt shingles (RAS) are permitted at the current [*Agency specified*] percentages, provided that the mixture meets all the requirements of these specifications.

4XX.02 Material

WMA may be produced by one or a combination of several technologies involving HMA plant foaming processes and equipment, mineral additives, or chemicals that allow the reduction of mix production temperatures to within 185°F to 275°F. *(Note: The upper temperature range is appropriate for modified asphalt binders and WMA mixtures which include higher percentages of reclaimed asphalt pavement.)*

Provide materials as specified in:

Aggregate	Subsection XXX
Liquid Antistrips	Subsection XXX
Asphalt Binder	Subsection XXX
HMA Additives	Subsection XXX
Lime for Asphalt Mixtures	Subsection XXX
Mineral Filler	Subsection XXX
Reclaimed Asphalt Pavement	Subsection XXX
Reclaimed Aggregate Material	Subsection XXX
Reclaimed Asphalt Shingles	Subsection XXX

4XX.03 Construction

A. *Mix Design.* Develop and submit a job mix formula for each mixture according to AASHTO R 35 or [*Agency specified procedure*]. Each job mix formula must be capable of being produced, placed, and compacted as specified. Apply all mix design requirements for HMA to the development of the WMA mix design.

(Note to Contracting Agency: Recommended mix design practices specific to WMA have not been established. Job mix formulas for WMA mixtures are currently developed with conventional HMA mix design practices and the WMA technology process or additives are included afterward. The Contracting Agency and WMA producer must ensure the WMA technology does not adversely affect the asphalt binder performance grade and WMA mixture performance during the development and verification of the WMA job mix formula. All acceptance and performance testing must be conducted with the WMA technology added. A specific WMA mix design recommended practice is expected upon the completion of the National Cooperative Highway Research Program (NCHRP) Project 09-43 "Mix Design Practices for Warm Mix Asphalt" detailed at www.trb.org/TRBNet/ProjectDisplay.asp?ProjectID=977.)

Submit a written job mix formula for review and approval at least [XX] calendar days before production, or when sources of asphalt binder, aggregates, WMA additives, or other components of the mix change.

Submit the following information:

1. All information required in the report section of AASHTO R 35 or [*Agency specified procedure*].
2. WMA technology and/or WMA additives information.
3. WMA technology manufacturer's established recommendations for usage.
4. WMA technology manufacturer's established target rate for water and additives, the acceptable variation for production, and documentation showing the impact of excessive production variation.
5. WMA technology material safety data sheets (MSDS).
6. Documentation of past WMA technology field applications including project type, project owner, tonnage, location, mix design, mixture volumetrics, field density, and performance; or documentation of WMA technology listing on [*Agency specified*] approved products list.
7. Temperature range for mixing.
8. Temperature range for compacting.
9. Asphalt binder performance grade test data over the range of WMA additive percentages proposed for use.
10. WMA mixture performance test results [*as required by the Contracting Agency*].
11. Laboratory test data, samples and sources of all mixture components, and asphalt binder viscosity-temperature relationships.

(Note to Contracting Agency: Some WMA technologies may alter the asphalt binder grade and conventional performance grading may not be suitable to quantify the WMA technology effects.)

B. *Additives.* Use anti-stripping additives, silicone additives, WMA additives, and WMA technologies as specified. Comply with approved mix design quantities. Confirm the addition rate through field tests performed during production.

(Note to Contracting Agency: Silicon additives are historically used as both an antifoam and defoamer to inhibit foaming in asphalt binder applications. Ensure silicon additive compatibility when asphalt binder foaming processes are used to produce WMA.)

Comply with the manufacturer's recommendations for incorporating additives and WMA technologies into the mix. Comply with manufacturer's recommendations regarding receiving, storage, and delivery of additives.

Maintain supplier recommendations on file at the asphalt mixing plant and make available for reference while producing WMA.

C. *Sampling*. Perform sampling according to the following standards:

1. *Aggregate*. AASHTO T 2 or [*Agency specified procedure*].
2. *Asphalt Binder*. AASHTO T 40 or [*Agency specified procedure*].
3. *Warm Mix Asphalt (WMA) Plant Mix*. AASHTO T 168 or [*Agency specified procedure*].

D. *Weather Limitations*.

1. Place WMA mixtures only on dry, unfrozen surfaces and only when weather conditions allow for proper production, placement, handling, and compacting.

2. Meet [*agency specified*] placement temperatures.

(*Note to Contracting Agency: The minimum HMA delivery, placement, and compaction temperatures should be reviewed to accommodate the WMA reduced temperature and achieve workability and density requirements. Documentation that demonstrates a proven history of the WMA technology's ability to be placed and compacted at the reduced temperatures may be required. A test strip or initial production verification requirement can be used to demonstrate placement and compaction at the reduced temperature. Minimum ambient paving temperature requirements may be lowered 20°F from normal temperature requirements. Do not lower ambient paving temperatures to below freezing.*)

E. *Equipment*. Use equipment and WMA technologies capable of producing an asphalt mixture that meet specification requirements and is workable at the minimum placement and compaction temperature desired, regardless of storage or haul distance considerations.

1. *Asphalt Mixing Plant*. Meet AASHTO M 156 or [*as further modified by the Agency*].

Modify the asphalt mixing plant as required by the manufacturer to introduce the WMA technology.

Plant modifications may include additional plant instrumentation, the installation of asphalt binder foaming 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.

(*Note: Implementation of best management practices in the control of aggregate moisture content prior to introduction to the drying or mixing drum is highly recommended in order to achieve the maximum benefit of WMA technology.*)

(*Note to Contracting Agency: It may be beneficial to produce an HMA mixture at conventional HMA temperatures immediately before WMA production at the lower temperatures in order to bring the plant up to temperature and ensure proper baghouse operating temperature. The following references published by the National Asphalt Pavement Association detail specifics related to plant modifications and operational changes in order to maximize the benefits of WMA production, especially regarding reduced fuel usage and reduced emissions:*
Quality Improvement Series 125 (QIP 125), "Warm Mix Asphalt: Best Practices".

Quality Improvement Series 126 (QIP 126), "Energy Conservation in Hot Mix Asphalt Production," and Environmental Council 101 (EC-101), "Best Management Practices to Minimize Emissions During HMA Construction")

All metering devices will meet the current [*Agency specified*] requirement for liquid or mineral additives. Document the integration of plant controls and interlocks when using WMA additive metering devices.

2. *Hauling Equipment*. Furnish equipment with tight, clean, smooth metal beds to haul WMA mixture. Keep beds free of petroleum oils, solvents, or other materials that would adversely affect the mixture. Apply a thin coat of approved release agent to beds as necessary to prevent mixture sticking. Do not use petroleum derivatives or other coating material that contaminates or alters the characteristics of the mix.

Be prepared to cover and insulate hauling beds. Equip each truck with a waterproof and windproof cover of suitable material and sufficient size to protect the mix from the weather. Securely fasten covers when necessary to maintain temperature. Ensure that covers do not allow water to enter the bed, paver, or mix transfer device during mix unloading. Use insulated truck beds when necessary to maintain temperature.

3. *Asphalt Pavers*. Provide self-propelled asphalt pavers with activated, heated, adjustable, vibratory screed assemblies to spread and finish to the specified section widths and thicknesses. Provide full width screw augers and provide auger extensions to ensure the paver's distribution system places the mixture uniformly, maintaining a consistent head of material in front of the screed. Screed or strike-off the surface without segregating, tearing, shoving, or gouging the mixture.

Operate the paver at consistent speeds and in a manner that results in an even, continuous layer. Avoid and minimize stop and start operation or allowing the paver to remain stationary during operation.

Equip pavers with automatic screed controls with sensors capable of continuously sensing grade, sensing the transverse slope of the screed, and providing the automatic signals that operate the screed to maintain grade and transverse slope. Control the screed to maintain the grade and transverse slope according to plan.

The Contractor may operate equipment manually in irregularly shaped, narrow, and minor areas.

If automatic controls fail, operate equipment manually only for the remainder of the work day and only if specified results are obtained.

Suspend paving if the specified surface tolerances are not met. Resume only after correcting the situation.

4. *Rollers*. Use rollers as required to achieve [*Agency specified*] pavement density and capable of reversing direction without shoving or tearing the mixture.

Operate rollers according to manufacturer's recommendations. Only use vibratory rollers equipped with separate energy and propulsion controls. Select equipment that will not crush the aggregate or displace the mixture.

F. *Mixing and Holding*. Heat the asphalt binder within the specified temperature range. Ensure a continuous supply of heated asphalt binder to the mixer.

Heat and dry aggregates to the required temperature. Avoid damaging or contaminating the aggregate.

Combine and mix the dried aggregates and asphalt binder to meet the job mix formula. Ensure a minimum of 95 percent uniform coating of aggregates according to AASHTO T 195 or [*Agency specified procedure*].

Correct procedures if storing or holding causes segregation, excessive heat loss, or a reduced quality mixture. Properly dispose of mixture which does not meet specifications.

G. *Preparing Base or Existing Surface*. Clear surface of debris and deleterious material. Apply and cure tack coat before placing the WMA. Apply a tack coat on all surfaces, curbs, gutters, manholes, or other structure surfaces, that will be in contact with the WMA.

Repair damaged areas of the base or existing surface. Restore the existing surface or base to a uniform grade and cross section before placing the mix.

H. *Pre-paving Requirements*. Prior to placing any WMA mix, produce a sufficient amount of WMA mix to properly calibrate the plant and procedures using the mix design approved for mainline construction. The Engineer will sample and test the WMA mix thus produced for the following:

1. voids in mineral aggregate (VMA);
2. asphalt binder content;
3. gradation;
4. air voids; and
5. tensile strength ratio (or Hamburg wheel tracking test for moisture damage)

Heat WMA field samples, transported to the laboratory, to the field production temperature, or lower, when reheating is required for WMA mixture testing.

(Note: Field produced WMA loose mix samples which are immediately compacted and tested, without reheating, may produce lower voids in mineral aggregate and lower air voids test results when compared to reheated samples. This should be validated during the test strip or initial production lot. One possible remedy is to cool the WMA sample to room temperature and reheat to a temperature that is less than or equal to the WMA field production temperature before laboratory compaction. This will minimize the WMA technology's effects on the test results and ensures the sample is not excessively aged.)

Place no WMA mixture that fails to meet specification requirements. WMA mixture not meeting the requirements may be used in the construction of temporary facilities when approved by the Engineer.

Construct a control strip or initial production lot with production materials and equipment. Select compacting methods to meet the specified density. The Engineer will take random loose mix and core samples to verify compliance with job mix and specification requirements. Reconstruct the test strip or initial production lot if the job mix formula, the compacting method, or compacting equipment changes, or if results do not meet specifications.

I. *Spreading and Finishing*. Spread and finish the mixture with asphalt pavers to specified grade and thickness.

Hand place material in areas inaccessible to mechanical spreading and finishing equipment. Maintain a consistent supply of mixture to ensure uninterrupted paving.

Minimize inconvenience to traffic and protect existing and finished surfaces. Leave only short lane sections, normally less than [26 ft (8 m)], where the abutting lane is not placed the same day, or according to [*Agency specified*] traffic safety requirements.

J. *Compacting.* Compact immediately after spreading and before the WMA mixture falls below the minimum job mix design compaction temperature. Discontinue paving if unable to achieve the specified density before the mixture cools below the minimum recommended WMA job mix design compaction temperature.

Provide the number, weight, type, and sequence of rollers necessary to compact the mixture without displacing, cracking, or shoving. Roll the WMA mixture parallel to the centerline. Begin rolling superelevated curves at the low side and continue to the high side, overlapping longitudinal passes parallel to the centerline.

Maintain a uniform roller speed with the drive wheels nearest the paver. Operate vibratory rollers uniformly at the manufacturer's recommended speed and frequency.

Continue rolling to eliminate all roller marks and to achieve the minimum [*Agency specified*] percent of theoretical maximum density or the recommended [*Agency specified*] percent of laboratory density as determined according to [*Agency-specified method*].

(Note to Contracting Agency: Air void and density requirements are important to provide long term performance of asphalt pavements. Due to the potential for increased workability of WMA mixtures and therefore increased density, it is important to monitor rolling operations to ensure excessive compaction does not occur and minimum air void requirements and/or the upper limit on percent of maximum density are not exceeded.)

Maintain the line and grade of the edge during rolling.

Prevent the mixture from adhering to the rollers by using very small quantities of detergent or other approved release material.

Hand compact areas inaccessible to rollers.

The Engineer will take random tests of the compacted pavement to verify specification compliance. At no cost to the Agency, remove and replace mixture that does not meet specification requirements or that becomes contaminated with foreign materials. Remove defective materials for the full thickness of the course by saw cutting the sides perpendicular and parallel to the direction of traffic. Coat saw cut edges with bituminous materials and replace the defective material with specification materials.

K. *Joints.* Protect ends of a freshly laid mixture from damage by rollers. Form transverse joints to expose the full depth of the course. Apply a tack coat on transverse and longitudinal joint contact surfaces immediately before paving. Construct all longitudinal joints within 12 in. (300 mm) of the lane lines. Offset longitudinal and transverse joints on succeeding lifts 6 inches (150 mm) to 12 inches (300 mm) 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.

L. *Surface Tests.* The Engineer will test pavement surfaces to verify compliance with [*Agency specified*] smoothness and texture requirements.

Correct pavement surfaces that do not meet specification requirements by cold milling, diamond grinding, overlaying, or removing and replacing according to the following:

a. *Diamond Grinding.* Diamond grind final pavement surfaces exposed to vehicle traffic to the required surface tolerance and cross section. Remove and dispose of all waste material.

b. *Cold Milling.* Cold mill intermediate pavement surfaces to the required surface tolerance and cross section. Remove and dispose of all waste materials.

c. *Overlaying.* Use specification materials for overlays. Overlay the full width of the underlying pavement surface. Place a minimum recommended overlay thickness of [1.6 in. (40 mm)]. Use only one overlay.

d. *Removing and Replacing.* Replace rejected areas with WMA pavement materials that meet specification requirements. Test the corrected surface area. Complete all corrections before determining pavement thickness.

4XX.04 Measurement

The Engineer will measure work acceptably completed as specified in Subsection XXX and as follows:

A. The Engineer will base quantities of asphalt binder on the theoretical mass incorporated into accepted product as verified by samples taken according to Subsection XXX.

4XX.05 Payment

Include costs of plant startup operations, considering both labor and materials, in the price bid for the mixture in place.

The Agency will pay for accepted quantities at the contract unit price as follows:

Pay Item Pay Unit
(A) Asphalt Binder ton (Mg), gal (L)
(B) WMA Plant Mix—Type _____ ton (Mg), yd^2 (m^2)

Such payment is full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

C2. Colorado

Colorado Procedure 59-12

Standard Practice for

Contractor Non-Standard Asphalt Mix Approval

1. SCOPE

1.1 This practice describes the procedures for submitting Non-Standard Asphalt Mix (NSM) technologies.

2. REFERENCED DOCUMENTS

2.1 *CDOT Procedural Directives:*
PD 1401.1 Product Evaluation and Experimental Features

2.2 *Colorado Procedures:*
CP 52 Contractor Asphalt Mix Design Approval Procedures

2.3 AASHTO Procedure:
AASHTO R35 (Appendix to) *Special Mixture Design Considerations and Methods for Warm Mix Asphalt (WMA)*

3. APPROVAL OF NSM TECHNOLOGIES

3.1 NSM technologies shall be in conformance with CP 52, CDOT Specifications and other specified Colorado, AASHTO, and ASTM procedures. Significant variances from these specifications will require an Experimental Feature in accordance with PD 1401.1.

3.2 For Warm Mix Asphalt (WMA) mixtures using proposed aggregate blends with total absorption equal to or less than 1.3% mix designs shall be conducted without additives for approval and setting of production targets. For WMA mixtures using proposed aggregate blends with total absorption greater than 1.3% the mix designs shall be conducted in accordance with the the Appendix to R35 referenced in Section 2.3 above. Regardless of mix design method, all WMA mixture and binder acceptance testing will be conducted according to existing CDOT HMA procedures, including established mixing and compaction temperatures. Proposed modifications to production properties and handling processes for WMA mixtures shall be detailed. Binder grade selection shall be in accordance with existing CDOT Superpave criteria. WMA shall not be produced at plant temperatures more than 100°F below existing HMA Superpave mixing temperatures.

3.3 For WMA mixtures with more than 20% RAP, the plant production temperature shall be in excess of the documented grade of the "as recovered" RAP binder.

3.4 NSM approval is required for each NSM Technology and/or each Contractor intending to use an NSM mixture. If the NSM Technology is already approved for use by CDOT each Contractor must receive approval for supply of an NSM mixture based on their submittal.

3.5 Changes in NSM properties or formulations that result in changes to mixture properties will require new NSM submittal and approval.

3.6 Only approved NSM technologies will be allowed on CDOT Projects.

4. NSM SUBMITAL REQUIREMENTS

4.1 All NSM submittals shall be submitted electronically to CDOT's Asphalt Program Manager. Acceptable formats include pdf, MS Excel, MS Word, PowerPoint, jpg and other compatible formats. Submittal shall be submitted in the order listed below. NSM must conform to the current CDOT HMA acceptance criteria. CDOT will determine if NSM Approval must be acquired for both the NSM Technology and the Contractor intending to supply the NSM.

4.2.1 NSM Technology Supplier – Submittals shall include:

(1) A summary of the NSM Technology:

A. Process controls.
B. A detailed list of additive types and quantities.
C. Description of additives' influence on NSM.
D. Benefits of the NSM.
E. Equipment and plant requirements.

(2) Performance History:

A. Product history.
B. Other projects, including those within Colorado, which utilized the NSM. Include site conditions, traffic, performance data and lab data on historical projects.
C. Research data on the NSM.
D. Sample specifications from other projects.
E. Approvals from other agencies.

(3) Design Considerations:

A. Lab design practices with NSM technology.
B. Conformities and deviations from CDOT design and acceptance criteria. See CP 52 and Specifications for Road and Bridge Construction.

(4) Production Considerations:

A. For WMA mixtures, provide a summary of anticipated differences in volumetric mix properties between the mix design values and the production target values.
B. For other NSM Mixtures provide field acceptance properties. Differences from current CDOT HMA requirements may trigger experimental feature process according to PD1401.1.
C. Sampling and testing requirements, including temperatures, laboratory handling, and variances from standard CDOT testing procedures. Detailed design, production, and testing requirements for use of the NSM shall be provided.
D. Acceptance criteria and justification if different than CDOT SuperPave requirements. Significant deviation from these criteria will require an experimental feature in accordance with PD 1401.1.

(5) Contacts

A. NSM product manufacturer's representative name, email, and phone number.
B. Name, email, and phone number of NSM product manufacturer representative who will be available during construction.

4.2.2 NSM Contractor Submittals shall include:

(1) Summary of Contractor's NSM Experience, if any. Contact names shall be included for owners of past projects.

(2) Design Considerations:

A. Lab design practices with NSM technology.
B. Conformities and deviations from CDOT design and acceptance criteria. See CP 52 and Specifications for Road and Bridge Construction.

(3) Production Considerations.

A. For WMA mixtures, provide a summary of anticipated differences in volumetric mix properties between the mix design values and the production target values. Mixture volumetric targets may be adjusted as approved by the RME. The contractor shall provide necessary data to support field volumetrics targets that are different from the HMA mix design values. At a minimum, three full volumetric samples will be produced at optimum AC (as determined from mix design without additive) with WMA additive to document impact on field volumetrics.
B. For other NSM Mixtures provide field acceptance properties. Differences from current CDOT HMA requirements may trigger experimental feature process according to PD1401.1.
C. Sampling and testing requirements, including temperatures, laboratory handling, and proposed variances from standard CDOT testing procedures. Detailed design, production, and testing requirements for use of the NSM shall be provided.

and approved prior to issue of the Form #43. Mixtures shall be tested for acceptance in accordance with established CDOT procedures.

D Acceptance criteria and justification if different than CDOT SuperPave requirements. Significant deviation from these criteria will require an experimental feature in accordance with PD 1401.1.

E If the NSM produced on a project fails mixture verification, goes in to condition red, or if the asphalt plant fails to satisfy the NSM production controls outlined in the submittal for NSM approval, NSM production shall cease, written explanation shall be provided for the failures, and production may be required to revert to conventional HMA.

(5) Contacts:

A. Contractor representative name, email, and phone number.

B. NSM product manufacturer's representative name, email, and phone number.

C. Name, email, and phone number of NSM product manufacturer's representative who will be available during construction.

D. Mix Designer name, email, and phone number.

5. PRELIMINARY CDOT REVIEW PROCESS

5.1 Preliminary review of Contractor's NSM proposal will be performed by the CDOT Asphalt Program in conjunction with Regional Material Engineers as needed.

5.2 CDOT may request additional information from Contractor.

5.3 Incomplete submittals may be rejected as unacceptable.

5.4 CDOT Asphalt Program will notify the Material Advisory Committee (MAC) of all NSM submittals processed.

5.5 If submittal package is not rejected during preliminary review, and when submittal package is deemed complete by the CDOT Asphalt Program, the NSM submittal will be sent to the MAC for formal review.

5.6 Preliminary review is estimated to take two weeks, depending upon completeness of initial NSM submittal.

6. CDOT REVIEW PROCESS

6.1 Formal review of NSM submittals will be performed by the MAC. Review may take place at a regularly scheduled MAC meeting (MAC meetings are scheduled once every-other month) or at a separate formal meeting, depending upon schedule.

6.2 The MAC, via the CDOT Asphalt Program, may request additional information from the Contractor.

6.3 Submittal may be rejected by the MAC as unacceptable under NSM procedures.

6.4 The MAC will determine if the NSM falls under the jurisdiction of PD 1401.1. If so, the MAC will approve the NSM with recommendations for the experimental feature process. If the NSM is not under the jurisdiction of PD 1401.1, then the NSM will be approved with recommendation on scope of allowed project use.

6.5 The MAC will recommend whether the NSM is to be paid for under the existing HMA bid items or under a new NSM-specific bid item. For WMA mixtures, existing HMA bid items will be used.

6.6 The MAC will itemize any limitations to the use of the NSM on CDOT projects.

6.7 MAC review is estimated to take six weeks upon receipt of a complete NSM submittal.

7. SCHEDULE

7.1 Notification of NSM approval/rejection from CDOT may take a minimum of 8 weeks. This time frame may be significantly increased if additional information is requested from the Contractor, or if the submittal is delivered during peak construction/production season.

8. RECORD

8.1 All requests for NSM information shall be made under the Colorado Open Records Act (CORA) and shall follow CDOT Procedural Directives 25.2, 51.2, and 51.3.

The Colorado Department of Transportation is subject to the provisions of the Colorado Open Records Act (C.R.S. 24-72-201, et seq.). Unless specifically excluded by the language of the act, all documents provided to or maintained by CDOT are considered to be a matter of public record.

Contractors submitting an NSM proposal to CDOT must identify the proposal as "Confidential" or "Available for Release". If, at any future date, a CORA request is made for any proposal identified as "Confidential", CDOT will notify the entity or individual making the request that the information is not available.

By identifying a proposal as "Confidential", the Contractor agrees to indemnify and hold harmless the Department and its employees from any legal action resulting from this decision to deny the documents, and to provide any necessary legal defense.

The NSM submittals shall include the following signed and checked statement:

☐ Available for Release

☐ Confidential

With this signature, I ____________________ (Name) with ________________ (Business Name) agrees to indemnify and hold harmless the Colorado Department of Transportation and its employees from any legal action which may result from its decision to withhold this document in response to requests made under the Colorado Open Records Act, and to provide any legal defense necessary if this decision is appealed.

8.2 All approved NSM technologies will be posted on the CDOT website.

8.3 All approved contractor users of an approved NSM technology will be posted on the CDOT website.

CP 59, NSM Technology Supplier Submittal Checklist

Supplier Name: ____________ Date: ____________
Contact Name: ____________ Contact Phone Number: ____________
Contact Email: ____________

NSM Name: ____________ NSM Type: ____________

Subsection		Yes/ No
4.1	All material submitted electronically	____
4.2.1 (1)	Summary of the NSM technology	____
	Process controls	____
	Detailed list of additive types and quantities	____
	Description of additives influence	____
	NSM benefits	____
	Equipment and plant requirements	____
	MSDS sheets for additives	____
4.2.1 (2)	Performance history	____
	Product history	____
	Other projects utilizing NSM (includes site conditions and performance data)	____
	Research data	____
	Specifications used on other projects	____
	Approvals from other agencies	____
4.2.1 (3)	Design considerations	____
	Lab design practices	____
	Conformities and deviations from CDOT criteria	____
4.2.1 (4)	Production considerations	____
	Summary of anticipated differences between mix design values and production targets	____
	Field acceptance properties, including differences from CDOT HMA requirements	____
	Sampling and testing requirements	____
	Acceptance criteria and justification	____
4.2.1 (5)	Contacts	____
	Manufacturer representative name, email, and phone number	____
	On-site manufacturer representative name, email, and phone number	____
8.1	Confidentiality statement	____

NSM Product Review
Advera WMA
April 14, 2011 – 1:00 P.M.
Microsoft Outlook Live Meeting via Participants' Desktops

DATE: June 2, 2011

FROM: Jim Zufall, Materials and Geotechnical Branch Manager

TO: MAC Members and Industry Partners

SUBJECT: Final Decision on Approval of Non-Standard Mix Submittal for Advera WMA

REFERENCE: Web TBD-- http://internal/MAC/Webhosting location for CDOT-Approved NSM

Overview
The review panel for evaluation of Non-Standard (NSM) asphalt mixture submittals convened on April 14, 2011, in accordance with the Colorado Procedure 59 (CP-59). PQ Corporation's Advera submittal was one of three technologies reviewed.

Quality of Submittal
Advera WMA was submitted for CDOT consideration. The submittal was very well prepared and comprehensive. Advera was one of three WMA technologies that took part in a 3-year experimental feature in the State of Colorado. The performance data collected and presented in this submittal showed that Advera performed as well as the HMA control section. PQ Corporation should be commended on their product development, documentation, and evaluation process.

NSM Decision
PQ Corporation's Advera WMA product is approved by the panel. This technology will be posted to the CDOT website as an approved NSM technology under the category of WMA technologies.

NSM Product Review
AquaBlack Solutions WMA
April 14, 2011 – 1:00 A.M.
Microsoft Outlook Live Meeting via Participants' Desktops

DATE: June 2, 2011

FROM: Jim Zufall, Materials and Geotechnical Branch Manager

TO: MAC Members and Industry Partners

SUBJECT: Final Decision on Approval of Non-Standard Mix Submittal for AquaBlack Solutions WMA

REFERENCE: Web TBD-- http://internal/MAC/Webposting location for CDOT-Approved NSM

Overview
The review panel for evaluation of Non-Standard (NSM) asphalt mixture submittals convened on April 14, 2011, in accordance with the Colorado Procedure 59 (CP-59). Maxam's AquaBlack Solutions WMA submittal was one of three technologies reviewed.

Quality of Submittal
AquaBlack WMA was submitted for CDOT consideration. While the submittal met all of the requirements of CP-59, the organization of the submitted material did not follow the structure of CP-59, which made identifying the required information difficult. While AquaBlack WMA shows promise based upon laboratory experimentation, there was no long-term performance data (e.g., rutting, cracking, raveling, etc.).

NSM Decision
Maxam's AquaBlack Solutions WMA product is approved by the panel, with the restriction of 5,000 tons per project. This technology will be posted to the CDOT website as a restricted NSM technology under the category of WMA technologies.

Addendum
Subsequent to the April 14th decision of the review panel, Maxam submitted several additional documents and requested that the review panel reconsider the 5,000 ton per project restriction. On May 27th the review panel discussed the new information, and determined that it did not provide enough long-term performance data. The 5,000 tons per project restriction remains in place.

NSM Product Review
Evotherm WMA
November 8, 2010 – 1:00 P.M.
Microsoft Outlook Live Meeting via Participants' Desktops

DATE: Dec. 8, 2010

FROM: Jim Zufall, Materials and Geotechnical Branch Manager

TO: MAC Members and Industry Partners

SUBJECT: Final Decision on Approval of NonStandard Mix Submittal for Evotherm WMA

REFERENCE: Web TBD-- http://internal/MAC/Webposting location for CDOT-Approved NSM

Overview
The review panel for evaluation of NonStandard (NSM) asphalt mixture submittals conducted the first NSM review on November 8, 2010 in accordance with the new Colorado Procedure 59 (CP-59). MeadWestvaco's Evotherm warm mix technologies were evaluated at the meeting.

Quality of Submittal
Evotherm ET, DAT, and the 3G products were submitted for CDOT consideration. The submittal was very well prepared and included over 300 projects constructed across the US and abroad with numerous locations formally documented with performance evaluations and/or research publications. MeadWestvaco should be commended on their product development, documentation and evaluation process. The submittal was well organized and comprehensive.

NSM Decision
The ruling of the review panel is summarized below for the following MeadWestvaco products:

Evotherm ET (Asphalt Emulsion)
Evotherm DAT (products F6 and H5)
Evotherm 3G (products J1 and M1)

The stated MeadWestvaco products are approved by the panel. Each will be posted to the CDOT website as approved NSM under the category of WMA technologies.

NSM Product Review

Green System WMA

April 14, 2011 – 1:00 A.M.

Microsoft Outlook Live Meeting via Participants' Desktops

DATE: June 2, 2011

FROM: Jim Zufall, Materials and Geotechnical Branch Manager

TO: MAC Members and Industry Partners

SUBJECT: Final Decision on Approval of Non-Standard Mix Submittal for Green System WMA

REFERENCE: Web TBD-- http://internal/MAC/Webposting location for CDOT-Approved NSM

Overview
The review panel for evaluation of Non-Standard (NSM) asphalt mixture submittals convened on April 14, 2011, in accordance with the Colorado Procedure 59 (CP-59). Astec, Inc's Green System WMA submittal was one of three technologies reviewed.

Quality of Submittal
Green System WMA was submitted for CDOT consideration. The submittal was well organized and was very thorough in its approach to meeting all requirements of CP-59. While the Green System shows promise based upon laboratory experimentation, there was no long-term performance data (e.g., rutting, cracking, raveling, etc.).

NSM Decision
Astec, Inc's Green System WMA product is approved by the panel, with the restriction of 5,000 tons per project. This technology will be posted to the CDOT website as a restricted NSM technology under the category of WMA technologies.

NSM Product Review
Ultrafoam GX2 WMA
May 27, 2011 – 9:00 A.M.
Microsoft Outlook Live Meeting via Participants' Desktops

DATE: June 2, 2011

FROM: Jim Zufall, Materials and Geotechnical Branch Manager

TO: MAC Members and Industry Partners

SUBJECT: Final Decision on Approval of Non-Standard Mix Submittal for Ultrafoam GX2 WMA

REFERENCE: Web TBD-- http://internal/MAC/Webposting location for CDOT-Approved NSM

Overview
The review panel for evaluation of Non-Standard (NSM) asphalt mixture submittals convened on May 27, 2011, in accordance with the Colorado Procedure 59 (CP-59). Gencor Industries' Ultrafoam GX2 WMA submittal was reviewed.

Quality of Submittal
Ultrafoam GX2 WMA was submitted for CDOT consideration. The submittal was well organized and was very thorough in its approach to meeting all requirements of CP-59. While the Ultrafoam GX2 shows promise based upon laboratory experimentation, there was no long-term performance data (e.g., rutting, cracking, raveling, etc.).

NSM Decision
Gencor Industries' Ultrafoam GX2 WMA product is approved by the panel, with the restriction of 5,000 tons per project. This technology will be posted to the CDOT website as a restricted NSM technology under the category of WMA technologies.

C3. Idaho

IDAHO SAND & GRAVEL

924 N. Sugar Street
Nampa, Idaho 83653-1310
Ph (208) 466-5001 Fax (208) 466-4167

LETTER OF TRANSMITTAL #74	
Date: July 1, 2011	ISG Job No: 142596
Attention: Shawna King P.E.	
RE: US-95, OR St Ln to MP 16.7, Owyhee Co	
A011(049), Key 11049	
Fax # 208-459-0161	

Idaho Transportation Department
District III, Region III
15430 HWY 44
Caldwell, ID 83605

WE ARE SENDING YOU: ☐ Attached ☐ Under Separate cover via ______ the following items

☐ Shop Drawings ☐ Prints ☐ Plans ☐ Samples ☐ Specifications

☐ Copy of Letter ☐ Change Order ☐ Other ______

Copies	Date	No.	Description
1	7/1/11		**Signed Change Order #1 - WMA**

THESE ARE TRANSMITTED AS CHECKED BELOW:

☐ For approval ☐ Approved as submitted ☐ Resubmit ______ copies for approval

☐ For your use ☐ Approved as noted ☐ Submit ______ copies for distribution

☐ As requested ☐ Returned for corrections ☐ Return ______ corrected prints

☐ For review and comment ☐ Other ______

REMARKS:

Please call me with any questions at (208) 466-5001.

Copy To: ITD

Signed: [signature]
JOHN MITCHELL, PROJECT MANAGER

IDAHO TRANSPORTATION DEPARTMENT
P.O. Box 8028
Boise, ID 83707-2028

(208) 334-8300
itd.idaho.gov

May 25, 2011

Mr. John Mitchell
Idaho Sand and Gravel Co.,
P.O. Box 1310
Nampa, ID 83653

Project: A011(049)
Location: US-95, Or St Line to MP 16.7, Owyhee County
Key: 11049
Contract: 7560

Subject: Change Order #1

Enclosed are two copies of form ITD0400, Change Order, for the referenced project. These documents are for change order number one. Per subsection 104.03, Changes and Extra Work, please sign and date each at the box identified for "Contractor's Signature" or return unsigned with your written explanation for not signing the change order.

Please return both originals to the ITD, District 3-Residency 3 Office within the next seven calendar days. The address is as follows:

Idaho Transportation Department
District 3 –Residency 3
15430 Hwy 44
Caldwell, Idaho 83607

If you have any questions, please contact the Residency 3 office at 459-7429.

Thank you,

Larry R. Vaughn
Residency Three Office Manager

Attachments

ITD 0400 (Rev. 1-08)

Change Order

See Contract Administration Manual Section 104.03

Key No.	Project No.		Contract No.	
11049	A011(049)		7560	
Authority No.	Location			
P093680	US 95, OR ST LN TO MP 16.7 OWYHEE CO			
Contractor's Name		Change Order No.	Date of Contractor Authorization	
IDAHO SAND AND GRAVEL		1	04-28-2011	

You are ordered to perform the following described work in accordance with the Standard Specifications and Special Provisions governing the above contract or as herein amended. The cost to perform this work includes all labor, equipment, materials, overhead, and all other incidental costs associated with completing the work.

Description of Work

CHANGE IN PLANS AND SPECIFICATIONS

1. Description- This work shall consist of providing the technology to construct one or more courses of plant produce warm mix asphalt (WMA) pavement on a prepared foundation, using prescribed manufactured WMA additives and/o WMA plant process modifications. All provisions of S405 shall apply except as modified below.

2. Material Requirements- The Contractor may produce Superpave WMA by one or a combination of severa approved technologies from the following categories as on the Departments QPL List:

Chemical Processes

Foaming Processes

Organic Processes

The Department will allow the use of recycled asphalt pavement (RAP).
The Department and Contract shall prepare Superpave WMA field samples, as recommended by the manufacturer' representative for WMA mixture testing.

3. **Construction Requirements-**

A. Mix Design

In addition to the mix design requirements specified in 405, provide the following documentation:

1. WMA technology information, WMA additives information, or both
2. WMA technology manufacturer's recommendations for use.
3. WMA technology manufacturer's target rate for water and additives, the acceptable variation for productio and documentation showing the impact of excessive production variation.
4. WMA technology material safety data sheets (MSDS)
5. WMA technology laboratory and field temperature range for mixing
6. WMA technology temperature range for compacting
7. Asphalt binder performance grade test data over the range of WMA additive percentages proposed for use.
8. Laboratory test data, samples and sources of all mixture components and asphalt binder –viscosity temperature relationships.

Use anti-stripping additives, silicone additives, WMA additives, and WMA technologies as specified. Comply wit approved mix design quantities. Confirm the addition rate through quality control field tests during production.

Comply with the manufacturer's recommendations for incorporating additives and WMA technologies into the mi Comply with manufacturer's recommendations regarding receiving, storage and delivery of additives.

Page 1 of 2

ITD 0400 (Rev.1-08)

Change Order

Key No.	Project No.	Contract No.	
11049	A011(049)	7560	
Authority No. P093680	Location US 95, OR ST LN TO MP 16.7 OWYHEE CO		
Contractor's Name	IDAHO SAND AND GRAVEL	Change Order No. 1	Date of Contractor Authorization 04-28-2011

Maintain manufacturer's recommendations on file at the asphalt mixing plant and make available for reference when producing Superpave WMA.

B. Asphalt Mixing Plant

Provide WMA metering devices that meet the WMA technology manufacturer's current recommendations for liquid or mineral additives. Document the integration of plant controls and interlocks when using WMA additive devices.

C. Acceptance Test Strip

In addition to tests specified in 405, the Engineer will test the produced material for the following:

1. Immersion Compression
2. Rutting Susceptibility (APA)

D. Compaction

Discontinue paving if unable to achieve the specified density before the mixture cools below the minimum recommended WMA job mix formula design compaction temperature.

4. **Method of Measurement-** No change in Method of Measurement.

5. **Basis of Payment-** No change in Basis of Payment:

6. **Contract Time:** There will be no change in Contract time.

By reason of this change, contract time will be adjusted by:

No change ☐ Working Days ☐ Calendar Days

We agree that if this Change Order is approved, we will perform the work detailed above and be compensated the prices shown.

Contractor's Signature [signature] Date 7/1/11

City, County, or Highway District Agency's Name

Authorized Representative's Signature

Title | Date

Approved for State of Idaho

Authorized Representative's Signature

Title Residency Engineer | Date

Page 2 of 2

C4. Illinois

Illinois Department of Transportation
2300 South Dirksen Parkway / Springfield, Illinois / 62764

May 21, 2009

CIRCULAR LETTER 2009-09

WARM MIX ASPHALT EXPERIMENTAL FEATURES

COUNTY ENGINEERS/SUPERINTENDENTS OF HIGHWAYS
MUNICIPAL ENGINEERS/DIRECTORS OF PUBLIC WORKS/MAYORS
CONSULTING ENGINEERS

The central Bureau of Materials and Physical Research (BMPR) and the central Bureau of Construction (BC) have issued a joint memorandum outlining the use of warm mix asphalt (WMA) through the experimental feature program. There are several modifications to the normal experimental feature program:

- Experimental feature is initiated by the contractor after the contract has been awarded;
- BMPR has completed the work plan for all projects (See attachment.);
- The BC must concur with substitution of WMA for Hot Mix Asphalt (HMA); and
- Attachment 3 of the work plan shall be completed by the contractor within 30 days of completion of paving.

If the local agency accepts the contractor's offer to substitute WMA for HMA, the local agency shall complete Attachment 2 of the work plan with the assistance of the district office. The district office shall forward Attachment 2 of the work plan to Mark Gawedzinski (mark.gawedzinski@illinois.gov) of the BMPR with a carbon copy to the central Bureau of Local Roads and Streets and the BC. The contractor shall not be allowed to start paving until approval is received by the BMPR and the BC.

Please contact the Local Policy and Technology Unit at DOT.LocalPolicy@illinois.gov with any questions.

Sincerely,

Darrell Lewis

Darrell W. Lewis, P. E.
Acting Engineer of Local Roads and Streets

Attachment

cc: Matt Mueller, BMPR
Jim Trepanier, BMPR
Mark Gawedzinski, BMPR
Marvin Traylor, IAPA
Hal Wakefield, FHWA
Brian Pfeifer, FHWA

Illinois Department of Transportation

Memorandum

To:	Regional Engineers	Attn: Project Implementation Engineers
From:	David L. Lippert and William R. Frey	
Subject:	Warm Mix Asphalt Experimental Features	
Date:	May 19, 2009	

The use of Warm Mix Asphalt (WMA) is quickly gaining interest here in Illinois and the country. In order to document our experience with the use of WMA technologies, IDOT will monitor WMA projects through the use of the experimental feature process. The attached experimental work plan for WMA has been approved by FHWA. The Regions are requested to submit basic project information and to include a half mile (in each direction) Hot Mix Asphalt (HMA) control section as part of this approval with FHWA when allowing a WMA project.

Warm mix proposals for state or local projects should be evaluated using the list of criteria shown in Attachment 1 of the work plan. Local agencies should coordinate warm mix proposals through their IDOT districts. Projects will be limited to non-interstates and facilities with less than 10 million design ESALs until further experience is gained. It is anticipated that the use of WMA in place of HMA will be a no-cost or credit substitution; however, if the percentage of reclaimed asphalt pavement is increased or relief from grade bumping results, a credit would be due.

To have a project considered for WMA, the Project Background form (Attachment 2 of the work plan) should be completed by the Region/local agency and submitted jointly to the Bureau of Materials and Physical Research (BMPR) and Bureau of Construction (BC). The contractor must address the key items in Attachment 1 of the work plan to the satisfaction of the Region. Concurrence from the Central Office Bureau of Construction regarding substitution of WMA for HMA will be required before the work can proceed.

Once a project is completed, the Production and Construction Information form (Attachment 3 of the work plan) should be completed by the contractor, approved by the district and then submitted to BMPR within 30 days of completion of paving.

Your assistance in notifying us of warm mix projects through this experimental feature program will enable us to rationally promote a promising technology and is greatly appreciated.

If you have any questions of BMPR please contact Mark Gawedzinski at 217/782-7200 and for questions of BC please contact Mike Renner at 217/782-6667.

cc:					
	E. Harm	D. Lewis	C. Ingersoll	M. Renner	J. Trepanier
	A. Schutzbach	P. Broers	J. Vespa	M. Gawedzinski	M. Mueller

Illinois Department of Transportation

Division of Highways / Bureau of Materials and Physical Research
126 East Ash Street / Springfield, Illinois / 62704-4766

May 8, 2009

Mr. Norman R. Stoner
Division of Administrator
Federal Highway Administration
Attn: Brian Pfeifer
Springfield, Illinois 62703

SUBJECT: Experimental Feature # IL 09-02
Warm Mix Asphalt
Contract: Various
District: Various

Dear Mr. Pfeifer:

Enclosed are two copies of the generic template Experimental Feature Work Plan. Since this process will be initiated by the contractor after the contract has been awarded, we propose an alternate method of reporting in lieu of Form 1461 for each project. Our proposal is to periodically provide summary tables that will include information provided on Form 1461. We request your approval of the subject Experimental Feature template and this method of submitting information.

The Experimental Feature will be using Warm Mix Asphalt (WMA) as a contractor substitute for Hot Mix Asphalt (HMA). It is our intention that the contractor will also use HMA on the project to serve as a control section for the project.

Projects are scheduled for 2009 and 2010 lettings. Your early consideration of this request is appreciated.

Sincerely,

Christine Reed
Director of Highways

By:
David L. Lippert, P.E.
Engineer of Materials and Physical Research

JV:jy

Atts.

cc: Patty Broers, Amy Schutzbach, Mark Gawedzinski, Jim Trepanier, Eric E. Harm

P: [illegible]/ Experimental Feature # IL 09-02

Experimental Work Plan for Warm Mix Asphalt in Illinois

Introduction Warm Mix Asphalt (WMA) was introduced from a joint owner industry scan of European asphalt production practices. It promises reduced emission and energy usage. Several technologies are used to produce WMA. Background and advice on technologies can be found at http://www.warmmixasphalt.com/ and http://www.fhwa.dot.gov/pavement/asphalt/wma.cfm. There are some differences in production compared to Hot Mix Asphalt (HMA) that may be advisable to consider with WMA such as assuring aggregate drying at lower production temperatures. WMA is an acceptable alternative to HMA provided that it meets the specification requirements of HMA.

Objective This project is designed to assess the performance of the various WMA technologies and allow the Illinois Department of Transportation (IDOT) to build on experience with this product. This experience will allow IDOT to develop specifications and a policy for WMA.

Projects IDOT has been entertaining proposals from contractors to substitute WMA for HMA on an individual project basis. This practice will be continued for future warm mix projects. Warm mix proposals for state or local projects will be evaluated using the list of criteria (Attachment 1) to assure equivalency. Local agencies should coordinate warm mix proposals through their IDOT districts. Projects will be limited to mainline usage on facilities with less than 10 million ESALS until further experience is gained with specific warm mix technologies. A copy of a project background form completed by the district/local agency (Attachment 2), as well as the contractor's QC plan addressing the key items in Attachment 1, will be submitted to the Bureau of Materials and Physical Research (BMPR) as soon as the use of WMA is approved by the district. A copy of a production and construction information form completed by the contractor and approved by the district (Attachment 3) will be submitted to the BMPR within 30 days of completion of paving. Control sections of HMA (minimum of 0.5 mile in each lane and in each direction) will be required on all WMA projects for performance comparisons.

Estimated Cost It is anticipated that use of WMA in place of HMA will be a no-cost substitution. Potential savings may be realized if RAP is used in the WMA as binder grade bumping is reduced. Any cost savings will be documented as part of this research.

Evaluation BMPR, with the districts'/local agencies' assistance, will maintain a record of warm mix usage throughout the state and monitor statewide performance of specific technologies and their performance. Evaluation will consist of images and sensor data (ride quality and rut data) and CRS collected by the department, either annually (interstate) or biennially (state system), as well as general observations from the district/local agency on an annual basis. The evaluation period for each project will be 5 years from completion of construction.

Considerations for WMA Use

1. Expected net cost savings

What is the monetary value (fuel savings minus WMA technology) of this proposal? What level of risk is the district willing to accept considering the facility, traffic levels and potential reduction in service life?

2. Climate Limitations

It has been reported that Sasobit may decrease the pavements resistance to thermal cracking and therefore may not be appropriate for full depth pavements in the northern districts. Likewise, foaming technologies (water or additive) may not be suitable for cold temps or long haul distances where mix may "crust over" due to temperature loss.

3. Traffic Limitations

Concern has been expressed by a national expert regarding use of WMA on high volume facilities. (Currently limited to ≤ 10 million ESALs)

4. RAP / Grade Bumping * (Required)

If the contractor intends to use ≥ 20% RAP they should indicate their proposed RAP % and proposed PG binder grade bump reduction in their QC Addendum. They also need to indicate how they will handle switching to a double bump PG binder grade if they need to increase the production temperature above 275° F or switch to HMA. This may require having two binder grades on hand.

5. Mix verification * (Required)

Some WMA technologies cannot be replicated and therefore verified in the laboratory. What steps will the contractor take to verify this mix will be suitable for the proposed application?

6. Determination of moisture sensitivity * (Required)

Discuss what efforts the contractor will make to ensure the WMA will not be susceptible to moisture damage (i.e., how HMA TSR criteria of 0.85 will be met). This may include preliminary moisture sensitivity testing and production split sample moisture sensitivity testing by contractor and district. This should also be addressed in the QC Addendum.

7. Proposed mix production temperature

Determine what WMA technology is being proposed, what temperature reduction is expected and what production temperature range the contractor anticipates running the WMA to make sure the application is appropriate.

8. Payment for Anti-Strip (A-S) Additive

Most WMA mixtures are more moisture sensitive and therefore require anti-strip additives. How will the anti-strip additive be paid for?

9. How will VMA be maintained? * (Required)

Some of the WMA technologies are known to decrease VMA by up to 1%. What steps will the contractor take to ensure the minimum VMA requirement is met?

10. Length of storage * (Required)

Discuss with the contractor whether the proposed WMA technology benefits are time sensitive (i.e. will the mix still be compactable at the reduced temperature after being stored for several hours?).

11. Haul time * (Required)

Determine the anticipated production temperature and haul time. Longer Haul times for WMA produced at the lower temperatures have caused laydown problems due to crusting of the mix.

12. Manufacturer's Representative

Will a representative for the WMA technology/equipment be available during mix production?

13. At what point will WMA production temperature be increased?

Contractor should indicate in the QC Addendum what conditions would necessitate increasing WMA production temperature. Keep in mind, reduced binder grade bumping for 20 to 30% RAP will not allow WMA production temperature to exceed 275° F. One condition should be hotter initial loads to heat up laydown equipment. This should also be addressed in the QC Addendum.

14. At what point do you switch back to HMA?

Contractor should indicate in the QC Addendum what conditions would necessitate switching back to HMA. Keep in mind, reduced binder grade bumping for WMA containing 20 to 30% RAP will not apply to the HMA. This should also be addressed in the QC Addendum.

15. Opening to Traffic * (Required)

Some mix tenderness has been reported for some WMA technologies. What is the manufacturer's recommendation on the appropriate time/temperature for opening to traffic to minimize risk of rutting?

ATTACHMENT 2

WMA EXPERIMENTAL FEATURE
PROJECT BACKGROUND FORM
(To be filled out by District/Local Agency)

Contract Number	
District/Local Agency	
Month/Year of Construction	
Route	
Facility Type	
ADT for year of construction	
Project Limits – in-place stationing	
Project Limits – key route stationing (not needed for Local Agency projects)	
Existing cross-section, including rehabilitation history	
WMA Technology	
Which lifts were WMA used in (surface/binder)	
District/Local Agency HMA Design Verification TSR value	
If value engineering criteria was assessed, indicate how (Attachment 1)	
Was credit given for use of WMA?	
If Yes, what was amount of credit?	
District Contact (name, title, phone no., e-mail address)	

ATTACHMENT 3

Warm Mix Asphalt Experimental Feature
Contractor Documentation

This form is to be filled out by the QC Manager and submitted to the District office for signature and submittal to the Bureau of Materials and Physical Research.

Locations: Contract #: ________ Route:_________

Limits of WMA (lane, exact in-place stationing begin/end in each direction)	
Limits of HMA Control Section (lane, exact in-place stationing begin/end in each direction)	

Production Temperature: WMA Technology: _______________ Plant Type: _______________

	Target °F	Min °F	Max °F	Average °F
HMA				
WMA				

Placement Temperature:

	Target °F	Min °F	Max °F	Average °F
HMA				
WMA				

Production Testing: Mix Design #_______, QC - Testing Temp: ____°F, QA - Testing Temp: ____°F

	Conditioned Tensile Strength (psi)	Unconditioned Tensile Strength (psi)	TSR	Visual Strip Rating Coarse/Fine
HMA				
WMA				

	VMA (% nearest tenth)			Voids (% nearest tenth)			Density (% nearest tenth)		
	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave
HMA									
WMA									

Ignition Moisture Correction: HMA ______% WMA ______%

Anti-Strip A-S Used? ______ Brand: ______________ Rate: ________

Precision Limits: 1 - never met 2 - sometimes met 3 - met half the time 4 - usually met 5 -always met

Rate the following QC vs QA: Air Voids ____ Asphalt Binder Content ____ VMA ____

ATTACHMENT 3

Laydown:

Average Haul Time: _______________

Rolling Pattern # passes: HMA _____ WMA _____

Pavement temp when opened to traffic: HMA ___ ºF WMA ___ºF: √ method: Gun ___ Probe ___

Rate Tenderness (1 to 5): 1 – extremely tender 5 – no tenderness

During compaction process ________ 2 days after paving ___________

Comments (include comments on necessary plant modifications, differences between HMA and WMA on handling, density as well as notable differences on any other laydown characteristics):

Printed Name: QC Manager: ____

Signature: QC Manager: ____

Contact Information: ____

Signature: District Materials Engineer: ________________________________

WARM MIX ASPHALT (WMA) (BMPR)

Effective: January 1, 2012

Description:

This work shall consist of designing, producing and constructing Warm Mix Asphalt (WMA) in lieu of Hot Mix Asphalt (HMA) for N30, N50 and N70 mixtures. The requirements of Section 406, 407, 408, 1030 and 1102 of the Illinois Department of Transportation Standard Specifications for Road and Bridge Construction (January 1, 2012) shall apply except as modified herein.

WMA is an asphalt mixture which can be produced at temperatures lower than allowed for HMA utilizing approved WMA technologies. WMA technologies are defined as the use of additives or processes which allow a reduction in the temperatures at which HMA mixes are produced and placed. WMA is produced by the use of additives, a water foaming process, or combination of both. Additives include minerals, chemicals or organics incorporated into the asphalt binder stream in a dedicated delivery system. The process of foaming injects water into the asphalt binder stream, just prior to incorporation of the asphalt binder with the aggregate.

Approved WMA technologies may also be used in HMA provided all the requirements specified herein, with the exception of temperature, are met. However, asphalt mixtures produced at temperatures in excess of 275 ºF (135 ºC)will not be considered WMA when determining the grade reduction of the virgin asphalt binder grade.

Materials:

Add the following to Article 1030.02 of the Standard Specifications:

"(h) WMA Technologies (Note 3)"

Add the following note to Article 1030.02 of the Standard Specifications:

"Note 3. Warm mix additives or foaming processes shall be selected from the current Bureau of Materials and Physical Research Approved List , "Warm-Mix Asphalt Technologies"."

Equipment:

Revise the first paragraph of Article 1102.01 of the Standard Specifications to read:

"1102.01 Hot-Mix Asphalt Plant. The hot-mix asphalt (HMA) plant shall be the batch-type, continuous-type, or dryer drum plant. The plants shall be evaluated for prequalification rating and approval to produce HMA according to the current Bureau of Materials and Physical Research Policy Memorandum, "Approval of Hot-Mix Asphalt Plants and Equipment." Once approved, the Contractor shall notify BMPR to obtain approval of all plant modifications. The plants shall not be used to produce mixtures concurrently for more than one project or for private work unless permission is granted in writing by the Engineer. The plant units shall be so designed, coordinated and operated that they will function properly and produce HMA having uniform temperatures and compositions within the tolerances specified. The plant units shall meet the following requirements."

Add the following to Article 1102.01(a) of the Standard Specifications:

"(13) Equipment for Warm Mix Technologies.

a. Foaming. Metering equipment for foamed asphalt shall have an accuracy of ± 2 percent of the actual water metered. The foaming control system shall be electronically interfaced with the asphalt binder meter.

b. Additives. Additives shall be introduced into the plant in accordance with the supplier's recommendations and shall be approved by the Engineer. The system for introducing the WMA additive shall be interlocked with the aggregate feed or weigh system to maintain correct proportions for all rates of production and batch sizes."

Mix Design Verification:

Add the following to Article 1030.04 of the Standard Specifications:

"(d) Warm Mix Technologies.

(1) Foaming. WMA mix design verification will not be required when foaming technology is used alone (without WMA additives). However, the foaming technology shall only be used on HMA mix designs previously approved by the Department."

(2) Additives. WMA mix designs utilizing additives shall be submitted to the Engineer for mix design verification. Additional mixture verification requirements include Hamburg Wheel testing according to IL Mod AASHTO T324 and tensile strength testing according to IL Mod AASHTO T283 which shall meet the criteria in Tables 1 and 2 respectively herein. The Contractor shall provide the additional material as follows:

a. Four (4) gyratory specimens to be prepared in the Contractor's lab according to IL Mod AASHTO T324

b. Sufficient mixture to conduct tensile strength testing according to IL Mod AASHTO T283.

Table 1. Illinois Modified AASHTO T324 Requirements.[1/]

Asphalt Binder Grade	# Wheel Passes	Max Rut Depth in. (mm)
PG 76-XX	20,000	½ in. (12.5 mm)
PG 70-XX	15,000	½ in. (12.5 mm)
PG 64-XX	10,000	½ in. (12.5 mm)
PG 58-XX		

Note: 1/ Loose WMA shall be oven aged at 270 ± 5 ºF (132 ± 3 ºC) for two hours prior to gyratory compaction of Hamburg Wheel specimens.

Table 2. Tensile Strength Requirements

Asphalt Binder Grade	Tensile Strength psi (kPa)	
	Minimum	Maximum
PG 76-XX	80 (552 kPa)	200 (1379 kPa)
PG 70-XX		
PG 64-XX	60 (414 kPa)	200 (1379 kPa)”
PG 58-XX		

Production:

Revise the second paragraph of Article 1030.06 (a) to read:

“At the start of mix production for HMA, WMA and HMA using WMA technologies, QC/QA mixture start-up will be required for the following situations: at the beginning of production of a new mix of a new mixture design, at the beginning of each production season, and at every plant utilized to produce mixtures, regardless of the mix.”

Insert the following between the sixth and seventh paragraph of Article 1030.06(a):

“(1) Warm Mix Technologies:

a. Mixture sampled to represent the Test Strip shall include additional material sufficient for the Department to conduct Hamburg Wheel testing according to IL Mod AASHTO T324 and tensile strength testing according to IL Mod AASHTO T283 (approximately 110 pounds (50 kg) total).

b. Upon completion of the Start-up, WMA production shall cease. The Contractor may revert to HMA production provided a start-up has been previously completed for the current construction season for the mix design. WMA may resume once all the test results, including Hamburg Wheel results are completed and found acceptable by the Engineer."

Add the following as a second paragraph to Article 1030.05(d)(2)c.:

"During production of each WMA mixture or HMA utilizing WMA technologies, the Engineer will request a minimum of one randomly located sample, identified by the Engineer, for Hamburg Wheel testing to determine compliance with the requirements specified in Table 1 herein."

Quality Control/Quality Assurance Testing:

Revise the table and notes in Article 1030.05(d)(2)a. to read as follows:

"Parameter	Frequency of Tests High ESAL Mixture Low ESAL Mixture	Frequency of Tests All Other Mixtures	Test Method See Manual of Test Procedures for Materials
Aggregate Gradation % passing sieves: 1/2 in. (12.5 mm), No. 4 (4.75 mm), No. 8 (2.36 mm), No. 30 (600 µm) No. 200 (75 µm) Note 1.	1 washed ignition oven test on the mix per half day of production Note 4.	1 washed ignition oven test on the mix per day of production Note 4.	Illinois Procedure
Asphalt Binder Content by Ignition Oven Note 2.	1 per half day of production	1 per day	Illinois-Modified AASHTO T 308
VMA Note 3.	Day's production ≥ 1200 tons: 1 per half day of production	N/A	Illinois-Modified AASHTO R 35
	Day's production < 1200 tons: 1 per half day of production for first 2 days and 1 per day thereafter (first sample of the day)		

"Parameter	Frequency of Tests High ESAL Mixture Low ESAL Mixture	Frequency of Tests All Other Mixtures	Test Method See Manual of Test Procedures for Materials
Air Voids Bulk Specific Gravity of Gyratory Sample Note 5.	Day's production ≥ 1200 tons: 1 per half day of production	1 per day	Illinois-Modified AASHTO T 312
	Day's production < 1200 tons: 1 per half day of production for first 2 days and 1 per day thereafter (first sample of the day)		
Parameter	Frequency of Tests High ESAL Mixture Low ESAL Mixture	Frequency of Tests All Other Mixtures	Test Method See Manual of Test Procedures for Materials
Maximum Specific Gravity of Mixture	Day's production ≥ 1200 tons: 1 per half day of production	1 per day	Illinois-Modified AASHTO T 209
	Day's production < 1200 tons: 1 per half day of production for first 2 days and 1 per day thereafter (first sample of the day)		

Note 1. The No. 8 (2.36 mm) and No. 30 (600 μm) sieves are not required for All Other Mixtures.

Note 2. The Engineer may waive the ignition oven requirement for asphalt binder content if the aggregates to be used are known to have ignition asphalt binder content calibration factors which exceed 1.5 percent. If the ignition oven requirement is waived, other Department approved methods shall be used to determine the asphalt binder content.

Note 3.The G_{sb} used in the voids in the mineral aggregate (VMA) calculation shall be the same average G_{sb} value listed in the mix design.

Note 4.The Engineer reserves the right to require additional hot bin gradations for batch plants if control problems are evident.

Note 5.The WMA compaction temperature for mixture volumetric testing shall be 270 ± 5 °F (132 ± 3 °C) for quality control testing. The WMA compaction temperature for quality assurance testing will be 270 ± 5 ºF (132 ± 3 ºC) if the mixture is not allowed to cool to room temperature. If the mixture is allowed to cool to room temperature it shall be reheated to standard HMA compaction temperatures."

Construction Requirements:

Revise the second paragraph of Article 406.06(b)(1) to read as follows:

"The HMA shall be delivered at a temperature of 250 to 350 ºF (120 to 175 ºC). WMA shall be delivered at a minimum temperature of 215 ºF (102 ºC)."

Basis of Payment:

This work will be paid at the contract unit price bid for the HMA pay items involved except a new pay item will be created to document the use of WMA. Anti-strip will not be paid for separately, but shall be considered as included in the cost of the work.

C5. Indiana

INDIANA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS MANAGEMENT

CERTIFIED HOT MIX ASPHALT PRODUCER PROGRAM
ITM 583-11P

1.0 SCOPE.

1.1 This procedure covers the requirements for a HMA plant to become a Certified Hot Mix Asphalt Producer. Mixtures produced shall be QC/QA HMA in accordance with 401, HMA in accordance with 402, and Stone Matrix Asphalt (SMA) in accordance with 410.

1.2 The values stated in either English or acceptable SI metric units are to be regarded separately as standard, as appropriate for a specification with which this ITM is used. Within the text, SI metric units are shown in parenthesis. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other, without combining values in any way.

1.3 This procedure may involve hazardous materials, operations and equipment and may not address all of the safety problems associated with the use of the test method. The user of this ITM is responsible for establishing the appropriate safety and health practices and determining the applicability of regulatory limitations prior to use.

2.0 REFERENCES.

REFERENCES. Documents required by the Program may be maintained electronically or by hard copy.

2.1 AASHTO Standards.

R 30	Mixture Conditioning of Hot Mix Asphalt
R 35	Superpave Volumetric Design for Hot Mix Asphalt (HMA)
R 46	Designing Stone Matrix Asphalt (SMA)
T 2	Sampling of Aggregates
T 11	Materials Finer Than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
T 27	Sieve Analysis of Fine and Coarse Aggregates
T 30	Mechanical Analysis of Extracted Aggregate
T 40	Sampling Bituminous Materials
T 166	Bulk Specific Gravity of Compacted Hot Mix Asphalt (HMA) Using Saturated Surface-Dry Specimens.
T 209	Theoretical Maximum Specific Gravity and Density of Hot Mix Asphalt Paving Mixtures
T 248	Reducing Samples of Aggregate to Testing Size
T 255	Total Evaporable Moisture Content of Aggregate by Drying
T 269	Percent Air Voids in Compacted Dense and Open Asphalt Mixtures

- T 275 Bulk Specific Gravity of Compacted Hot Mix Asphalt (HMA) Using Paraffin-Coated Specimens
- T 305 Determination of Draindown Characteristics in Uncompacted Asphalt Mixtures
- T 312 Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor
- T 331 Bulk Specific Gravity and Density of Compacted Asphalt Mixtures Using Automatic Vacuum Sealing Method
- TP 71 Evaluation of Superpave Gyratory Compactor (SGC) Internal Angle of Gyration Using Simulated Loading

2.2 ASTM Standards.

- D 5821 Determining the Percentage of Fractured Particles in Coarse Aggregate

2.3 ITM Standards.

- 207 Sampling Stockpiled Aggregates
- 571 Quantitative Extraction of Asphalt/Binder and Gradation of Extracted Aggregate from HMA Mixtures
- 572 Drying HMA Mixtures
- 580 Sampling HMA
- 581 Performance Graded Binder Approved Supplier Certification (ASC) Program
- 586 Binder Content by Ignition
- 587 Reducing HMA Samples to Testing Size
- 588 Percent Within Limits (PWL)
- 902 Verifying Sieves
- 903 Verifying Ovens
- 905 Verifying Vacuum Systems
- 906 Verifying Mechanical Shakers
- 908 Verifying Calibrations Settings for Superpave Gyratory Compactors
- 909 Verifying Thermometers
- 910 Verifying Balances
- 913 Verifying HMA Gyratory Molds, Top Plates and Base Plates

2.4 A Certified HMA plant laboratory shall have the following current documents on file:

2.4.1 Indiana Department of Transportation Standard Specifications (Includes applicable Supplemental Specifications)

2.4.2 Pertinent contract Special Provisions

2.4.3 Indiana HMA Quality Assurance Certified Technician Program Manual

2.4.4 All applicable ITM, AASHTO, and ASTM Test Methods

2.4.5 Testing equipment calibrations or verifications

2.4.6 Mix design, DMF, and JMF for each Mixture

2.4.7 Fines correction data for each DMF and JMF if applicable

2.4.8 PG 58-28 and PG 64-22 binder test reports from the Supplier whenever in-line blending with SBR polymer latex

2.4.9 Type A certifications for the SBR polymer latex

2.4.10 PG 64-28 and PG 70-22 binder test reports from an AASHTO accredited laboratory whenever PG 58-28 and PG 64-22 are in-line blended with SBR polymer latex

2.4.11 Process control test results

2.4.12 Type D certifications issued to active Department contracts

2.5 A Certified HMA plant shall have the following current documents on file:

2.5.1 The Quality Control Plan (QCP) for the HMA plant

2.5.2 Bill of ladings of the binder from a Supplier for the most current date of shipment

2.5.3 Instructions from the Supplier concerning storage and handling of the binder

2.5.4 Flow meter calibration reports and flow computer printouts whenever in-line blending with SBR polymer latex

2.5.5 The IDEM Legitimate Use Approval letter from the post-consumer asphalt shingle processing company

2.5.6 HMA plant calibrations for each DMF

2.5.7 Daily diary

2.5.8 Annual calibration of HMA plant scales and verification of meters

2.5.9 Fiber certification from the manufacturer

2.5.10 Instructions from the manufacturer concerning storage and handling of fibers

3.0 TERMINOLOGY. Definitions for terms and abbreviations will be in accordance with the Department's Standard Specifications Section 101 and the following:

3.1 Addenda. Any addition or deletion to the QCP

3.2 Addenda Summary Sheet. A page of the QCP that is used to record a brief description of addenda until such time that the revisions are incorporated into the QCP

3.3 Actual Binder Content. The binder content determined in accordance with ITM 586 or the total of the binder content determined in accordance with ITM 571 and the binder absorption percent from the DMF

3.4 Certified Asphalt Technician. An individual who has successfully completed the requirements of the Department Hot Mix Asphalt QA/QC Certified Technician Training Program

3.5 Certified HMA Plant. A HMA plant that meets the requirements of the Program, continues to be under the same ownership, and is approved by the Department

3.6 Corrective Action. Corrective action shall include, but is not limited to, investigation for cause, correction of known cause, or re-testing

3.7 Coarse Aggregate. Aggregate that has a minimum of 20 percent retained on the No. 4 (4.75) mm sieve

3.8 District. The Department District Office responsible for administrating the materials and tests function in a local area of the state

3.9 Fine Aggregate. Aggregate that is 100 percent passing the 3/8 in. (9.5 mm) sieve and a minimum of 80 percent passing the No. 4 (4.75) mm sieve

3.10 Mixture. QC/QA HMA, HMA, or SMA produced for the Department's use in accordance with ITM 583 and the Specifications

3.11 Moving Average. Average of the last four or five tests as stated in the QCP

3.12 National Institute of Standards and Technology (NIST). A federal technology agency that develops and applies technology, measurements, and standards

3.13 Office of Materials Management. An office of the Indiana Department of Transportation, located at 120 S. Shortridge Rd. in Indianapolis, Indiana 46219-0389.

3.14 Producer. A company or owner who shall assume responsibility for a Certified HMA Plant. A Producer, in accordance with ITM 581, may modify a PG binder from a Supplier by in-line blending SBR polymer latex at the HMA plant for immediate use.

3.15 Program. ITM 583, Certified Hot Mix Asphalt Producer Program

3.16 QCP Annex. A page of the QCP, located in the Appendix, that is used to record revisions for HMA Plant major components, Certified Asphalt Technicians, and movement of the HMA Plant.

3.17 Qualified Technician. An individual who has successfully completed the written and proficiency testing requirements of the Department Qualified Laboratory and Technician Program.

3.18 Supplier. A Supplier shall be a refinery or terminal that produces modified or unmodified PG binders in accordance with ITM 581.

3.19 Warm Mix Asphalt (WMA). WMA represents a group of technologies that allow a reduction in the temperature at which mixtures are produced and placed.

4.0 **SIGNIFICANCE AND USE.** The Certified Hot Mix Asphalt Producer Program is a program whereby the Producer takes responsibility for the production of quality mixture in accordance with contract requirements, and the Department monitors the Producers production, sampling, and testing procedures.

5.0 **PRODUCER PERSONNEL.** The Producer personnel shall include a Management Representative, Certified Asphalt Technician, and a Qualified Technician, if applicable.

5.1 **Management Representative.** The Management Representative shall be responsible for all aspects of mixture production and control at the HMA plant and on the pavement as required by the Program.

5.2 **Certified Asphalt Technician.** The Certified Asphalt Technician shall compact and analyze the mixture specimens, and perform the maximum specific gravity test. The technician shall supervise all other sampling and testing of materials, the maintenance of control charts, and the maintenance of the diary.

5.3 **Qualified Technician.** The Qualified Technician shall conduct all sampling and testing used for acceptance of materials produced in accordance with 402. The tests required to determine the air void content in the HMA shall be conducted by a Certified Asphalt Technician.

6.0 LABORATORY.

6.1 Process control testing shall be performed at the HMA Plant or as permitted in 6. 3. The Producer shall provide and maintain a laboratory for process control testing. The laboratory shall have the necessary space, equipment, and supplies for the tests to be performed.

6.2 The laboratory testing equipment shall meet the requirements of the test methods identified for the required sampling and testing, except that an electronic balance shall be provided. The electronic balance shall be readable to 0.1 g and accurate to 0.2 g or 0.1 percent of the test load, whichever is greater, at any point within the range of use. The gyratory compactor shall tilt the specimen mold at an average internal angle of $1.16 \pm 0.02°$ (20.2 ± 0.35 mrad) as determined in accordance with AASHTO TP 71. The gyratory compactor shall be on the Department's List of Approved Superpave Gyratory Compactors.

6.3 Performance of process control tests at laboratory facilities other than at the HMA Plant will be permitted provided the laboratory facilities are owned by the Producer, all test procedure criteria are satisfied in accordance with 6.2, and the test results are furnished in writing to the HMA Plant within two working days.

6.4 The Engineer shall be permitted access to inspect any laboratory used for process control testing, and witness process control activities during production of mixtures.

7.0 TEST EQUIPMENT CALIBRATION.

7.1 The test equipment furnished by the Producer shall be properly calibrated or verified and maintained within the limits described in the applicable test method.

7.2 The Producer shall calibrate or verify equipment at the frequency indicated.

7.3 The equipment calibration or verification documentation shall include:

7.3.1 A description of the equipment calibrated or verified including Model and Serial Number

7.3.2 Name of the person performing the calibration or verification

7.3.3 Identification of the calibration equipment used, if any (namely, standard weights, proving rings, thermometers, etc.)

7.3.4 Last date calibration or verification was performed and next due date

7.3.5 A reference to the procedure used

7.3.6 Detailed records showing the results of the calibration or verification performed

7.4 The testing equipment shall be calibrated or verified in accordance with the following:

Equipment	Requirement	Minimum Frequency	Procedure
Balances	Standardize	12 mo.	ITM 910
Gyratory Compactor	Verify Ram Pressure, Angle of Gyration, Frequency of Gyration, LVDT	1 mo.	ITM 908
Gyratory Compactor Internal Angle	Verification	12 mo.	AASHTO TP 71
Gyratory Mold and Plate Dimensions	Verification	12 mo.	ITM 913
Ignition Oven	Conduct Lift Test	Weekly	Operators Manual
Mechanical Shakers	Verify Sieving Thoroughness	12 mo.	ITM 906
Ovens	Verify Temperature Settings	12 mo.	ITM 903
Sieves	Verify Physical Condition	12 mo.	ITM 902
Thermometers	Verification	12 mo.	ITM 909
Vacuum Pump	Verification	12 mo.	ITM 905
Vacuum Chamber	Verification	3 mo.	ITM 905

7.5 The equipment used to calibrate or verify the testing equipment shall be NIST traceable and shall be calibrated in accordance with the following frequencies:

Calibration Equipment	Testing Equipment	Minimum Frequency
Bore Gauge	Gyratory Compactor Molds – ITM 913	12 mo.
Dynamometer or Load Cell & Proving Ring	Gyratory Compactor – AASHTO T 312	24 mo.
Height Gage Blocks	Gyratory Compactor – AASHTO T 312	24 mo.
Height Billet	Gyratory Compactor – AASHTO T 312	24 mo.
Vacuum Gage	Vacuum Systems – ITM 905 Vacuum Flask – AASHTO T 209	36 mo.
Weights, Min. Class 3	Balances – ITM 910	12 mo.

8.0 DIARY

8.1 The Producer shall maintain a diary at the HMA Plant. The diary shall be an open format book with at least one page devoted to each day mixture is produced.

8.2 The Producer shall keep the diary on file for a minimum period of three years.

8.3 Entries in the diary shall as a minimum include:

8.3.1 The type of mixture produced and quantity, DMF or JMF number, and the contract or purchase order number for each mixture

8.3.2 The time the sample was obtained and the time the test was completed

8.3.3 Non-conforming tests and the resulting corrective action taken

8.3.4 Any significant events or problems

8.3.5 WMA Production

a) Daily weather conditions, production rates and mixture discharge temperature ranges

b) Observations on aggregate coatings at discharge

c) Observations on plant and bag-house performance

d) Observations on plant fuel consumption

e) Observations on silo storage times

f) Haul distances and times

g) Delivery temperature at paver

8.4 The Certified Asphalt Technician or Management Representative shall sign the entry in the diary. On occasion the diary may be signed by another person; however, the diary is required to be counter-signed by the Certified Asphalt Technician or Management Representative.

9.0 MATERIALS SAMPLING AND TESTING. The Producer shall designate the sampling and sample reduction procedures, test methods, sampling locations, and size of samples necessary for the quality control. Mixture shall be sampled in accordance with ITM 580. Testing of the samples shall be completed within two working days. Test values shall be reported to the nearest 0.1 percent, except as follows:

a) Coarse aggregate angularity shall be reported to the nearest 1 percent

b) Mixture temperature shall be reported to the nearest 1°F (0.5°C)

c) Mixture moisture content and draindown shall be reported to the nearest 0.01 percent

Rounding shall be in accordance with 109.01(a). The Producer shall keep the test results on file for a minimum period of three years.

The VMA shall be calculated in accordance with AASHTO R 35 using the actual binder content from the most recent binder content determination. The maximum specific gravity shall be mass determined in water in accordance with AASHTO T 209. Gyratory specimens shall be compacted at 300 ± 9°F (150 ± 5°C) for dense graded mixtures and SMA, and 260 ± 9°F (125 ± 5°C) for open graded mixtures.

9.1 QC/QA HMA and SMA Mixtures. The following items shall be addressed in the QCP as a minimum:

9.1.1 Aggregates

a) Stockpile

b) Blended

9.1.2 Binder

9.1.3 Recycled Materials

a) Actual Binder Content

b) Gradation

c) Moisture Content

d) Coarse Aggregate Angularity

9.1.4 Mixture Sampled at the HMA plant

a) Actual Binder Content

b) Gradation (for SMA mixtures only)

c) Moisture Content (HMA and WMA mixtures)

1. WMA -- each production sublot within the first lot
2. WMA -- each production day thereafter

d) Temperature

e) Draindown (for open graded and SMA mixtures only)

9.1.5 Mixture Sampled from the Pavement

a) Air Voids

b) VMA

c) Actual Binder Content

d) Gradation (for SMA mixtures only)

e) Moisture Content (for surface mixtures only)

f) Bulk Specific Gravity

g) Maximum Specific Gravity

9.2 **HMA Mixtures.** HMA mixture produced concurrently with QC/QA HMA mixture shall be sampled and tested in accordance with 9.1. All other HMA mixture shall be sampled at the HMA plant or the roadway at the Contractor's option and tested for Binder Content, Coarse Aggregate Angularity (mixtures containing gravel), Gradation, and Air Voids in accordance with the following minimum frequency:

9.2.1 The first 250 t (250 Mg) and each subsequent 1000 t (1000 Mg) of each DMF or JMF in a construction season for base and intermediate mixtures

9.2.2 The first 250 t (250 Mg) and each subsequent 600 t (600 Mg) of each DMF or JMF in a construction season for surface mixtures

10.0 ADJUSTMENT PERIOD. The adjustment period shall only apply to QC/QA HMA and SMA mixtures.

10.1 The Producer will be allowed an adjustment period for each DMF in which changes may be made. The adjustment period shall be from the beginning of production and extending until 5000 t (5000 Mg) of base or intermediate mixtures or 3000 t (3000 Mg) of surface mixture has been produced. A reduced adjustment period may be allowed.

10.2 The aggregate and recycled materials blend percentage and the amount passing all sieves on the DMF may be adjusted provided the gradation limits do not exceed the requirements of 401.05 or 410.05 and the dust/calculated effective binder ratio is in accordance with 401.05. Adjustments to the aggregate and recycled materials blend percentage, gradation and the new combined aggregate bulk specific gravity shall be included on the JMF.

10.3 The total binder content on the JMF may be determined by adjusting the DMF a maximum of ± 0.5 percent provided the dust/calculated effective binder ratio is in accordance with 401.05. The recycled materials binder content may be adjusted as part of the total binder content provided the binder replacement percentage is in accordance with 401.06 or 410.06.

10.4 The VMA value on the JMF for QC/QA HMA may be adjusted from the DMF provided the new value is in accordance with 401.05.

10.5 The air voids on the JMF for open graded mixtures may be adjusted from the DMF provided the new value is in accordance with 401.05.

10.6 The gyratory specimen target weight on the JMF may be adjusted from the DMF to produce specimen heights of 115 ± 5 mm in accordance with AASHTO T 312.

10.7 The JMF shall be submitted in writing for approval to the District Testing Engineer one working day after the receipt of the original test results for the binder content, VMA, and air voids of the adjustment period.

10.8 A DMF will be allowed one adjustment period in a construction season. A new adjustment period will not be allowed for only a binder source change. Any adjusted DMF from the previous construction season may retain the adjustments for subsequent use provided the binder content is within ± 0.5 percent from the original referenced DMF. The DMF/JMF will be allowed a new adjustment period if production extends into the next construction season.

11.0 CONTROL LIMITS. The control limits shall only apply to QC/QA HMA and SMA mixtures.

11.1 Target mean values shall be as follows:

11.1.1 The target value for the air void content shall be as designated by the Producer.

11.1.2 The target values for the binder content of the mixture and the VMA shall be as indicated on the JMF.

11.2 Control limits for single test values shall be as follows.

Parameter	Maximum % Passing, Control Limits (±)		
	Aggregate Stockpiles	Blended Aggregate Base and Intermediate Mixtures	Blended Aggregate Surface Mixture
3/4 in. (19.0mm)	10.0	10.0	
1/2 in. (12.5mm)	10.0	10.0	10.0
No.4 (4.75mm)	10.0	10.0	10.0
No.8 (2.36mm)	10.0	10.0	8.0
No.16 (1.18mm)	8.0	8.0	8.0
No.30 (600um)	6.0	6.0	4.0
No.50 (300um)	6.0	6.0	4.0
No.100 (150um)	6.0	6.0	3.0
No.200 (75um)	2.0	2.0	2.0
Parameter			**Control Limits**
Binder Content of Mixture and RAP, %			± 0.7
VMA @ Ndes, % (QC/QA HMA)			± 1.0
VMA @ N_{100}, Minimum % (SMA)			17
Target Air Voids % (Dense Graded Mixtures, SMA)			± 1.0
Target Air Voids % (Open Graded Mixtures)			± 3.0

12.0 RESPONSE TO TEST RESULTS.

12.1 The Producer shall take corrective action when the control limits for QC/QA HMA and SMA or specification limits for HMA Mixtures are exceeded for the appropriate properties of Mixture Binder Content, Air Voids, or VMA.

12.2 **Moisture Content.** The Producer shall take corrective action when the moisture content of the mixture sampled at the HMA Plant exceeds 0.30 percent or when the moisture content of the surface mixture sampled from the pavement exceeds 0.10 percent.

12.3 The Producer in-line blending SBR latex at the HMA plant shall take corrective action if the latex solids content is more than 0.2% below the lower target limit for more than 15 minutes of production.

12.4 **Documentation.** All corrective action shall be documented in the diary.

13.0 QUALITY CONTROL PLAN.

13.1 Each Producer providing mixture under the Program shall have a written QCP which shall be HMA plant specific and be the basis of control. The QCP shall contain, but not be limited to, the methods of sampling, testing, calibration, verification, inspection, and anticipated frequencies.

13.2 If applicable, the QCP shall include the following information for each HMA Plant:

13.2.1 The location of the HMA Plant site, including the county and reference to the nearest identifiable points such as highways and towns.

13.2.2 The name, telephone number, fax number, email address, duties, and employer of the Management Representative, Certified Asphalt Technician(s), and Qualified Technician(s), if applicable. The duties of all other personnel responsible for implementation of the QCP shall be included.

13.2.3 A list of test equipment that is calibrated or verified, the test methods and frequency of calibration or verification of the equipment, and a statement of accessibility of the laboratory to Department personnel.

If the laboratory is not located at the HMA Plant, the location of the laboratory shall be designated, and the procedure for transporting the mixture to the laboratory included.

13.2.4 A HMA plant site layout diagram which shall include the location of the stockpile area, binder tanks, fuel tank, fiber supply, anti-adhesive supply, field laboratory, visitor parking area, and major components of the mixing HMA plant.

13.2.5 A plan for controls of the aggregate and recycled material stockpiles. Controls for identification of stockpiles by signing or other acceptable methods, techniques for construction of proper stockpiles, and cold bin loading procedures to prevent overflow of material from one bin into another shall be included.

13.2.6 A plan for the identification of the grade of binder in each storage tank and the use of more than one binder grade in a binder tank. The sampling location shall be indicated.

13.2.7 A plan for in-line blending SBR polymer latex at the HMA plant to include a QCP in accordance with ITM 581 as an addendum to the plant QCP

13.2.8 A plan for the production of WMA. The necessary plant modifications, plant production start-up process, planned mixture production temperature ranges, and moisture testing on mixtures sampled at the plant for each DMF / JMF shall be included.

13.2.9 The procedure for the consistent uniform addition of baghouse fines when returned into the HMA plant.

13.2.10 The procedure for the consistent uniform addition of fibers into the HMA plant.

13.2.11 The procedure for using an anti-adhesive agent for the truck bed, and a statement that the agent is on the Department's List of Approved Anti-Adhesive Materials.

13.2.12 The procedure for sealing the surge bin when used for extended storage of the mixture up to one working day, and the method to prevent the discharge when the mixture falls below the top of the cone.

13.2.13 The procedure for loading mixture into the trucks.

13.2.14 A sampling plan that includes locations, test methods, devices, techniques, frequencies, and sample reduction procedures.

13.2.15 A testing plan that includes the types of tests, and test methods.

13.2.16 A description of any other process control techniques that may be used. These controls may include, but are not limited to:

a) Different types of material testing

b) Visual checks, and monitoring of HMA plant production

13.2.17 A statement of the procedure for handling addenda to the QCP including a time schedule for submittal.

13.2.18 A documentation plan with details on control charting, test data, and the diary. Copies of the forms may be included.

13.3 The last page of the QCP shall contain two signatures. One signature shall be the Producer Management Representative. The date of submittal and the corporate title of the Producer Management Representative making the signature shall be included. The other signature shall be for approval by the Manager, Office of Materials Management.

13.4 Production of mixture shall not begin before the QCP has been approved. The Producer shall submit two copies of the QCP to the Department for review. One copy shall be submitted to the District Testing Engineer, and one copy to the Office of Materials Management. Acceptance or rejection of the QCP will be made within 15 days of receipt of the QCP. One approved copy will be returned to the Producer.

13.5 The Producer shall transmit all applicable process control changes to the District Testing Engineer for approval. This shall be done in the format of addenda to the QCP. Each page of the QCP that is revised shall include the HMA plant number, date of revision, and means of identifying the revision. The addenda shall be signed and dated by the Management Representative and subsequently signed and dated when approved by the District Testing Engineer.

Revisions for HMA plant major components, Certified Asphalt Technicians, and movement of the HMA plant shall be submitted in the format of a QCP Annex as they occur, and upon approval by the District Testing Engineer shall be included in the Appendix of the QCP. Revisions, other than items on the QCP Annex, shall be maintained on the Addenda Summary sheet in the QCP Appendix.

Addenda may be submitted at the audit close-out meeting or within the first two months of each calendar year. The addenda shall include items on the QCP Annex, items on the Addenda Summary Sheet, and any other necessary revisions at the time of submittal. Upon incorporation into the QCP as addenda, the QCP Annex and items on the Addenda Summary Sheet shall be removed from the QCP Appendix.

13.6 Movement of the HMA Plant to a new location will require an addendum to the QCP. Verification of the calibration of all meters, scales and other measuring devices in accordance with 14.3 shall be completed.

14.0 CERTIFICATION.

14.1 Each Producer requesting to establish a Certified Plant shall do so in writing to the Manager, Office of Materials Management.

14.2 Upon receipt of the request for certification, the District Testing Engineer will be notified to inspect the plant and laboratory.

14.3 A plant inspection, including the correction of any deficiencies and calibration of all meters, scales and other measuring devices to an accuracy within 0.5% throughout their range, shall be completed prior to certification.

14.4 Each HMA plant meeting the requirements of the Program will be certified upon the approval of the QCP.

14.5 The Producer, in accordance with ITM 581, shall submit a written request to the Asphalt Engineer, Office of Materials Management, to in-line blend SBR polymer latex at the HMA plant.

14.6 In the event of a change in ownership of the Certified HMA Plant, the certification shall expire on the date of such change. The new ownership may avoid expiration by submitting a statement to the Manager, Office of Materials Management indicating recognition of the details of the Program, the existing QCP, and a clear pronouncement of intent to operate in accordance with the requirements of both documents prior to providing mixture for the Program.

15.0 DEPARTMENT RESPONSIBILITIES.

15.1 The Department will conduct annual audits on a random basis of each HMA Plant.

15.2 The Department will maintain the List of Approved Certified Hot Mix Asphalt Producers. Producers meeting the requirements of the ASC program for in-line blending of SBR polymer latex will be indicated as a Performance-Graded Asphalt Binder Approved Supplier on the List.

15.3 The Department will administer a Certified Asphalt Technician Training Program for those Asphalt Technicians that perform the required duties for the Certified HMA Plant. Certification of the Technicians will be provided by the Department upon passing a certification test.

15.4 The removal of a Producer from the Department's List of Approved Certified Hot Mix Asphalt Producers will be the responsibility of the Office of Materials Management. The Producer shall have the right to appeal the removal from the Department's List of Approved Certified Hot Mix Asphalt Producers to the Director, Highway Management.

C6. Iowa

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 215°F (102°C) and 280°F (138°C) until placed on the grade.
- **b)** Do not produce WMA mixtures more than 10°F (5 °C) below the target temperature designated in the mixture design without the approval of the Engineer.
- **c)** Keep the production temperature of HMA mixtures between 215°F (102°C) and 330°F (165°C) 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, °F (°C)
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, °F (°C)
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 240°F (115°C).

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^2 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 240°F (115°C). 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 240°F (115°C) 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 240°F (115°C), 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 240°F (115°C), 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 240°F (115°C), 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.

DS-09041
(New)

Iowa Department of Transportation

DEVELOPMENTAL SPECIFICATIONS
FOR
WARM MIX ASPHALT

Effective Date
May 18, 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 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. WMA – Warm Mix Asphalt. Warm mix asphalt 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:

~~Hot Mix~~ Asphalt Concrete Mixture.

Replace Article 6:

6. Prepare gyratory ~~HMA~~ asphalt concrete mixture designs for base, intermediate, and surface mixtures. Follow the procedure outlined in ~~Materials I.M. 510~~ Appendix A of this specification. Submit a mixture design complying with ~~Materials I.M. 510~~ Appendix A of this specification. Propose both a production and a compaction temperature between 215°F (102°C) and 280°F (138°C) for WMA mixture designs.

Add the following Article:

8. WMA is required for surface, intermediate, and base 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. ~~AASHTO T 283~~ 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 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. ~~Use equipment meeting the requirements of Section 2001 with the following modifications.~~

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 ~~the same~~ asphalt binder ~~grade used in the HMA and applied~~ at a rate of 0.20 to 0.25 gallons per square yard (0.9 to 1.1 L/m²). Use the same binder grade used in the asphalt concrete mixture. For binders containing a WMA technology, P~~p~~lace 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) Coring aids may be added with the Engineer's approval.~~

2303.03, C, 3, d, 4.

Replace the Article:

4) ~~Unless the Engineer approves, do not allow the temperature of the mixtures to exceed 330°F (165°C).~~ Adhere to the following temperature restrictions during production:

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

b) Do not produce WMA mixtures more than 10°F below the target temperature designated in the mixture design without the approval of the Engineer.

c) Keep the production temperature of HMA mixtures between 215°F (102°C) and 330°F (165°C) 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 ~~HMA~~ Asphalt Mixtures

Nominal Thickness - inches (mm)	Road Surface Temperature, °F (°C)
1 1/2 (40)	40 (4)
2 - 3 (50 - 80)	35 (2)
Over 3 (Over 80)	~~25 (-4)~~ 35 (2)

Table 2303.03-2: Surface Course Lifts of ~~HMA~~ Asphalt Mixtures

Nominal Thickness - inches (mm)	Road Surface Temperature, °F (°C)
1 (30)	~~50 (10)~~ 40 (4)
1 1/2 (40)	~~45 (7)~~ 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 240°F (115°C).

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	265	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 be verified by 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. ~~Separately h~~Heat the combined aggregate batch and binder containing the WMA technology (at the dosage recommended by the manufacturer) to ~~275° ± 5°F (135° ± 3°C) as checked by~~ 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 ~~275°F (135°C)~~ the proposed production temperature. 1 hour into curing, all

samples are removed, thoroughly stirred and placed back into the oven for remainder of curing time

11. Place approximately 4800 grams of material into the mold for gyratory specimens. Compact specimens at ~~275°F (135°C)~~ 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 T283-07 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. 150mm 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 150mm diameter specimens, in which cases 100mm diameter gyratory compacted specimens may be used.

3. Condition the mixture in a flat shallow pan at an even thickness of 21-22 kg/m3 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 R30 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 tensile strength ratio (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 240°F (115°C). Once this temperature is reached, this set is removed from the oven, compacted as per IM 325 or IM 325G, cooled to ambient temperature and G_{mb} determined. The second set of samples is cooled to ambient temperature, reheated to 240°F (115°C) then compacted as per IM 325 or IM 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 240°F (115°C), compact specimens as per IM 325 or IM 325G, cool to ambient temperature and test for density.
     - 2) Set #2 – Cool to ambient temperature, return to oven, reheat to 240°F (115°C), compact as per IM 325 or IM 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
     - 1) Sample #1 – Cool sample and perform Rice Test.
     - 2) 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 240°F (115°C), compact as per IM 325 or IM 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.

5. Document results and submit to the DME.

SP-090087
(New)

Iowa Department of Transportation

SPECIAL PROVISIONS
FOR
WARM MIX ASPHALT WITH RECYCLED ASPHALT SHINGLES

Muscatine County
HSIPX-061-4(107)--3L-70

Effective Date
July 20, 2010

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

090087.01 Description.
This work consists of HMA shoulder paving in cooperation with Iowa DOT and Iowa State University research. Mixtures containing RAP, recycled asphalt shingles (RAS), and warm mix asphalt (WMA) shall be produced and placed according to the following requirements.

090087.02 Materials.

- Mix Design
  1. Test Section S1 (Control)
     Design and submit for approval, a WMA mixture which contains approximately 20% binder replacement (80% virgin) from RAP only.
  2. Test Section S2
     Design and submit for approval, a WMA mixture containing 5% RAS and a percentage of RAP which results in a combined binder replacement of approximately 30%.
  3. Test Section S3
     Design and submit for approval, a WMA mixture containing 7% RAS and a percentage of RAP which results in a combined binder replacement of approximately 30%.
- The Contractor may request an HMA test strip
- Produce and place the mixtures such that each appears in each lift in approximately equal quantities.
- Design, production and placement of WMA mixtures shall adhere to the Developmental Specifications for Warm Mix Asphalt. Do not use a water-injection system. Moisture sensitivity testing for shoulder mixtures used on this project shall be for information only and is not subject to penalty.
- RAS shall adhere to the Developmental Specifications for Recycled Asphalt Shingles. Do not use pre-consumer RAS.
- Adjust the prescribed binder grade as required by Materials I.M. 510 and the Developmental Specifications for Warm Mix Asphalt
- Do not use multiple RAP sources.

090087.03 Research Sampling.
Provide advanced notification of mixture placement to the Engineer such that research sampling can be coordinated. Provide safe access to Iowa State University research personnel at the plant and on the grade to collect samples. Research samples shall be for information only.

Nordholm, Gail [DOT]

From:	Nordholm, Gail [DOT]
Sent:	Tuesday, June 09, 2009 3:33 PM
To:	Nordholm, Gail [DOT]
Subject:	Warm Mix Asphalt Information

TO: County Engineers, City Representatives, and Consultants
gail.nordholm@dot.iowa.gov

CC: Scott Schram, Office of Materials, District Local Systems Engineers, Service Bureau and Office of Local Systems

FROM: Office of Local Systems

SUBJECT: Warm Mix Asphalt Information

DATE: June 9, 2009

The following is being sent on behalf of the Iowa DOT Office of Materials. If you have any questions, **please do not reply to this note**. Instead, you may contact the person shown below. See the links below this message for the referenced attachments.

* * * * * * * * * * * * * * * * * * * *

Good afternoon,

The Office of Materials is evaluating Warm Mix Asphalt (WMA) as a viable alternative to Hot Mix Asphalt. Given the rapid emergence of this technology, we anticipate more inquiries to the counties permitting its use. The DOT is currently working with Iowa State University to evaluate quality and performance of WMA as a developmental specification is drafted. In the meantime, 3-5 state projects are planned for WMA demonstration this summer.

While countless technical reports are available on WMA, a condensed background is attached for distribution to the County Engineers. I have also attached a project nomination form that was sent to the industry (for informational purposes only). We have received great interest thus far, with some county projects getting nominations. While we are only considering state/federal funded projects for this demonstration, we would encourage willing counties to gain field knowledge of these technologies as they deem appropriate.

Please distribute to counties and other interested parties. The Office of Materials appreciates the support of the local agencies as we move forward with implementing WMA.

Best Regards,

Scott A Schram, Ph.D., P.E.
State Bituminous Engineer

Iowa Department of Transportation
Office of Materials
800 Lincoln Way
Ames, IA 50010
515-239-1604 (office)
515-290-4679 (cell)
515-239-1092 (fax)
scott.schram@dot.iowa.gov

* * * * * * * * * * * * * * * * * * * *

The Warm Mix Asphalt white paper is available at:

http://www.iowadot.gov/local_systems/mailing/2009/june/wma_white_paper.pdf.

The project nomination form is available at:

http://www.iowadot.gov/local_systems/mailing/2009/june/warm_mix_nomination_form.pdf.

Some of the documents referenced above are in Adobe Acrobat's Portable Document Format (PDF). If you do not have the Adobe Acrobat Reader software, you can download it free of charge at:
http://www.adobe.com/products/acrobat/readstep.html.

Mailings are available at the Office of Local Systems Weekly Mailings web page at:
http://www.iowadot.gov/local_systems/mailing/main_mailing.htm

White Paper:
Warm Mix Asphalt
June 2nd 2009

Background

Warm Mix Asphalt (WMA) utilizes additives and/or processes which reduce the viscosity of the liquid asphalt binder allowing complete coating of the aggregate at temperatures approaching 100 °F less than those used for production and placement of traditional Hot Mix Asphalt (HMA). WMA provides many potential benefits for contractors and owners such as:

- Increased haul distances
- Longer paving season
- Increased RAP use
- Reduced fuel consumption
- Reduced plant emissions
- Improved working conditions
- Reduced compactive effort

WMA Technologies

Already used extensively in Europe, WMA has rapidly emerged as a viable alternative to HMA in the U.S. Technologies can be classified as those that use water (foam), those that use an organic additive or wax, and those that use chemical additives or surfactants. Technologies used in the U.S. include but are not limited to:

WMA Technology	Type
Advera®	Foaming Additive
Aspha-min®	Foaming Additive
Rediset™ WMX	Chemical Additive
Evotherm	Chemical Additive/Emulsion
Revix™	Chemical Additive
Sasobit®	Organic Additive
WAM Foam	Foaming Process
Double Barrel Green	Foaming Process
Low Energy Asphalt (LEA)	Foaming Process

Research

Several national research efforts are underway to determine the effects of these technologies on performance using local materials. Initial trials have indicated a potential concern for moisture susceptibility, while rut depths have been shown to be less than those found in some HMA control sections. Fuel cost savings of 13% and reduced emissions have been reported for some

Prepared by the Iowa Department of Transportation
Contact: scott.schram@dot.iowa.gov

technologies. Results from these studies have promoted the use of WMA in both the private and public sectors.

Implementation for Iowa DOT

Over a half million tons of WMA have been placed in Texas since 2007 with a number of other states implementing special provisions. The Iowa DOT is working with Iowa State University to determine how to best utilize this technology while maintaining quality and performance. Demonstration projects are being planned for the 2009 construction season to gain field knowledge of WMA and provide a framework for a developmental specification. Please visit www.warmmixasphalt.com for additional information on Warm Mix Asphalt.

Prepared by the Iowa Department of Transportation
Contact: scott.schram@dot.iowa.gov

Warm Mix Asphalt Project Nomination

The Iowa Department of Transportation is extending its solicitation for warm mix asphalt (WMA) project nominations for the 2009 construction season. The intent of these demonstration projects is to gain field knowledge on warm mix asphalt technology for implementing future developmental specifications. The Iowa DOT anticipates up to three demonstration projects with regional representation (West, Central, and East) and may include a one day open house in partnership with the Asphalt Paving Association of Iowa. It is desirable to demonstrate a different additive/process for each project. Please do not nominate projects that require a majority of night work, projects that include DS-01122 (PWL), or projects funded under the American Recovery and Reinvestment Act of 2009. Please also consider the following:

- Non-interstate surface mixes will be considered
- At least 75% of the total project tonnage must be Hot Mix Asphalt
- No more than 1 day's production (≤ 3500 tons) of WMA may be used
- Field voids and lab voids will not be used for acceptance of WMA test sections
- The DOT may pay a maximum $3/ton toward the cost of warm mix additives, however cost neutral projects will receive the greatest consideration
- Multiple technologies (up to 2) will receive greater consideration

Please submit your application by **June 23rd** for full consideration.

Contractor Name:

Contractor Contact Person:

Project Identification Number:

County:

Anticipated Start Date:

Project Tonnage and ESAL Design Level:

Proposed Warm Mix Asphalt Technology(ies):

Proposed Tonnage of Warm Mix for Project (500ton minimum to 1-day of production maximum)

Will this be cost neutral?

If the project is not cost neutral, what is the estimated per tonnage additional cost?

Please return the nomination form to Scott Schram at the Iowa DOT at scott.schram@dot.iowa.gov. If needed, the nomination may be faxed to 515-239-1092 (please notify Scott before sending fax). E-mail confirmation will be provided. Please contact Scott Schram at 515-239-1604 or John Hinrichsen at 515-239-1601 for questions. **Project selections are anticipated the week of July 1st.**

C7. Kansas

KANSAS DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION TO THE
STANDARD SPECIFICATIONS, EDITION 2007

SECTION 602

HOT MIX ASPHALT (HMA) CONSTRUCTION
(Quality Control/Quality Assurance (QC/QA))

Page 600-2, replace subsection 602.2a. with the following:

a. General. Provide qualified personnel and sufficient equipment complying with the requirements listed in Part V to conduct quality control testing that complies with Appendix B, Sampling and Testing Frequency Chart for Asphalt Construction Items for Quality Control/Quality Assurance Projects.

Allow the Engineer access to the Contractor's laboratory to observe testing procedures, calculations, test documentation and plotting of test results.

Calibrate and correlate the testing equipment with prescribed procedures, and conduct tests in compliance with specified testing procedures as listed in Section 5.17.10, Part V.

Store and retain the most recent 2 lots per mix designation of quality control samples for KDOT. KDOT will retain the most recent 2 lots per mix designation gyratory compacted air voids (Va) verification samples and the remaining material not previously used for testing (back half of sample). Do not retain more than the previous 3 lots per mix designation of quality control or verification samples. When the hot mix plant shuts down for the winter, discard the samples after 7 days.

Maintain control charts on an ongoing basis. Record all original documentation in a bound field book or other KDOT approved bound record and turn over to KDOT at the end of the project.

At the completion of the project, all documentation shall become the property of KDOT.

Provide the following test data to the KDOT Project Representative:

- Copies of all test results and control charts on a weekly basis, representing the prior week's production;
- Copies of the quality control summary sheet on a daily basis. Include, as a minimum, mix gradation, binder content, theoretical maximum specific gravity (Gmm), Va at Ndes, percent Gmm at Nini and Nmax, voids in mineral aggregate (VMA), voids filled with asphalt (VFA) and dust to effective binder content (D/B) ratio; and
- Copies of all failing test results (based on a moving average of 4 tests, when appropriate). Include all applicable sieves, VMA, VFA, density at Nini and Nmax, and D/B ratio.

Page 600-3, subsection 602.2d.(5). In the second paragraph change "subsection 602.2d.(1) and (4)" to "subsections 602.2d.(1) through (4)".

Page 600-4. Add the following to the end of subsection 602.3a.:

Exception: The mixing temperature may be increased no more than 10°F above the maximum mixing temperature shown on the bill of lading provided all the following are met:

1. The air temperature is below 70°F.
2. The plant has not produced mix earlier in the day.
3. Do not exceed a mix temperature of 350°F.
4. No truck has returned for its second load of the day.

Once a previously loaded truck returns for its next load, reduce the temperature to not higher than the maximum mix temperature shown on the bill of lading, not to exceed 340°F.

Page 600-4, replace subsection 602.3d. with the following:

d. Combined Aggregates. Provide combined aggregates for the mixes required in the Contract Documents as shown in **TABLE 602-1**.

Mixes may use any combination of aggregate and mineral filler supplements complying with the applicable requirements in **TABLES 1103-1** and **1103-2**.

Provide materials with less than 0.5% moisture in the final mixture.

The maximum quantity of crushed steel slag used in the mix is 50% of the total aggregate weight.

For all mixes used on the traveled way, the maximum quantity of natural sand is 35%.

Natural sand shall be called SSG-1, SSG-2, etc. in the mix design.

Additional requirements for SM-9.5T and SR-9.5T:

- Traveled way mixes shall include a minimum of 40% primary aggregate based on total aggregate weight.
- A minimum of 50% of the plus No. 4 mesh sieve material in the mixture shall be from the primary aggregate.
- A minimum of 45% of the plus No. 8 mesh sieve material in the mixture shall be from the primary aggregate; and
- Primary aggregates are designated as CS-1 (excluding limestone), CS-2 (excluding limestone), CG, CH-1 and CSSL as described in **subsection 1103.2a.(1)**. Primary aggregate requirements do not apply to the mixture used on the shoulder.

Page 600-5, replace subsection 602.3e. with the following:

***e.* Contractor Trial Mix Design.** A minimum of 10 working days before the start of HMA production, submit in writing to the DME for review and approval, a proposed JMF for each combination of aggregates. For each JMF submitted, include test data to demonstrate that mixtures complying with each proposed JMF shall have properties specified in **TABLE 602-1** for the designated mix type at the Recommended Percent Asphalt (P_{br}). Submit the proposed JMF on forms provided by KDOT. Submit the worksheets used in the design process to include at a minimum the mix properties listed in **TABLE 602-2**. Contact the DME to determine if additional information should be submitted. Provide sufficient material as identified in **TABLE 602-3**. Contact the DME to determine if additional material is needed for additional design checks such as the modified Lottman test (KT-56).

When more than 25% of the virgin aggregates in a mix are comprised of siliceous materials, the minimum amount of anti-strip required in the mix is 0.01% for every percent of natural sand in the mix. Thus, if 35% natural sand is in a mix, then 0.35% anti-strip by weight of total asphalt binder is required in the mix. The total asphalt binder is determined from the ignition oven analysis (KT-57).

When RAP containing siliceous material is included in a mix, the minimum amount of anti-strip required in the mix is 0.01% for every percent of RAP in the mix. Thus, if 25% RAP is in the mix, then 0.25% anti-strip is required. The District Materials Engineer will determine the composition of the RAP aggregates. These minimum values of anti-strip are additive.

If during production, the TSR values (both KDOT and Contractor) exceed 85%, then the Contractor and the District Materials Engineer, working together, may decide on a lower amount of anti-strip.

Submit for the Engineer's review and approval, the test data listed in **TABLE 602-4** for each blend and the proposed JMF. In addition, for mixes containing RAP, submit for the Engineer's review and approval, the test data listed in **TABLE 602-5** for each blend and the proposed JMF. For mixes containing Warm Mix Asphalt (WMA) additives, submit for the Engineer's review and approval, the additive or process used, the recommended rate of application, and the temperature ranges for mixing and compaction. Submit a mix design for each blend and the proposed JMF as outlined in **TABLE 602-6**.

For each aggregate used in the mix design, determine the specific gravity using KT-6. This may be accomplished while the project is being constructed or anytime during the 12 months preceding the start of construction on a project. If construction has not yet begun, notify the DME 5 working days prior to obtaining the material for the specific gravity test so that companion samples may be obtained at the same time. If construction has already begun on the project, then the specific gravity values of the individual aggregates shall be determined before 10,000 tons of HMA is produced. Provide the test results to the DME within 14 days of sampling the material. If the producer of the aggregate has been required to submit material to KDOT for a new Official Quality test, since the time the Contractor ran the specific gravity tests, then perform KT-6 on the aggregate currently produced. The specific gravity values obtained from these tests shall not be used in the mix design calculations for current projects unless mutually agreeable to both parties. The information shall be used, as soon as it becomes available, as part of the process to verify and update the "Monthly Hot Mix Aggregate Specific Gravity Values" posted on KDOT's Internet site.

Page 600-5, add subsection 602.3f:

f. Additives. Provide Warm Mix Asphalt (WMA) additives or processes that comply with **special provision 07-12002, latest revision**. The Contractor is permitted to use WMA unless otherwise shown on the plans.

For mixes containing Warm Mix Asphalt (WMA) additives, submit for the Engineer's review and approval, the additive or process used, the recommended rate of application, and the temperature ranges for mixing and compaction.

Mixing temperature range is provided by the Asphalt Binder Supplier. When using WMA, the mixing temperature may be reduced no more than 30°F for WMA water foaming processes, and no more than 70°F for WMA chemical and organic additives. The minimum mixing temperature for WMA is 220°F.

Page 600-6, replace TABLE 602-1 and its notes with the following:

TABLE 602-1: COMBINED AGGREGATE REQUIREMENTS

Nom. Max. Size Mix Designation	Percent Retained – Square Mesh Sieves									Min. VMA (%)	D/B Ratio
	$1^1/_2$"	1"	$^3/_4$"	$^1/_2$"	$^3/_8$"	No. 4	No. 8	No. 16	No. 200		
SM-4.75A				0	0-5	0-10		40-70	88-94	16.0	0.9 – 2.0
SR-4.75A			0	0-2	0-5	0-10		40-70	88-94	16.0	0.9 – 2.0
SM-9.5A				0	0-10	10 min.	33-53		90-98	15.0	0.6 – 1.2
SR-9.5A			0	0-2	0-10	10 min.	33-53		90-98	15.0	0.6 – 1.2
SM-9.5B				0	0-10	10 min.	53-68		90-98	15.0	0.8 – 1.6
SR-9.5B			0	0-2	0-10	10 min.	53-68		90-98	15.0	0.8 – 1.6
SM-9.5T				0	0-10	10 min.	53-68		90-98	15.0	0.8 – 1.6
SR-9.5T			0	0-2	0-10	10 min.	53-68		90-98	15.0	0.8 – 1.6
SM-12.5A			0	0-10	10 min.		42-61		90-98	14.0	0.6 – 1.2
SR-12.5A		0	0-2	0-10	10 min.		42-61		90-98	14.0	0.6 – 1.2
SM-12.5B			0	0-10	10 min.		61-72		90-98	14.0	0.8 – 1.6
SR-12.5B		0	0-2	0-10	10 min.		61-72		90-98	14.0	0.8 – 1.6
SM-19A		0	0-10	10 min.			51-65		92-98	13.0	0.6 – 1.2
SR-19A	0	0-2	0-10	10 min.			51-65		92-98	13.0	0.6 – 1.2
SM-19B		0	0-10	10 min.			65-77		92-98	13.0	0.8 – 1.6
SR-19B	0	0-2	0-10	10 min.			65-77		92-98	13.0	0.8 – 1.6

1. The requirements for Course Aggregate Angularity (CAA), Fine Aggregate Angularity (FAA), Sand Equivalent (SE), Gyratory compaction revolutions N_{ini}, N_{des}, N_{max}, N_{x} level of compaction and VFA shall be as shown in the Contract Special Provisions for each mix designation.
2. The flat and elongated particles in the combined course aggregate shall not exceed 10% for the total sample.
3. The maximum percent moisture in the final mixture shall not exceed 0.5 for any mix designation.
4. The target air voids (V_a) for any mix designation shall be 4.0% at N_{des} gyrations.
5. The minimum tensile strength ratio (%TSR) shall be 80% for any mix designation.
6. The level of compaction of the mix when compacted to N_{ini} gyrations shall be less than the percent of the G_{mm} shown in the Contract Special Provision, and when compacted to N_{max} gyrations shall be a maximum of 98.0% of the G_{mm}.

Page 600-7, replace TABLE 602-5 with the following:

TABLE 602-5: RAP TEST DATA SUBMITTALS	
Submittal	**Information**
RAP	Source and location where RAP will be obtained.
RAP Aggregate	Bulk Specific Gravity (G_{sb}) Mixes ≤ 15% RAP, the Effective Specific Gravity (G_{se}) shall be calculated as shown in subsection 5.17.04e.(3), Part V and used as the G_{sb}. Mixes > 15% RAP, the G_{sb} will be provided on the Contract Special Provision.
Asphalt Binder Content of RAP	Determined from ignition oven analysis using KT-57
RAP G_{mm}	Determined by KT-39.
Asphalt Binder Specific Gravity	Specific Gravity of the asphalt binder in the RAP (G_b) shall be set equal to 1.035.
Corrected Asphalt Binder Content of the total recycled mixture	Determined from ignition oven analysis using KT-57

Page 600-8, replace subsection 602.4a.(1)(c) with the following:

(c) Anti-Strip Additives. If liquid anti-strip additives are added at the Contractor's plant, install a "totalizer" to monitor the quantity of anti-strip additive being added. The Engineer may approve alternative methods for including anti-strip additives in a batch plant. If added at the plant, the anti-strip will be added in line with the asphalt binder as it is being transferred from the transit unit to the asphalt binder storage tank. Provide a method for the Engineer to monitor the percent of additive being added.

If hydrated lime is added, mix it in an approved pug mill to coat the combined aggregates. Moisten the combined virgin aggregate to a minimum of 3% above the saturated surface dry condition prior to, or during the addition of the hydrated lime.

Page 600-8, add subsection 602.4a.(1)(d).

(d) WMA Additives. If WMA additives are added at the Contractor's plant, install a "totalizer" to monitor the quantity of WMA additive being added. Provide a method for the Engineer to monitor the percent of additive being added.

Page 600-9, add subsection 602.4a.(4).

(4) End of Day Quantities. At the end of each day of production provide the Engineer with a document signed by the Plant Foreman or the Project Manager listing the dry weight of each aggregate, mineral filler, RAP, and WMA chemical or organic additive, the tons of asphalt binder, the tons of anti-strip agent used for the project during the day, and the tons of water used in the WMA foaming process. The dry weight is the tons of the material less the water content.

Page 600-12, subsection 602.4e.(7)(a), delete the first paragraph and replace with the following:

(a) For mixes with a specified thickness greater than or equal to 1 ½ inches.

For lots 1 and 2, control density as shown in **subsection 602.4e.(7)(b)**. Before beginning production, the Contractor has the option to accept the pay adjustment for density on both Lots 1 and 2, or only Lot 2. If the Contractor chooses to accept the pay adjustments for density on both Lots 1 and 2, or only Lot 2, control the density as shown in **subsections 602.4e.(7)(a)(i-ii)**. If the Contractor chooses to accept pay adjustment for density on Lot 1, the pay adjustment can not be rejected on Lot 2.

Page 600-12, replace subsection 602.4e.(7)(c) with the following:

(c) For all lots, achieve the maximum density before the temperature of the HMA falls below 175°F. When using WMA, achieve the maximum density before the temperature of the WMA falls below 165°F. Do not crush the aggregate. When the mat temperature falls below 175°F or 165°F for WMA, roller marks may be removed from the mat with a self-propelled static steel roller.

Page 600-14, replace TABLE 602-12 and its notes with the following:

TABLE 602-12: SPECIFICATION WORKING RANGES (QC/QA)

Mix Characteristic	Tolerance from JMF			
	Single Test Value	Plot	4 Point Moving Average Value	Plot
Binder Content	±0.6%	*	±0.3%	*

Mix Characteristic	Tolerance for Specification Limits			
	Single Test Value	Plot	4 Point Moving Average Value	Plot
Gradation (applicable sieves in **TABLE 602-1**)	N/A	*	zero tolerance	*
Air Voids @ N_{des} gyrations	±2.0%	*	N/A	
Voids in Mineral Aggregate (VMA)	1.0% below min.	*	zero tolerance	*
Voids Filled with Asphalt (VFA)	N/A		zero tolerance	*
Course Aggregate Angularity (CAA)	zero tolerance		N/A	
Sand Equivalent (SE)	zero tolerance		N/A	
Fine Aggregate Uncompacted Voids (FAA)	zero tolerance		N/A	
%Tensile Strength Ratio (%TSR)	zero tolerance	*	N/A	
Density @ N_{ini} and N_{max}	N/A		zero tolerance	
Dust to Effective Binder (D/B) Ratio	zero tolerance	*	zero tolerance	*

* Plot data according to **subsection 106.4d.(2)**
For gradations, as a minimum, plot the No. 4, 8, 30 and 200 sieves.
Plot G_{mm} to third decimal point.
Indicate Job Mix Formula (JMF) and specification working range limits for single test results on the control charts using a green ink dotted line.
Indicate the specification working range limits for the 4-point moving average results with a green ink solid line.

Page 600-15, replace Equation B with the following:

Equation B Deduct = BP*Q*(%RAP_{J}-%RAP_{max})

Page 600-18, replace subsection 602.8c.(2) with the following:

(2) For V_a dispute resolution (the statistical comparison fails and the Contractor questions KDOT results), the following procedure applies for the lots in question.

- Determine which lots to dispute. Only dispute the lot produced immediately prior to the lot currently under production and being tested. Notify the Engineer prior to the completion of all Contractor V_a testing for this lot. (When production is completed for any mix, the last lot may be challenged the day production is completed). When the hot mix plant shuts down for the winter, the Contractor has a maximum of 7 calendar days to dispute the last lot produced prior to winter shut down.
- Discard V_a and V_a pay adjustment factors previously determined within the lots being questioned.
- All saved gyratory compacted V_a quality control and verification samples and back half of samples within the lots in question will be taken by KDOT to the District Materials Laboratory. All back half of samples shall be a minimum of 35 pounds. Failing to obtain enough material removes the right to dispute resolution. Copies of all paperwork, including work sheets, associated with previous V_a calculations for the disputed lots will also be taken to the District Materials Laboratory.

The following retesting will be completed by KDOT:

- Check the samples to be sure they are dry before retesting. Reweigh the original gyratory compacted V_a quality control and verification samples. Determine the G_{mb} at N_{des} revolutions for all saved gyratory plugs. Compare retest results with original test results. Use this information to isolate potential testing errors, but continue with the remainder of the retesting steps.
- Determine the G_{mm} using the back half of all samples within each lot being questioned. Normally, there will be 5 back halves (4 Contractor's and 1 KDOT) to test within each lot.
- Compact the back halves to N_{max} revolutions and determine the G_{mb} at N_{des} revolutions.
- Use G_{mm} determined above and the G_{mb} determined from the recompacted samples to calculate V_a at N_{des} revolutions for the lots in question.
- Using the retest V_a results, a statistical comparison will be made. If the t-test passes, the Contractor's retest results will be used to calculate the pay factor and KDOT will pay for all retesting. Use the procedures shown in **subsection 602.9d**. If the t-test fails, KDOT's retest results will be used to calculate the pay factor, and the Contractor will pay for all retesting.

Page 600-19, replace subsection 602.8g with the following:

g. Increased Lot Size. After 8 consecutive sublots have been produced within the tolerance shown for all mix characteristics listed in **TABLE 602-12** and without a V_a penalty, the sublot size may be increased to 1,000 tons (lot size of 4,000 tons), provided the normal production rate of the plant is greater than 250 tons per hour. Provide immediate notification of lot size changes to the Engineer any time a change is made.

After 8 additional consecutive sublots have been produced at the 1,000 ton sublot size, the sublot size may again be increased to 1,250 tons per sublot (lot size of 5,000 tons), provided all 8 consecutive 1,000 ton sublots have been produced within the tolerances shown for all mix characteristics listed in **TABLE 602-12**, without a V_a penalty, production rates for the previous 2 days have been greater than 3,750 tons per day, and a minimum of 2 of the last 3 segregation profile checks comply with **TABLE 602-14.**

TABLE 602-14: SEGREGATION PROFILE CHECKS FOR INCREASED SUBLOT SIZE

Mix Designation	Maximum Density Range (highest minus lowest)	Maximum Density Drop (average minus lowest)
All	3.1 lbs./cu. ft.	1.9 lbs./cu. ft.

If subsequent test results fall outside the tolerances shown for any mix characteristic listed in **TABLE 602-12** or a V_a penalty is incurred, the sublot size shall be decreased to 750 tons. If the production rates fall below 3,750 tons per day for 2 consecutive days or a minimum of 2 of the last 3 segregation profile checks fail the above requirements, then the 1,250 ton sublots size shall be reduced to 1,000 ton per sublot provided the **TABLE 602-12** criteria is met and no V_a penalty is incurred.

When the increased lot size criteria are again met for 4 consecutive sublots, the sublot may be increased as the limits given above.

Page 600-22, subsection 602.9c. After Equation 1, in "S", delete "Section 5.17.0", and replace with "Section 5.17.09".

Page 600-23, subsection 602.10b. Delete the fifth paragraph and replace with the following:

The Engineer will determine the total core thickness for pay by taking 3 caliper measurements at approximately 120° apart and record each to the nearest 0.1 inch. The average of the 3 caliper measurements rounded to the nearest 0.1 inch shall represent the average measured thickness. The Engineer will use the total pavement thickness measurements to determine thickness pay adjustment factors.

Page 600-24, subsection 602.10b. In the third full paragraph (For Percent Within Limits...), change all "1 inch" to "1.0 inch".

Page 600-24, subsection 602.10c. In the first paragraph, replace "1 inch" with "1.0 inch". In the second and third paragraphs, replace all "½ inch" with "0.5 inch".

Page 600-24, subsection 602.10d. In the first paragraph, replace "1 ½ inches" with "1.5 inches". In the second and fourth paragraphs, replace all "¾ inches" with "0.8 inches".

Page 600-26, subsection 602.10e. In the definition for $\overline{X}$ following Equation 8, change "1/8 inch" to "0.1 inch". In the definition for LSL_i change "½ inch" to "0.5 inch" and change "¾ inch" to "0.8 inch".

Page 600-27, subsection 602.10e. Replace Equation 14 with the following:

Equation 14: $$\text{Minimum Quantity (Tons)} = \frac{0.93\,(A)(T)(G_{mm})}{42.7}$$

Page 600-27, subsection 602.11b. In the second and fourth paragraphs, replace all "⅛ inch" with "0.01 feet". In the third paragraph, replace the both "3.0 inches" with "0.25 feet".

Page 600-28, subsection 602.11e. Delete the second paragraph and replace with the following:

Payment for "Material for HMA Patching (Set Price)" at the contract set unit price includes all excavation, compaction of subgrade or subbase if required, disposal of waste material and all material (including emulsified asphalt for tack), all labor, equipment, tools, supplies, incidentals and mobilization necessary to complete the work.

Page 600-28, subsection 602.11f. Add the following paragraph:

The Engineer will not measure for payment Quality Control Testing (HMA) for the bid item Material for HMA Patching (Set Price).

Part V Sec. 5.9.50 KT-50 delete **7.1** and replace with the following:

7.1. Record to the nearest 0.1% uncompacted voids. Report the results to the nearest 1% uncompacted voids.

08-11-11 C&M
Oct-11 Letting

KANSAS DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION TO THE
STANDARD SPECIFICATIONS, EDITION 2007

Add a new section to DIVISION 1200:

WARM MIX ASPHALT ADDITIVES

1.0 DESCRIPTION

This specification covers Warm Mix Asphalt (WMA) additives and processes.

2.0 REQUIREMENTS

Provide prequalified WMA additives or processes.

3.0 TEST METHODS

WMA additives and processes will be tested and evaluated by the Texas Department of Transportation following the procedures outlined in **subsection 4.0**.

4.0 PREQUALIFICATION

Obtain prequalification procedures by writing to the Texas Department of Transportation, Director of Construction and Maintenance, 125 East 11th Street, Austin, TX 78701-2483. A list of prequalified additives and processes based on the prequalification process for the Texas Department of Transportation and field performance within Kansas will be maintained by the KDOT Bureau of Materials and Research. The KDOT prequalified list establishes the acceptable additives and processes to be incorporated into KDOT projects. Products will remain on the KDOT list provided field performance is satisfactory. Products may be removed from the KDOT list if the manufacturer requests the removal of their own product.

5.0 BASIS OF ACCEPTANCE

a. WMA Foaming Processes.

(1) Prequalification as required by **subsection 4.0**
(2) Field observation of WMA production.

b. WMA additives.

(1) Prequalification as required by **subsection 4.0**
(2) Receipt and approval of a Type C certification as specified in **DIVISION 2600**
(3) Field observation of WMA production.

07-23-10 M&R (GS)
Oct-10 Letting

Kansas
Department of Transportation
Bureau of Materials & Research

LIST OF PREQUALIFIED WARM MIX ASPHALT ADDITIVES (07-12002-R*)

PQL – 4.3 **REVISED – 02/01/11**

CMS MATERIAL CODE GROUP (024)

FOAMING

WMA TECHNOLOGY	SUPPLIER	MAX MIX TEMP REDUCTION
Aquablack Solutions	Maxam Equipment	30° F
Double Barrel Green	Astec Industries, Inc.	30° F
Terex	Terex Roadbuilding	30° F
Ultrafoam GX	Gencor Industries	30° F

OTHER ADDITIVES

WMA TECHNOLOGY	PROCESS TYPE	SUPPLIER	MAX MIX TEMP REDUCTION
Advera	Chemical	PQ Corporation	70° F
Aspha-Min	Chemical	Aspha-Min	70° F
Evotherm	Chemical	MeadWestvaco Asphalt Innovations	70° F
Redi-Set WMX	Chemical	Akzo Nobel Surfactants	70° F
Sasobit	Organic	Sasol Wax Americas, Inc.	70° F

C8. Maine

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION
16 STATE HOUSE STATION
AUGUSTA, MAINE 04333-0016

Paul R. LePage
GOVERNOR

David Bernhardt
COMMISSIONER

March 4, 2011
Subject: **Wells**
Federal Project No: STP-1706(400)X &
STP-1801(200)X
State PINs: 017064.00 & 018012.00
Amendment No. 1

Dear Sir/Ms:

Make the following changes to the Bid Document:

In the Bid Book (page 1) "NOTICE TO CONTRACTORS" in the lines that begin "Description:" and "Location:" **CHANGE** the Federal Aid Project Number from "STP-1760(400)X" to read "**STP-1706(400)X**". Make this change in pen and ink.

In the Bid Book (pages 67 and 68) **REMOVE** "SPECIAL PROVISION, SECTION 108, PAYMENT, (Asphalt Escalator)" 2 pages dated January 24, 2011 and **REPLACE** with the attached new "SPECIAL PROVISION, SECTION 108, PAYMENT, (Asphalt Escalator)" 2 pages dated March 1, 2011.

Consider this information prior to submitting your bid on March 16, 2011.

Sincerely,

Scott Bickford
Contracts & Specifications Engineer

THE MAINE DEPARTMENT OF TRANSPORTATION IS AN AFFIRMATIVE ACTION - EQUAL OPPORTUNITY EMPLOYER
PHONE: (207)624-3000 TTY 888-516-9364 FAX: (207) 624-3001

March 1, 2011
Supersedes January 24, 2011

SPECIAL PROVISION
SECTION 108
PAYMENT
(Asphalt Escalator)

108.4.1 Price Adjustment for Hot Mix Asphalt: For all contracts with hot mix asphalt in excess of 500 tons total, a price adjustment for performance graded binder will be made for the following pay items:

Item 403.206 Hot Mix Asphalt - 25 mm
Item 403.207 Hot Mix Asphalt - 19 mm
Item 403.2071 Hot Mix Asphalt - 19 mm (Polymer Modified)
Item 403.2072 Hot Mix Asphalt - 19 mm (Asphalt Rich Base)
Item 403.2073 Warm Mix Asphalt - 19 mm
Item 403.208 Hot Mix Asphalt - 12.5 mm
Item 403.2081 Hot Mix Asphalt - 12.5 mm (Polymer Modified)
Item 403.2083 Warm Mix Asphalt - 12.5 mm
Item 403.209 Hot Mix Asphalt - 9.5 mm (sidewalks, drives, & incidentals)
Item 403.210 Hot Mix Asphalt - 9.5 mm
Item 403.2101 Hot Mix Asphalt - 9.5 mm (Polymer Modified)
Item 403.2102 Hot Mix Asphalt - 9.5 mm (Asphalt Rich Base)
Item 403.2103 Warm Mix Asphalt - 9.5 mm
Item 403.211 Hot Mix Asphalt – Shim
Item 403.2111 Hot Mix Asphalt – Shim (Polymer Modified)
Item 403.2113 Warm Mix Asphalt - Shim
Item 403.212 Hot Mix Asphalt - 4.75 mm (Shim)
Item 403.2123 Warm Mix Asphalt - 4.75 mm (Shim)
Item 403.213 Hot Mix Asphalt - 12.5 mm (base and intermediate course)
Item 403.2131 Hot Mix Asphalt - 12.5 mm (base and intermediate course Polymer Modified)
Item 403.2132 Hot Mix Asphalt - 12.5 mm (Asphalt Rich Base and intermediate course)
Item 403.2133 Warm Mix Asphalt - 12.5 mm (base and intermediate course)
Item 403.214 Hot Mix Asphalt - 4.75 mm (Surface)
Item 403.2143 Warm Mix Asphalt - 4.75 mm (Surface)
Item 461.13 Maintenance Surface Treatment

Price adjustments will be based on the variance in costs for the performance graded binder component of hot mix asphalt. They will be determined as follows:

The quantity of hot mix asphalt for each pay item will be multiplied by the performance graded binder percentages given in the table below times the difference in price between the base price and the period price of asphalt cement. Adjustments will be made upward or downward, as prices increase or decrease.

Item 403.206: 4.8%

Item 403.207–5.2%	Item 403.2071–5.2%	Item 403.2072–5.8%	Item 403.2073–5.2%
Item 403.208–5.6%	Item 403.2081–5.6%		Item 403.2083–5.6%
Item 403.209–6.2%			
Item 403.210–6.2%	Item 403.2101–6.2%	Item 403.2102–6.8%	Item 403.2103–6.2%

Item 403.211–6.2%	Item 403.2111–6.2%		Item 403.2113–6.2%
Item 403.212–6.8%			Item 403.2123–6.8%
Item 403.213–5.6%	Item 403.2131–5.6%	Item 403.2132–6.2%	Item 403.2133–5.6%
Item 403.214–6.8%			Item 403.2143–6.8%
Item 461.13–6.4%			

Hot Mix Asphalt: The quantity of hot mix asphalt will be determined from the quantity shown on the progress estimate for each pay period.

Base Price: The base price of performance graded binder to be used is the price per standard ton current with the bid opening date. This price is determined by using the average New England Selling Price (Excluding the Connecticut market area), as listed in the Asphalt Weekly Monitor.

Period Price: The period price of performance graded binder will be determined by the Department by using the average New England Selling Price (Excluding the Connecticut market area), listed in the Asphalt Weekly Monitor current with the paving date. The maximum Period Price for paving after the adjusted Contract Completion Date will be the Period Price on the adjusted Contract Completion Date.

C9. Michigan

MICHIGAN
DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION
FOR
WARM-MIX ASPHALT (WMA)
(M-59 CS 63041 JN 110761)

a. Description. This work consists of furnishing a WMA mixture using a water-injection foaming device or water foaming additive for Superpave HMA Mixture 5E10. All work must be in accordance with the standard specifications and applicable special provisions, except as modified herein. No deviations to acceptance test methods/procedures will be allowed.

b. Materials. Provide materials in accordance with the Special Provision for Superpave HMA Mixtures.

Base lab testing temperatures for compaction of gyratory sampleson the binder suppliers recommended value.

Take the daily asphalt binder sample from a sampling spigot located in the pipeline supplying asphalt binder to the plant, in a position between the location in which the water or water foaming additive is added and the point where the asphalt binder enters the mixture.

c. Construction.

1. Equipment. Provide equipment for the water-foaming additive or water-foaming injection device that is attached to the HMA plant.

2. Placing WMA. The Department will reject loads with a temperature either below 250 degrees F or greater than ± 20 degrees F from the recommended maximum mixing temperature specified by the binder producer at the time of discharge from behind the screed.

d. Measurement and Payment. The completed work, as described, will be measured and paid for at the contract unit price using the following contract item (pay item):

Contract Item (Pay Item)	**Pay Unit**
Warm Mix Asphalt, 5E10	Ton

C10. New Hampshire

NHDOT Qualified Warm Mix Asphalt (WMA) Technologies
June 1, 2011

WMA Technology	Technology Provider Contact Information	Approval Date
Foamers		
Terex Foamed WMA System	Terex Roadbuilding Oklahoma City, OK www.terex.com	1/5/11
Eco-Foam II	AESCO/Madsen Auburn, WA www.asphaltequipment.com	1/5/11
Double Barrel Green System	Astec Industries, Inc. Chattanooga, TN www.astecindustries.com	1/5/11
Aqua Foam System	Meeker Equipment Hatfield, PA www.meekerequipment.com info@meekerequipment.com	1/5/11
Maxam	Maxam Equipment, Inc. Kansas City, MO www.maxamequipment.com	1/5/11
Ultrafoam GX	Gencor Industries, Inc. Orlando, FL www.gencor.com	1/5/11
Organic Waxes		
SONNEWARMix	Sonneborn, Inc. Mahwah, NJ chris.strack@sonneborn.com	6/1/11
Chemical Additives		
Evotherm WMA	MWV Asphalt Innovations North Charleston, SC everett.crews@mwv.com	6/1/11

C11. New York

ITEM 404.XXYZQ191 – WARM MIX ASPHALT

DESCRIPTION. This work shall consist of developing, producing and paving a Warm Mix Asphalt (WMA) mixture. WMA is standard HMA produced using a WMA technology typically resulting in a production mixture temperature of 275°F or lower. A WMA technology may include an additive, specialty equipment, or both.

WMA pavement course shall be constructed in accordance with this specification and in reasonably close conformity with the required lines, grades, thicknesses, and typical sections shown on the plans or established by the Engineer. The Contractor is responsible for compacting pavement to a specified density requirement.

The words "hot mix asphalt" and "HMA" in the standard specifications and other documents referenced by this specification shall apply to WMA.

MATERIALS. Requirements of §401-2 and §402-2 shall apply except as noted herein.

WMA Technology. Use a WMA technology appearing on the State's Approved List for Warm Mix Asphalt Technologies.

WMA Design. Modify a HMA design, currently in production status according to MM 5.16, *Superpave Hot Mix Asphalt Mixture Design and Mixture Verification Procedure*, using a WMA technology. Comply with the manufacturer's recommendations for incorporating the WMA technology. Notify the Regional Material Engineer (RME) how the WMA technology will be incorporated prior to fabricating the test specimens. Test specimens may be made from plant produced or laboratory prepared WMA. Test specimens must be made from plant produced WMA if adding the WMA technology in the lab does not simulate the production process. The RME may require a State representative be present during the fabrication and testing. Submit the WMA design to the RME for review and verification at least 14 calendar days before production, including:

- Test data from the one point verification comparing the original HMA design to the WMA design satisfying all design criteria in MM 5.16.
- Name of WMA technology, target rate and acceptable variation (min/max rate)
- AASHTO T 283 moisture susceptibility test results meeting the requirements in MM 5.16 for both the HMA and WMA.
- Samples of the PG Binder, any WMA additive, and MSDS if requested by RME.
- Production Quality Control Plan revisions incorporating the WMA technology if not previously submitted. WMA Quality Control guidelines are available from the Materials Bureau.
- Test results for both the HMA and WMA samples using one of the test methods in Table 1, Allowable Mixture Rut Performance Tests. The HMA and WMA must be tested using the same test.

TABLE 1 ALLOWABLE MIXTURE RUT PERFORMANCE TESTS				
Type of Test	AASHTO Test Method	Test Specimen Air Voids[1]	Test Temperature	
			Upstate	Downstate
Asphalt Pavement Analyzer (APA)	T 340	7.0 ± 1.0%	136°F (58°C)	147°F (64°C)
Hamburg Wheel Track (HWT)	T 324	7.0 ± 1.0%	122°F (50°C)	122°F (50°C)
Asphalt Mixture Performance Tester (AMPT)	TP 79	7.0 ± 1.0%	122°F (50°C)	127°F (53°C)

Note 1. Condition the mixture for 2 hours ± 5 minutes at the desired field compaction temperature.

ITEM 404.XXYZQ191 – WARM MIX ASPHALT

Shim Course. Select a desired WMA mixture temperature within the mixing and compaction range as recommended by the WMA technology provider.

Due to the experimental nature of this specification and on-going research, rut performance test result criteria are not listed. The Director, Materials Bureau, will provide Contractors and Producers the current criteria being used to evaluate test results, upon request. When test results do not meet the current criteria, the Contractor and Producer will have the opportunity to meet with Department representatives to discuss additional data and information indicating the mix will perform as expected. Based on additional data and information, the mix may be considered accepted for general use, accepted for restricted use, or unacceptable.

The Director, Materials Bureau will review and make the final decision regarding the status of WMA mix designs. The State reserves the right to suspend any mixture design when the mixture demonstrates unacceptable paving quality or exhibits properties that will affect the anticipated pavement performance. The Contractor may request to use a HMA design if the submitted WMA mixture design is considered unacceptable or is subsequently suspended.

CONSTRUCTION DETAILS. Requirements of §401-3 and §402-3 shall apply except as noted herein.

Mix Temperature. Select a desired WMA mixture temperature within the mixing and compaction range as recommended by the WMA technology provider.

METHOD OF MEASUREMENT. Requirements of §401-4 and §402-4 shall apply except as noted herein.
The WMA will be measured by the number of tons of compacted mixture in the accepted work. In addition, quality payment adjustments are applicable for all warm mix asphalt in accordance with this specification.

Plant Production Quality Payment Adjustment. The quality assurance technician (QAT) will determine the quality adjustment factor (QAF) for each day's production in accordance with MP 401 and this section. Production meeting the specification requirements will be assigned a QAF of 1.00. Production failing to meet the specification requirements will be assigned a QAF of 0.85 and be subject to evaluation according to §401-4.03 Evaluation of Sublots Represented by 0.85 QAF. The Engineer will use the Daily QAF to calculate the quality payment adjustment for each day's production and apply it to the accepted quantity.

BASIS OF PAYMENT. The unit price bid for WMA mixtures shall meet the requirements specified in §402-5 Basis of Payment.

Item No.	Item	Pay Unit
404.01790291	True & Leveling F9, Superpave WMA, 70 Series Compaction	Ton
404.01890291	True & Leveling F9, Superpave WMA, 80 Series Compaction	Ton
404.05890291	Shim Course F9, Warm Mix Asphalt	Ton
404.09510291	9.5 F1 Superpave WMA, 50 Series Compaction	Ton
404.09512291	Pavement Density Quality Adjustment to 404.09510291	Quality Units
404.09515291	Test Section Adjustment to 404.09510291	Quality Units
404.09520291	9.5 F2 Superpave WMA, 50 Series Compaction	Ton
404.09522291	Pavement Density Quality Adjustment to 404.09520291	Quality Units
404.09525291	Test Section Adjustment to 404.09520291	Quality Units

ITEM 404.XXYZQ191 – WARM MIX ASPHALT

404.09610291	9.5 F1 Superpave WMA, 60 Series Compaction	Ton
404.09612291	Pavement Density Quality Adjustment to 404.09610291	Quality Units
404.09615291	Test Section Adjustment to 404.09610291	Quality Units
404.09620291	9.5 F2 Superpave WMA, 60 Series Compaction	Ton
404.09622291	Pavement Density Quality Adjustment to 404.09620291	Quality Units
404.09625291	Test Section Adjustment to 404.09620291	Quality Units
404.09630291	9.5 F3 Superpave WMA, 60 Series Compaction	Ton
404.09632291	Pavement Density Quality Adjustment to 404.09630291	Quality Units
404.09635291	Test Section Adjustment to 404.09630291	Quality Units
404.09710291	9.5 F1 Superpave WMA, 70 Series Compaction	Ton
404.09715291	Test Section Adjustment to 404.09710291	Quality Units
404.09720291	9.5 F2 Superpave WMA, 70 Series Compaction	Ton
404.09725291	Test Section Adjustment to 404.09720291	Quality Units
404.09730291	9.5 F3 Superpave WMA, 70 Series Compaction	Ton
404.09735291	Test Section Adjustment to 404.09730291	Quality Units
404.09810291	9.5 F1 Superpave WMA, 80 Series Compaction	Ton
404.09820291	9.5 F2 Superpave WMA, 80 Series Compaction	Ton
404.09830291	9.5 F3 Superpave WMA, 80 Series Compaction	Ton
404.09890291	9.5 F9 Superpave WMA, Shoulder Course, 80 Series Compaction	Ton
404.12510291	12.5 F1 Superpave WMA, 50 Series Compaction	Ton
404.12512291	Pavement Density Quality Adjustment to 404.12510291	Quality Units
404.12515291	Test Section Adjustment to 404.12510291	Quality Units
404.12520291	12.5 F2 Superpave WMA, 50 Series Compaction	Ton
404.12522291	Pavement Density Quality Adjustment to 404.12520291	Quality Units
404.12525291	Test Section Adjustment to 404.12520291	Quality Units
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404.12635291	Test Section Adjustment to 404.12630291	Quality Units
404.12710291	12.5 F1 Superpave WMA, 70 Series Compaction	Ton
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404.12725291	Test Section Adjustment to 404.12720291	Quality Units
404.12730291	12.5 F3 Superpave WMA, 70 Series Compaction	Ton
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404.12810291	12.5 F1 Superpave WMA, 80 Series Compaction	Ton
404.12820291	12.5 F2 Superpave WMA, 80 Series Compaction	Ton
404.12830291	12.5 F3 Superpave WMA, 80 Series Compaction	Ton
404.12890291	12.5 F9 Superpave WMA, Shoulder Course, 80 Series Compaction	Ton
404.19590291	19 F9 Superpave WMA, 50 Series Compaction	Ton
404.19592291	Pavement Density Quality Adjustment to 404.19590291	Quality Units
404.19595291	Test Section Adjustment to 404.19590291	Quality Units
404.19690291	19 F9 Superpave WMA, 60 Series Compaction	Ton
404.19692291	Pavement Density Quality Adjustment to 404.19690291	Quality Units
404.19695291	Test Section Adjustment to 404.19690291	Quality Units
404.19790291	19 F9 Superpave WMA, 70 Series Compaction	Ton

ITEM 404.XXYZQ191 – WARM MIX ASPHALT

404.19795291	Test Section Adjustment to 404.19790291	Quality Units
404.19890291	19 F9 Superpave WMA, 80 Series Compaction	Ton
404.25590291	25 F9 Superpave WMA, 50 Series Compaction	Ton
404.25592291	Pavement Density Quality Adjustment to 404.25590291	Quality Units
404.25595291	Test Section Adjustment to 404.25590291	Quality Units
404.25690291	25 F9 Superpave WMA, 60 Series Compaction	Ton
404.25692291	Pavement Density Quality Adjustment to 404.25690291	Quality Units
404.25695291	Test Section Adjustment to 404.25690291	Quality Units
404.25790291	25 F9 Superpave WMA, 70 Series Compaction	Ton
404.25795291	Test Section Adjustment to 404.25790291	Quality Units
404.25890291	25 F9 Superpave WMA, 80 Series Compaction	Ton
404.37690291	37.5 F9 Superpave WMA, 60 Series Compaction	Ton
404.37692291	Pavement Density Quality Adjustment to 404.37690291	Quality Units
404.37695291	Test Section Adjustment to 404. 37690291	Quality Units
404.37790291	37.5 F9 Superpave WMA, 70 Series Compaction	Ton
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WMA Design. Modify a HMA design, currently in production status according to MM 5.16, *Superpave Hot Mix Asphalt Mixture Design and Mixture Verification Procedure*, using a WMA technology. Comply with the manufacturer's recommendations for incorporating the WMA technology. Notify the Regional Material Engineer (RME) how the WMA technology will be incorporated prior to fabricating the test specimens. Test specimens may be made from plant produced or laboratory prepared WMA. Test specimens must be made from plant produced WMA if adding the WMA technology in the lab does not simulate the production process. The RME may require a State representative be present during the fabrication and testing. Submit the WMA design to the RME for review and verification at least 14 calendar days before production, including:

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- Name of WMA technology, target rate and acceptable variation (min/max rate).
- AASHTO T 283 moisture susceptibility test results meeting the requirements in MM 5.16 for both the HMA and WMA.
- Samples of the PG Binder, any WMA additive, and MSDS if requested by RME.
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Note 1: Condition the mixture for 2 hours ± 5 minutes at the desired field compaction temperature.

ITEM 404.XXYZQ291 – WARM MIX ASPHALT

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> Due to the experimental nature of this specification and on-going research, rut performance test result criteria are not listed. The Director, Materials Bureau, will provide Contractors and Producers the current criteria being used to evaluate test results, upon request. When test results do not meet the current criteria, the Contractor and Producer will have the opportunity to meet with Department representatives to discuss additional data and information indicating the mix will perform as expected. Based on additional data and information, the mix may be considered accepted for general use, accepted for restricted use, or unacceptable.

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CONSTRUCTION DETAILS. Requirements of §401-3 and §402-3 shall apply except as noted herein.

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METHOD OF MEASUREMENT. Requirements of §401-4 and §402-4 shall apply except as noted herein.
The WMA will be measured by the number of tons of compacted mixture in the accepted work. In addition, quality payment adjustments are applicable for all warm mix asphalt in accordance with this specification.

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404.09515291	Test Section Adjustment to 404.09510291	Quality Units
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404.09522291	Pavement Density Quality Adjustment to 404.09520291	Quality Units
404.09525291	Test Section Adjustment to 404.09520291	Quality Units

ITEM 404.XXYZQ291 – WARM MIX ASPHALT

404.09610291	9.5 F1 Superpave WMA, 60 Series Compaction	Ton
404.09612291	Pavement Density Quality Adjustment to 404.09610291	Quality Units
404.09615291	Test Section Adjustment to 404.09610291	Quality Units
404.09620291	9.5 F2 Superpave WMA, 60 Series Compaction	Ton
404.09622291	Pavement Density Quality Adjustment to 404.09620291	Quality Units
404.09625291	Test Section Adjustment to 404.09620291	Quality Units
404.09630291	9.5 F3 Superpave WMA, 60 Series Compaction	Ton
404.09632291	Pavement Density Quality Adjustment to 404.09630291	Quality Units
404.09635291	Test Section Adjustment to 404.09630291	Quality Units
404.09710291	9.5 F1 Superpave WMA, 70 Series Compaction	Ton
404.09715291	Test Section Adjustment to 404.09710291	Quality Units
404.09720291	9.5 F2 Superpave WMA, 70 Series Compaction	Ton
404.09725291	Test Section Adjustment to 404.09720291	Quality Units
404.09730291	9.5 F3 Superpave WMA, 70 Series Compaction	Ton
404.09735291	Test Section Adjustment to 404.09730291	Quality Units
404.09810291	9.5 F1 Superpave WMA, 80 Series Compaction	Ton
404.09820291	9.5 F2 Superpave WMA, 80 Series Compaction	Ton
404.09830291	9.5 F3 Superpave WMA, 80 Series Compaction	Ton
404.09890291	9.5 F9 Superpave WMA, Shoulder Course, 80 Series Compaction	Ton
404.12510291	12.5 F1 Superpave WMA, 50 Series Compaction	Ton
404.12512291	Pavement Density Quality Adjustment to 404.12510291	Quality Units
404.12515291	Test Section Adjustment to 404.12510291	Quality Units
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404.12525291	Test Section Adjustment to 404.12520291	Quality Units
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404.12725291	Test Section Adjustment to 404.12720291	Quality Units
404.12730291	12.5 F3 Superpave WMA, 70 Series Compaction	Ton
404.12735291	Test Section Adjustment to 404.12730291	Quality Units
404.12810291	12.5 F1 Superpave WMA, 80 Series Compaction	Ton
404.12820291	12.5 F2 Superpave WMA, 80 Series Compaction	Ton
404.12830291	12.5 F3 Superpave WMA, 80 Series Compaction	Ton
404.12890291	12.5 F9 Superpave WMA, Shoulder Course, 80 Series Compaction	Ton
404.19590291	19 F9 Superpave WMA, 50 Series Compaction	Ton
404.19592291	Pavement Density Quality Adjustment to 404.19590291	Quality Units
404.19595291	Test Section Adjustment to 404.19590291	Quality Units
404.19690291	19 F9 Superpave WMA, 60 Series Compaction	Ton
404.19692291	Pavement Density Quality Adjustment to 404.19690291	Quality Units
404.19695291	Test Section Adjustment to 404.19690291	Quality Units
404.19790291	19 F9 Superpave WMA, 70 Series Compaction	Ton

ITEM 404.XXYZQ291 – WARM MIX ASPHALT

404.19795291	Test Section Adjustment to 404.19790291	Quality Units
404.19890291	19 F9 Superpave WMA, 80 Series Compaction	Ton
404.25590291	25 F9 Superpave WMA, 50 Series Compaction	Ton
404.25592291	Pavement Density Quality Adjustment to 404.25590291	Quality Units
404.25595291	Test Section Adjustment to 404.25590291	Quality Units
404.25690291	25 F9 Superpave WMA, 60 Series Compaction	Ton
404.25692291	Pavement Density Quality Adjustment to 404.25690291	Quality Units
404.25695291	Test Section Adjustment to 404.25690291	Quality Units
404.25790291	25 F9 Superpave WMA, 70 Series Compaction	Ton
404.25795291	Test Section Adjustment to 404.25790291	Quality Units
404.25890291	25 F9 Superpave WMA, 80 Series Compaction	Ton
404.37690291	37.5 F9 Superpave WMA, 60 Series Compaction	Ton
404.37692291	Pavement Density Quality Adjustment to 404.37690291	Quality Units
404.37695291	Test Section Adjustment to 404. 37690291	Quality Units
404.37790291	37.5 F9 Superpave WMA, 70 Series Compaction	Ton
404.37795291	Test Section Adjustment to 404.37790291	Quality Units
404.37890291	37.5 F9 Superpave WMA, 80 Series Compaction	Ton

WMA Technology Approval Process

1. Initial Meeting with NYSDOT

- NYSDOT overview of WMA approval process (if not previously done or if any questions)
- Technology supplier presents technology specific information
- Technology supplier provides the following information (may be submitted after the meeting)
    - Experience in other States
        - Location
        - Quantity placed
        - Traffic volume ESALs preferred (AADT with % trucks acceptable)
    - Contact information for agencies evaluating performance
        - State DOT representative
        - FHWA state office representative
    - PG binder and WMA test results from mixes in other states

2. Submit Binder and Additive Samples

- NYSDOT will determine (actual) PG Binder grade of the binder with and without the WMA additive, if practical, according to AASHTO R29 (Section 6)/M320
- NYSDOT may conduct the following testing for informational purposes
    - MSCR/J_{NR} determination according to AASHTO TP70
    - Performance Grade of binder with additive aged in the RTFO at the typical WMA production temperature
    - NYSDOT may recover binder from plant samples for PG grade determination; especially when binder samples after adding the WMA technology are not easily obtained, such as foaming technologies

3. **Required Testing on NYSDOT Mix Designs** – WMA technology supplier will provide test results for both the WMA and corresponding NYSDOT production status HMA mix design meeting the following requirements:

<u>Mix Type</u>

- 75 gyration design
- PG 64-22 (neat) or PG 70-22 (neat)
- 9.5 or 12.5 Top Course (may specify depending on predominant mix type in an area)
    - HMA without RAP
    - WMA without RAP
- WMA technology added at a typical rate

Note: Additional mixes may be required if different addition rates are used for different applications, if anti-strip agent is required for some aggregates, etc.

WMA Technology Approval Process

Required Mix Design Testing

- Gradation
- Asphalt Content
- Volumetric Properties per MM 5.16 (list any special WMA sample conditioning/preparation and non-standard test temperatures)
- Moisture Susceptibility – AASHTO T283
- Hamburg Wheel-Track Testing of Compacted Hot Mix Asphalt (HMA) AASHTO T324-04 (2008) – other rut performance tests may be considered by the Director, Materials Bureau upon request

Note: May use current HMA QC/QA data for HMA volumetric properties, gradation and asphalt content test requirements.

4. Submit ***Production, Testing and Compaction Details***

General Product Information

- Product Name
- Company
- Contact Information
  - Name
  - Address
  - Phone number
  - E-mail Address
- Type of technology (foaming, chemical or mineral additive)
- Pre-blended in binder or added during production
- Production facility equipment requirements and calibrations

Mix Design and Production

- Potential concerns with other binder modifiers
- Storage/handling requirements of additive or pre-blended binder
- Addition rate
  - Typical rate
  - Min and Max addition rates
  - Allowable production tolerance
  - Criteria for adjusting rate (ie. RAP/no RAP or other parameters)
- Anti-strip requirements
- Production temperatures (expected)
  - Typical
  - Min and Max temperatures
  - Criteria for adjusting temperature
- Silo storage limitations

Testing

- Sample preparation (list any special sample conditioning or preparation requirements)
- Temperature each QC/QA test should be run at and allowable tolerance

Compaction

- Temperature
  - Typical field compaction temperature
  - Min and Max temperatures
- Laydown, compaction, and/or hand work concerns compared to HMA

WMA Technology Approval Process

5. Approval

- Acceptable Information from Other States
  - Minimum of 1 year experience in 1 state or Canada
  - Placed on mainline pavement with >3 million ESALs
  - Positive feedback from State and FHWA contacts
  - Comparable WMA to HMA laboratory and pavement performance results
  - No negative impact to binder performance grade
- Acceptable NYSDOT binder test results showing the WMA technology does not negatively impact the PG Binder grade
- Acceptable test results on NYSDOT specific WMA Mix Design
  - Comparable and in-spec volumetric properties, gradation, asphalt content, etc. according to MM 5.16
  - AASHTO T 283 moisture susceptibility test results >80% TSR
  - AASHTO T 324 HWT results meeting one of the following

HWT Minimum Allowable Passes Specimens made to 7.0 ± 1.0% Air Voids	
High Temperature Binder Grade	Minimum Passes to 0.5-inch Rut Depth
PG 64 or lower	10,000
PG 70 or higher	15,000
Note: If the WMA's passes does not meet the value in this table then compare the HMA's and the WMA's passes to each other. The acceptable difference between the HMA's and the WMA's passes shall not be more than 500.	

Note: Due to on-going research and evaluation of WMA, rut performance test result criteria are subject to change. When test results do not meet the current criteria, the technology supplier will have the opportunity to meet with Department representatives to discuss additional data and information indicating that mixes using the technology will perform as expected. Based on additional data and information, the technology may be considered acceptable. The Director, Materials Bureau will review and make the final decision regarding the status of WMA technology.

- Submission of acceptable *Production, Testing and Compaction Details*.

PRODUCTION, TESTING AND COMPACTION DETAILS

Basically this document should be a set of directions from the technology supplier to any of the possible users of that technology to ensure its proper use.

Keep in mind that the online Approved List will link to this document, and will be used by the Contractor/Producers in determining which technology best meets their needs. If there is a concern with publishing certain information, please contact NYSDOT for more directions.

In addition to the general product and company information the following should be considered the type if information that needs to be conveyed to all the parties involved, but may not be all inclusive of the information needed.

While it is expected that all the parties will follow the directions that are laid out in this document, it is also understood that not all situations can be foreseen. This document can be easily amended, by the Technology supplier, throughout the year to accommodate these situations on a global basis. If the situation is more plant or project specific, amendments can also be made on a plant/project specific basis.

Any questions regarding these details please contact Chris Euler at 518-457-4581 or ceuler@dot.state.ny.us.

At the PG Binder Primary Source for Chemical and Organic Additives (If Applicable)

- Equipment Needs – What equipment is needed to properly mix the additive with the PG Binder?
  - Pumps – capable of pumping a minimum of XX.XX gpm
  - In Line Mixers – Static, High Shear, etc
  - Meters to control the dosage rate – "capable of measuring a flow rate of XX.XX"
- Dosage Rate(s) – What is the proper dosage rate?
  - If varying dosage rates are used, what are the criteria for using various rates?
- Storage/handling Requirements
  - Are there any special handling precautions for the additive?
  - What is the shelf life of the additive itself?
  - Are there any special environmental conditions that the additive itself needs to be stored at? Cool, dry etc.?
  - How long can the PG Binder be stored after mixing with the additive?
  - At what temperature should the PG Binder with the additive be stored?
  - Is any mixer or recirculation needed?
- Shipping Requirements
  - Are there any special shipping requirements/needs?

<u>At the HMA Producers Facility</u>

- **Chemical or Organic Additives that are Pre-Blended into the PG Binder (If applicable)**
  - Are there any special storage/handling requirements for the pre-blended material?
    - Allowable storage time?
    - Mixing or recirculation needs?
  - Is there any dosage rate information that the HMA plant should be aware of when ordering pre-blended PG Binder?
    - Varying dosage rates for various RAP Contents?
    - Varying dosage rates for other variations?
    - What should the HMA plant do if situations change? For example, the plant plans on running a mix with 20% RAP. They order a pre-blended PG Binder containing the proper dosage for that amount of RAP. The RAP belt breaks down during production, what should the HMA Producer do? Should they stop producing the WMA mix? Does the dosage rate have a detrimental effect a non-RAP mix?
  - What is the recommended mixing temperature(s)?
    - Is this a set temperature or a drop of XX degrees from the HMA mixture?
- **Chemical, Organic, or Zeolites that are blended into the PG Binder or the mixture at the HMA plant (If applicable)**
  - Are there any special storage/handling requirements for the additive itself?
    - What is the shelf life of the additive itself?
    - Are there any special environmental conditions that the additive itself needs to be stored at? Cool, dry etc.?
  - What is required to get the additive into the PG Binder or the mixture?
    - Can this be done on Drum and Batch plants? And what are the differences in the equipment needed?
  - What equipment is needed?
    - Pumps – capable of pumping a minimum of XX.XX gpm
    - In Line Mixers – Static, High Shear, etc
    - Meters to control the dosage rate – "capable of measuring a flow rate of xxx"
    - What connections need to be made?
    - What is used to meter the amount of additive?
  - Plant automation
    - For Drum plants, does the plant need to be run at a constant speed when using this technology? Or is the additive equipment variable, linked to, and calibrated to the plant speed?
    - Recordation of the dosage rate is required by NYSDOT. How does this need to be accomplished?
  - What is the dosage rate?

    - Can this rate vary with the type of mix being used? Mix with 20% RAP versus a mix with no RAP?
    - Are there other reasons to vary the dosage rate?
  - What is the recommended mixing temperature(s)?
    - Is this a set temperature or a drop of XX degrees from the HMA mixture?

- **Foaming Processes (If applicable)**
  - Equipment requirements
    - Does this system work with drum plants? Batch plants? Both?
    - Is this a retrofit system? Or does it come with new plants, drums, etc?
    - Is your system compatible with plants manufactured by others?
    - What does your system come with?
    - What equipment is the HMA Producer responsible for having or purchasing?
    - What are the electrical requirements of the plant?
    - How is the system connected to the plant?
    - How is the water attached to the system? Is the water required to be used from a holding tank, or can the system be directly connected to a municipal water supply?
  - Plant Automation
    - How is the water dosage controlled? This dosage also needs to be calibrated and recorded according to NYSDOT specifications, how will this be accomplished?
  - What is the dosage rate?
    - Can this rate vary with the type of mix being used? Mix with 20% RAP versus a mix with no RAP?
    - Are there other reasons to vary the dosage rate?
  - What is the recommended mixing temperature(s)?
    - Is this a set temperature or a drop of XX degrees from the HMA mixture?
  - Equipment maintenance issues?

<u>Mixture Design and Quality Control/Quality Assurance Testing Requirements</u>

- Are there special handling requirements?
- Does the sample need to be aged or conditioned before performing volumetric mix testing? (For example some technologies require the mixture be placed in an oven for 2 hours before testing.)
  - If needed, what are some of the details
    - Aged/Conditioned at what temperature?
    - Aged or Condition for what time period?
    - Does the mix need to be turned or remixed every half hour while aging/conditioning, etc?
- At what temperature should the gyratory specimens be made at?

- Other?

Information for the Contractors (Laydown Crews)

- Are there special handling requirements?
- At what temperature(s) should the mixtures be arriving?
- When compared to conventional mixtures, can the contractor expect to laydown the same loose thicknesses to achieve a specified compacted thickness? (For example, the contractor places the mixture 2 ½ inches thick, expecting to have a 2 inch thick mat after final compaction.)
- At what temperature should compaction of the mixture take place?
    - Is there a temperature at which the mix returns to acting like a conventional mix?
- At what temperature is it safe to return traffic to the road?
- If multiple lifts of material are being placed, what temperature should the first lift be at before placing the second lift?
- Are there any concerns with handwork?

Technical Services - Materials - Approved List

Bituminous Materials

WARM MIX ASPHALT (WMA) TECHNOLOGIES

A. ORGANIC (WAXES) ADDITIVES (712-1010)

TECHNOLOGY	TECHNOLOGY PROVIDER	CONTACT	DETAILS (Approval Date)
SONNEWARMix™	Sonneborn, Inc. 575 Corporate Drive, Suite 415 Mahwah, NJ 07430	Chris Strack 203-261-8582 chris.strack@sonneborn.com	SONNEWARMix (06/08/2010)

B. CHEMICAL ADDITIVES (712-1020)

TECHNOLOGY	TECHNOLOGY PROVIDER	CONTACT	DETAILS (Approval Date)
Evotherm WMA	MWV Asphalt Innovations 5255 Virginia Avenue North Charleston, SC 29406	Everett Crews 843-697-5509 everett.crews@mwv.com	Evotherm (09/10/2010)
Low Emission Asphalt-Lite (LEA-Lite)	McConnaughay Technologies 1911 Lorings Crossing Cortland, NY 13045	Gary Foux 607-752-1100 ext. 311 gfoux@suit-kote.com	LEA-Lite (06/08/2010)

C. FOAMING PROCESSES (712-1030)

TECHNOLOGY	TECHNOLOGY PROVIDER	CONTACT	DETAILS (Approval Date)
Astec Double Barrel Green, Green Pac for Continuous, and Green Pac for Batch	ASTEC Industries, Inc. PO Box 72787 4101 Jerome Ave. Chattanooga, TN 37407	**Sales:** Tom Baugh 423-867-4210 tbaugh@astecinc.com **Service & Technical:** Astec Service 423-867-4210 service@astecinc.com	ASTEC (07/06/2011)
Low Emission Asphalt (LEA)	McConnaughay Technologies 1911 Lorings Crossing Cortland, NY 13045	Gary Foux 607-752-1100 ext. 311 gfoux@suit-kote.com	LEA (06/08/2010)
MAXAM AQUABlack warm mix asphalt system	MAXAM Equipment, Inc. 1575 Universal Ave. Kansas City, MO 64120	Ron Murphy 800-262-6070 rmurphy@maxamequipment.com	AQUABlack (02/10/2011)
Terex® foamed warm mix asphalt system	Terex Roadbuilding 9528 W. I-40 Service Road Oklahoma City, OK 73128	Scott McMaster 405-208-3982 scott.mcmaster@terex.com	Terex (07/27/2010)

Revised on: July 6, 2011

C12. Ohio

Warm Mix Asphalt

What is it?[1]

Warm Mix Asphalt (WMA) is the generic term for a variety of technologies that allow asphalt mixtures to be produced, transported, placed, and compacted at lower temperatures. WMA technologies typically result in temperatures 30 to 75 degrees Fahrenheit lower than traditional hot-mix asphalt (HMA). Because less energy is needed to heat the asphalt mix, in many cases, less fuel is required to produce WMA. Fuel consumption during WMA production may be reduced by 20 percent with proper production plant modifications. It is a proven technology that can:

- Improve compaction that improves pavement performance.
- Reduce fuel or energy usage.
- Improve worker comfort by reducing exposure to higher temperatures, fuel emissions, fumes, and odors.

In addition, WMA technologies allow asphalt mixtures to be hauled longer distances and can extend the paving season due to WMA's ability to maintain workability at lower temperatures. The proper use of WMA may result in reduced overall paving costs.

WMA technologies enhance mixture workability through the addition of additives (organic, chemical, water-based, or hybrids). Asphalt mixtures are primarily composed of aggregates and asphalt binder. Aggregates are hard materials such as crushed stone. Asphalt binder is a dark brown to black, sticky liquid that holds together the aggregates when mixed. Some WMA technologies work by reducing the viscosity, which increases the ability to flow or pour the asphalt binder. This allows the aggregates to be properly coated with asphalt binder at lower temperatures. WMA also improves workability during construction allowing the mixture to be properly transported, paved, and compacted at lower temperatures. Proper compaction provides increased pavement density and is necessary for pavement performance.

Warm Mix Asphalt in Ohio

The Ohio Department of Transportation's Office of Materials Management has established specifications for Warm Mix Asphalt (WMA). The specifications set forth the foaming method to be used when WMA is made for Ohio, as this method only utilizes water instead of other costly additives – making it more cost effective and ecologically friendly.

Since the adoption of WMA specifications in 2008, approximately 33% of all asphalt on ODOT projects has gone down as WMA. This technical update includes the details from sections 402.09, 401.05 and 441.09 (C) 1st paragraph (quality control) from the ODOT specifications.

For additional information regarding the Safety Edge technique, please contact Ohio LTAP [614-387-7358, 877-800-0031, or email: ltap@dot.state.oh.us] or ODOT's Office of Materials Management [614-275-1387].

Ohio Department of Transportation Materials Section: Warm Mix Asphalt Specifications

402.09 Water Injection System for Warm Mix Asphalt. *

When allowed by specification use a Department approved water injection system for the purpose of foaming the asphalt binder and lowering the mixture temperature. Only use equipment that has been proven stable and effective thru project use on non-ODOT projects. Ensure equipment for water injection meets the following requirements:

1. Injection equipment computer controls are in the plant control room and are tied to the plant computer metering.
2. Injection equipment has variable water injection control controlled by the plant operation rate and the water injection can never exceed 1.8% by weight of asphalt binder.
3. Water injection rate cannot be manually overridden by the plant operator once in the computer.
4. Injection equipment stops water flow when a control or equipment failure in the injection system occurs.
5. The water injects into the asphalt binder flow before the asphalt binder spray hits aggregate. Do not allow water to touch aggregate before the binder spray.
6. Injection equipment includes water storage and pump control tied to the injection computer controls.
7. Water storage low water alarm installed in the control room.
8. Provide a PG binder sampling valve between the last piping tee on the tank side of the line and the injection equipment to sample PG binder before water is injected.
9. Provide a PG Binder sampling valve at the injection equipment to sample binder prior to spray.

401.05 Mixing Plants. [iii]

The Department will approve mixing plants before preparation of the mixtures. General requirements for asphalt concrete mixing plants are specified in Item 402.

Set the asphalt binder controls for the computerized plant at the virgin asphalt binder content of the JMF at all times unless change is authorized by the Laboratory.

Asphalt mixtures may be produced using the warm mix asphalt method according to 402.09 except as restricted by specification.

441.09 (C) Air Voids and MSG. [iv]

Determine the air voids of the asphalt concrete by analyzing a set of compacted specimens and a corresponding MSG determination. Use the MSG to calculate the air voids of the compacted specimens. Ensure that the cure temperature and specimen compaction temperature are the same. Use a 1-hour cure for all mix samples used in voids analysis. The Contractor may use a 2-hour cure time if voids are consistently near the low void warning band. In this case, use the 2-hour cure for all voids testing through the remainder of the project. For hot mix asphalt use the JMF lab compaction temperature. For warm mix asphalt according to 402.09 use a lab compaction temperature 30.0 ºF (16.7 ºC) less than the JMF lab compaction temperature for hot mix asphalt. Use a compaction temperature tolerance of +/- 5.0 ºF (3.0 ºC). Record on the TE-199 if the mixture produced was ran at the asphalt plant as a hot mix asphalt (HMA) or as a warm mix asphalt (WMA) produced according to 402.09 or another approved method.

...

[i] Copied in whole from the Every Day Counts FHWA program website, available at: http://www.fhwa.dot.gov/everydaycounts/summit/asphalt.cfm (Last visited 3/17/2011).
[ii] Available on line at: http://www.dot.state.oh.us/Divisions/ConstructionMgt/OnlineDocs/Specifications/2010CMS/400/402.htm (Last visited 3/22/2011).
[iii] Available on line at: http://www.dot.state.oh.us/Divisions/ConstructionMgt/OnlineDocs/Specifications/2010CMS/400/401.htm (Last visited on 3/22/2011).
[iv] Available on line at: http://www.dot.state.oh.us/Divisions/ConstructionMgt/OnlineDocs/Specifications/2010CMS/400/441.htm#a_441_09 (Last visited 3/22/2011).

C13. Oregon

Oregon
John A. Kitzhaber, M.D., Governor

Department of Transportation
Technical Services
Office of Project Letting
4040 Fairview Industrial Drive SE
Salem, OR 97302
Telephone 503-986-4040

DATE: May 5, 2011

Addenda No. 1

TO: **PLAN HOLDERS**

PREPARED BY: Christopher Harris

APPROVED BY: Justin Moderie P.E., G.E.

SUBJECT: OR22: French Creek Road (Detroit) - US20 (Santiam Jct.) Section
North Santiam Highway
Linn County
Paving Project
(Bids to be opened and read May 12, 2011)

The following changes are made to the Project Special Provisions:

1. Subsection **00745.00 Scope** - Add the following paragraph to the end of this section:

   The Contractor at their option may substitute Warm Mix Asphalt Concrete (WMAC) on all lifts from MP 49.550 to MP 55.000. WMAC will be subject to all requirements for HMAC in Section 00745, except as modified below.

2. Subsection **00745.02 Definitions** – This subsection is added after subsection 00745.00:

   00745.02 Definitions - Add the following paragraph to this section.

   Warm Mix Asphalt Concrete (WMAC) – An asphalt concrete mix following all requirements of HMAC, except that through use of approved additives or processes it is mixed, placed and compacted at lower temperatures.

   Add the following bullet to the definition of Lot Size

   - A new lot will be established for WMAC technology

3. Subsection **00745.11(d) WMAC Asphalt Cement Additives** - This subsection is added after subsection 00745.11(b):

Add the following to the end of this section

(d) WMAC Asphalt Cement Additives – If WMAC is proposed for use in this contract, only Warm Mix Asphalt Concrete (WMAC) additives or processes listed on the approved list below shall be used unless otherwise approved by the Engineer.

WMAC Technology	**Process Type**	**Supplier**
LEA-CO	Foaming Process	Advanced Concepts Engineering Co.
Eco-Foam II	Foaming Process	AESCO/Madsen
Redi-Set WMX	Chemical Additive	Akzo Nobel Surfactants, Inc.
CECABASE RT	Chemical Additive	Arkema Group
Aspha-Min (Synthetic Zeolite)	Foaming Process	Aspha-Min
Double Barrel Green System	Foaming Process	Astec Industries
Green Machine	Foaming Process	Gencor Industries
HGrant Warm Mix System	Foaming Process	Herman Grant Company
Qualitherm	Chemical Additive	Iterchimica
Aquablack Warm Mix Asphalt	Foaming Process	Maxam Equipment Inc.
Low Emission Asphalt	Chemical Additive	McConnaughay Technologies
Evotherm	Chemical Additive	MeadWestvaco Asphalt Innovations
Meeker Warm Mix	Foaming Process	Meeker Equipment Corp. Inc.
Advera (Synthetic Zeolite)	Foaming Process	PQ Corporation
Sasobit	Organic Additive	Sasol Wax Americas, Inc.
Shell Thiopave	Chemical Additive	Shell
Accu-Shear Dual Warm-Mix Additive System	Foaming Process	Stansteel
Tri-Mix Warm Mix Injection	Foaming Process	Tarmac Inc.
Warm Mix Asphalt System	Foaming Process	Terex Roadbuilding

If WMAC is proposed for use in this contract, the Contractor shall submit the proposed WMAC technology to be used and a plan for its implementation at the pre-construction conference.

Comply with the manufacturer's recommendations for incorporating additives and WMAC technologies into the mix. Comply with manufacturer's recommendations regarding receiving, storage, and delivery of the additives.

4. Subsection 00745.13 Job Mix Formula (JMF) Requirements - This subsection is added after subsection 00745.11(d) WMAC Asphalt Cement Additives:

   00745.13 Job Mix Formula (JMF) Requirements – Add the following after the paragraph ending with ". . . JMF requirements of 00745.13(b) are met."

   A separate JMF will be issued for WMAC. If WMAC is used on this contract provide the following information in addition to the requirements listed:

   1) WMAC technology and/or WMAC additives information.
   2) WMAC technology manufacturer's established recommendations of usage.
   3) WMAC technology manufacturer's established target rate for water and/or additives, the acceptable variation for production, and documentation showing the impact of excessive production variation.
   4) WMAC technology material safety data sheets (MSDS) if applicable.
   5) Temperature range for mixing.
   6) Temperature range for compacting.
   7) Asphalt binder performance grade test data of the asphalt binder and chemical additive at the manufacturer's recommended dosage rate. (Note: this does not apply to foaming technology)
   8) WMAC mixture performance test results per 00745.13(c). (Note: this testing will be done on production mix for foaming technology on specimens compacted at WMA compaction temperatures)
   9) Recycled asphalt shingles cannot be used in WMA mixes with minimum compaction temperatures less then 260 degrees Fahrenheit.

5. Subsection **00745.16 HMAC Production QC/QA** - This subsection is added after subsection **00745.14 Tolerance and Limits:**

   00745.16 HMAC Production QC/QA: Replace the subsection title with **HMAC & WMAC Production QC/QA**.

6. Subsection **00745.16(b-1-a) General** – Replace the first paragraph with the following:

   a. General - Prior to beginning production and placement of any WMAC:

   1. Perform MDV tests on HMAC as required at start-up according to 00745.16(b-1-c).
   2. Two consecutive running averages of four MDV test results from testing of HMAC shall be within the limits of 00745.16(b-1-a).

Perform MDV testing on projects with Level 2, Level 3, or Level 4 dense graded HMAC or WMAC. Perform MDV tests on every sublot and as required at start up according to 00745.16(b-1-c) and the MFTP. Perform gradation and asphalt content testing with each MDV test. Calculate the following values for each MDV test.

7. Subsection **00745.16(b-1-c) MDV Requirements at Start-up** - The paragraph that begins with the words "Perform MDV testing at the start-up…" is replaced with the following:

   Perform MDV testing at the start-up of the HMAC JMF production according to the following process:

8. Subsection **00745.16(b-4) MDV for WMAC** - This subsection is added after subsection **00745.16(b-3) MDV for Open Graded HMAC:**

   00745.16(b-4) MDV for WMAC – Perform MDV testing on WMAC per the requirements of 00745.16(b-1-a). Continued production and placement of WMAC will be allowed at the discretion of the Engineer.

9. Subsection **00745.21 HMAC Mixing Plant** - This subsection is added after subsection **00745.16(b-4) MDV for WMAC:**

   00745.21 HMAC Mixing Plant – Add the following to the end of this section:

   (g) WMAC Mixing Production - Modify the asphalt mixing plant as required by the manufacturer to introduce the WMAC technology. Plant modifications may include additional plant instrumentation, the installation of asphalt binder foaming systems and/or WMAC additive delivery systems, tuning the plant burner and adjusting the flights in order to operate at lower production temperatures and/or reduced tonnage. Document the integration of plant controls and interlocks.

10. Subsection **00745.43(b) Heating Temperatures** – This subsection is added after subsection **00745.40 Season and Temperature Limitations**:

00745.43(b) Heating Temperatures - Add the following table:

	WMAC Temperature, °F
Grading	**Minimum Behind Paver**
Dense	215

11. Subsection **00745.49(a-1) Temperature** - This subsection is added after subsection **00745.48(b) Depositing**:

    00745.49(a-1) Temperature – Add the following after the first sentence in the first paragraph.

    For WMAC, complete breakdown and intermediate compaction before the WMAC temperature drops below 160°F.

12. Subsection **00745.49(b-2-b) Core Correlation of Nuclear Gauge Readings** - This subsection is added after subsection **00745.49(b-1) General**:

    00745.49(b-2-b) Core Correlation of Nuclear Gauge Readings – Replace this section with the following:

    b. Core Correlation of Nuclear Gauge Readings - Perform core correlation of nuclear gauge readings on the HMAC wearing course and the WMAC wearing course.

    Apply correlation factors to all nuclear gauge readings for all dense graded mixtures placed on the Project. Cut the required cores and patch the core holes with dense graded HMAC or WMAC. Determine the core correlation factor according to WAQTC TM 8 and ODOT TM 327.

    New correlations are required if the aggregate source or the asphalt cement source changes. Perform additional core correlation of nuclear gauge readings for each lift when requested by the Engineer or Contractor. The party requesting the core correlation pays the costs of coring and lab testing of the cores. The party performing nuclear gauge testing pays the costs of the nuclear gauge testing.

These changes will be included in the Contract for this Project. It is understood that your Bid will be submitted accordingly.

C14. South Dakota

STATE OF SOUTH DAKOTA
DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION
FOR
WARM MIX ASPHALT CONCRETE
FIELD TRIAL SECTION

PROJECT NUMBER, PCN NUMBER
NAME COUNTY

MARCH 30, 2010

The following specification modifications to the Special Provision for Gyratory Controlled Quality Control/Quality Assurance Specifications for Hot Mixed Asphalt Concrete Pavement shall only apply to all Warm Mix Asphalt (WMA) produced for a field trial section.

Section 320.1 - Add the following to this section:

A field trial section(s) of WMA concrete pavement shall be placed in accordance with these specifications except as otherwise noted and as directed by the Engineer. This trial section will have an established control section of Q_N placed concurrently with the trial section of WMA.

Section 320.2 A. - Add the following to the end of the first paragraph of this section:

WMA additives utilized in the field trial sections shall be combined to the mixture or asphalt binder as recommended by the manufacturer. The dosage rate for the WMA additive shall be based on the mixture type, aggregate, asphalt binder, and job mix formula specific to this project. The dosage rate shall be recommended and verified by the manufacturer. The job mix formula, as noted in this section and specific for this project, shall be the starting point for addition of WMA additives and any changes to the job mix formula as well as the addition of WMA additives shall be verified in writing by the Bituminous Engineer. If the WMA additive is added to the asphalt binder, a separate sample of the asphalt binder with additive shall be submitted to the Bituminous Engineer in addition to the requirements of Section 320.3 D.3.d.

Section 320.3 A. - Add the following note under the table of minimum air temperatures & seasonal limitations.

Seasonal limit of May 1 may be waived for control section and WMA field trial section as directed by the Bituminous Engineer. Minimum temperature requirements shall remain in place unless it is deemed by the Bituminous Engineer that conditions are conducive to completion and analysis of the field trial sections (control and WMA).

Section 320.3 B.1. - Add the following to the end of this section:

The plant shall be capable of monitoring burner fuel usage during the production of the control and the WMA field trial tonnage. A beginning and ending burner fuel quantity for the production of the control and the WMA tonnage will be acceptable.

Section 320.3 D.5.c.1 - Add the following paragraphs after the table of Pay Factor Attributes:

For the WMA field trial section, the Pay Factor Attributes of a. % Air Voids and b. In Place Density (% Compaction) shall be evaluated as follows:

> **Air Voids:** A modified test procedure temperature will be determined based on the production and compaction temperature of the trial placement. Nominal air void assessment will be made and compared to the results from testing the same sample at conventional test temperatures. WMA field trial material will not be subject to the pay factor analysis but may be price adjusted (DOT-18) for deviations due to plant failure and/or production errors.
>
> **In Place Density:** Field test results shall be compared to the applicable lower specification limits for the class of mix produced. WMA field trial material will not be subject to the pay factor analysis but may be price adjusted (DOT-18) for deviations due to low density.
>
> The pay factor analysis (Quality Index) shall still be computed for the WMA field trial lot but payment shall be as noted above.

Section 320.3 J - Delete the first sentence of the 9th paragraph on page 26 and replace with the following:

Irregularities shall be corrected before the temperature of the WMA drops below 140° F (60°C) or as recommended by the manufacturer and approved by the Bituminous Engineer.

Section 320.3 J.1 - Delete the second sentence and replace with the following:

Compaction rolling shall be completed before the temperature of the WMA drops below 140° F (60°C) or as recommended by the manufacturer and approved by the Bituminous Engineer.

Section 320.5.A - Add the following to this section:

The accepted quantities of asphalt binder for the WMA field trial section will be paid for at the negotiated contract unit price for PG XX-XX (WMA modified). This item shall include all modification, shipping, production and mixing costs associated with the asphalt binder for the WMA field trial section.

Section 320.5.B - Add the following to this section:

The accepted quantities of asphalt concrete for the WMA field trial section, only, will be paid for at the negotiated contract unit price for Class Qx Asphalt Concrete (WMA modified). This item shall include all storage, mixing and placement costs associated with the WMA asphalt concrete.

The price of the Class Qx Asphalt Concrete (WMA modified) will be adjusted downward based on the documented burner fuel savings. Burner fuel savings will be calculated as follows: burner fuel utilized in production of the control section mixture minus the burner fuel utilized in production of WMA tonnage pro-rated and the savings shared 50%/50% by the Department and Contractor.

*****

C15. Washington

5-04 HOT MIX ASPHALT

5-04.1 Description

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.

HMA shall be composed of asphalt binder and mineral materials as may be required, mixed in the proportions specified to provide a homogeneous, stable, and workable mixture.

5-04.2 Materials

Materials shall meet the requirements of the following sections:

Asphalt Binder	9-02.1(4)
Cationic Emulsified Asphalt	9-02.1(6)
Anti-Stripping Additive	9-02.4
Warm Mix Asphalt Additive	9-02.5
Aggregates	9-03.8
Recycled Asphalt Pavement	9-03.8(3)B
Blending Sand	9-03.8(4)
Mineral Filler	9-03.8(5)
Recycled Material	9-03.21

The Contract documents may establish that the various mineral materials required for the manufacture of HMA will be furnished in whole or in part by the Contracting Agency. If the documents do not establish the furnishing of any of these mineral materials by the Contracting Agency, the Contractor shall be required to furnish such materials in the amounts required for the designated mix. Mineral materials include coarse and fine aggregates, blending sand, and mineral filler.

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.

The grade of asphalt binder shall be as required by the Contract. Prior to the submittal of the mix design, the Contractor shall provide a written designation of the grade of PG asphalt binder to be used. The Contractor may propose the substitution of alternate grades of performance grade (PG) asphalt binder at no cost to the Contracting Agency. The proposal will be approved if the proposed alternate asphalt binder has an average 7-day maximum pavement design temperature that is equal to or higher than the specified asphalt binder and has a minimum pavement design temperature that is equal to or lower than the specified asphalt binder. The substituted asphalt binder shall not exceed a one grade change for either of the design temperatures with a minimum pavement design temperature no lower than minus 28°C. The substituted alternate grade of asphalt binder shall be used in all HMA Contract items of the same class and originally specified grade of asphalt binder. Blending of asphalt binder from different sources is not permitted.

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.

When the Contracting Agency provides aggregates or provides a source for the production of aggregates, the Contract Provisions will establish the approximate percentage of asphalt binder required in the mixture for each class of HMA.

Production of aggregates shall comply with the requirements of Section 3-01.

Preparation of stockpile site, the stockpiling of aggregates, and the removal of aggregates from stockpiles shall comply with the requirements of Section 3-02.

5-04.3 Construction Requirements

5-04.3(1) HMA Mixing Plant

Plants used for the preparation of HMA shall conform to the following requirements:

1. **Equipment for Preparation of Asphalt Binder.** Tanks for the storage of asphalt binder shall be equipped to heat and hold the material at the required temperatures. The heating shall be accomplished by steam coils, electricity, or other approved means so that no flame shall be in contact with the storage tank. The circulating system for the asphalt binder shall be designed to ensure proper and continuous circulation during the operating period. A valve for the purpose of sampling the asphalt binder shall be placed in either the storage tank or in the supply line to the mixer.
2. **Thermometric Equipment.** An armored thermometer, capable of detecting temperature ranges expected in the HMA mix, shall be fixed in the asphalt binder feed line at a location near the charging valve at the mixer unit. The thermometer location shall be convenient and safe for access by Inspectors. The plant shall also be equipped with an approved dial-scale thermometer, a mercury actuated thermometer, an electric pyrometer, or another approved thermometric instrument placed at the discharge chute of the drier to automatically register or indicate the temperature of the heated aggregates. This device shall be in full view of the plant operator.
3. **Heating of Asphalt Binder.** The temperature of the asphalt binder shall not exceed the maximum recommended by the asphalt binder manufacturer. The asphalt binder shall be heated in a manner that will avoid local variations in heating. The heating method shall provide a continuous supply of asphalt binder to the mixer at a uniform average temperature with no individual variations exceeding 25°F. Also, when a WMA additive is included in the asphalt binder, the temperature of the asphalt binder shall not exceed the maximum recommended by the manufacturer of the WMA additive.
4. **Sampling and Testing of Mineral Materials.** The HMA plant shall be equipped with a mechanical sampler for the sampling of the mineral materials. The mechanical sampler shall meet the requirements of Section 1-05.6 for the crushing and screening operation. The Contractor shall provide sufficient space as required for the setup and operation of the field testing facilities of the Contracting Agency.
5. **Sampling HMA.** The HMA plant shall provide for sampling HMA by one of the following methods:
   a. A mechanical sampling device attached to the HMA plant.
   b. Platforms or devices to enable sampling from the hauling vehicle without entering the hauling vehicle.

5-04.3(2) Hauling Equipment

Trucks used for hauling HMA shall have tight, clean, smooth metal beds and shall have a cover of canvas or other suitable material of sufficient size to protect the mixture from adverse weather. Whenever the weather conditions during the workshift include, or are forecast to include, precipitation or an air temperature less than 45°F, the cover shall be securely attached to protect the HMA.

In order to prevent the HMA mixture from adhering to the hauling equipment, truck beds are to be sprayed with an environmentally benign release agent. Excess release agent shall be drained prior to filling hauling equipment with HMA. Petroleum derivatives or other coating material that contaminate or alter the characteristics of the HMA shall not be used. For hopper trucks, the conveyer shall be in operation during the process of applying the release agent.

5-04.3(3) Hot Mix Asphalt Pavers

HMA pavers shall be self-contained, power-propelled units, provided with an internally heated vibratory screed and shall be capable of spreading and finishing courses of HMA plant mix material in lane widths required by the paving section shown in the Plans.

Prior to the use of any HMA paver, the Contractor shall certify the paver is equipped with the most current equipment available from the manufacturer for the prevention of the segregation of the coarse aggregate particles. The certification shall list the make, model, and year of the paver and any equipment that has been retrofitted to the paver.

The screed shall be operated in accordance with the manufacturer's recommendations and shall effectively produce a finished surface of the required evenness and texture without tearing, shoving, segregating, or gouging the mixture. A copy of the manufacturer's recommendations shall be provided upon request by the Contracting Agency. Extensions will be allowed provided they produce the same results, including ride, density, and surface texture as obtained by the primary screed. Extensions without augers and an internally heated vibratory screed shall not be used in the Traveled Way.

The paver shall be equipped with automatic screed controls with sensors for either or both sides of the paver. The controls shall be capable of sensing grade from an outside reference line, sensing the transverse slope of the screed, and providing automatic signals that operate the screed to maintain the desired grade and transverse slope. The sensor shall be constructed so it will operate from a reference line or a mat referencing device.

The transverse slope controller shall be capable of maintaining the screed at the desired slope within plus or minus 0.1-percent. The paver shall be equipped with automatic feeder controls, properly adjusted to maintain a uniform depth of material ahead of the screed.

Manual operation of the screed will be permitted in the construction of irregularly shaped and minor areas. These areas include, but are not limited to, gore areas, road approaches, tapers and left-turn channelizations.

When specified in the Contract, reference lines for vertical control will be required. Lines shall be placed on both outer edges of the Traveled Way of each Roadway. Horizontal control utilizing the reference line will be permitted. The grade and slope for intermediate lanes shall be controlled automatically from reference lines or by means of a mat referencing device and a slope control device. When the finish of the grade prepared for paving is superior to the established tolerances and when, in the opinion of the Project Engineer, further improvement to the line, grade, cross-section, and smoothness can best be achieved without the use of the reference line, a mat referencing device may be substituted for the reference line. Substitution of the device will be subject to the continued approval of the Project Engineer. A joint matcher may be used subject to the approval of the Project Engineer. The reference line may be removed after the completion of the first course of HMA when approved by the Project Engineer. Whenever the Engineer determines that any of these methods are failing to provide the necessary vertical control, the reference lines will be reinstalled by the Contractor.

The Contractor shall furnish and install all pins, brackets, tensioning devices, wire, and accessories necessary for satisfactory operation of the automatic control equipment.

If the paving machine in use is not providing the required finish, the Project Engineer may suspend Work as allowed by Section 1-08.6. Any cleaning or solvent type liquids spilled on the pavement shall be thoroughly removed before paving proceeds.

5-04.3(3)A Material Transfer Device/Vehicle

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. HMA placed in irregularly shaped and minor areas such as road approaches, tapers, and turn lanes are excluded from this requirement.

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. 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.

5-04.3(4) Rollers

Rollers shall be of the steel wheel, vibratory, or pneumatic tire type, in good condition and capable of reversing without backlash. Operation of the roller shall be in accordance with the manufacturer's recommendations. When ordered by the Project Engineer for any roller planned for use on the project, the Contractor shall provide a copy of the manufacturer's recommendation for the use of that roller for compaction of HMA. The number and weight of rollers shall be sufficient to compact the mixture in compliance with the requirements of Section 5-04.3(10). The use of equipment that results in crushing of the aggregate will not be permitted. Rollers producing pickup, washboard, uneven compaction of the surface, displacement of the mixture or other undesirable results shall not be used.

5-04.3(5) Conditioning of Existing Surface

When the surface of the existing pavement or old base is irregular, the Contractor shall bring it to a uniform grade and cross-section as shown on the Plans or approved by the Project Engineer.

Preleveling of uneven or broken surfaces over which HMA is to be placed may be accomplished by using an asphalt paver, a motor patrol grader, or by hand raking as approved by the Project Engineer.

5-04.3(5)A Preparation of Existing Surfaces

Before construction of HMA on an existing paved surface, the entire surface of the pavement shall be clean. All fatty asphalt patches, grease drippings, and other objectionable matter shall be entirely removed from the existing pavement. All pavements or bituminous surfaces shall be thoroughly cleaned of dust, soil, pavement grindings, and other foreign matter. All holes and small depressions shall be filled with an appropriate class of HMA. The surface of the patched area shall be leveled and compacted thoroughly.

A tack coat of asphalt shall be applied to all paved surfaces on which any course of HMA is to be placed or abutted. 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. For Roadways open to traffic, the application of tack coat shall be limited to surfaces that will be paved during the same working shift. The spreading equipment shall be equipped with a thermometer to indicate the temperature of the tack coat material.

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.

Unless otherwise approved by the Engineer, the tack coat shall be CSS-1, CSS-1h, or STE-1 emulsified asphalt. 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. The tack coat shall not exceed the maximum temperature recommended by the emulsified asphalt manufacturer.

5-04.3(5)B Preparation of Untreated Roadway

When designated in the Plans the existing Roadway shall be prepared and primed. The Roadway preparation shall be performed in accordance with the Bituminous Surface Treatment provisions for this type of Work (Section 5-02.3(2)A), except that only one application of asphalt and one application of aggregate shall be applied. The aggregate shall conform either to the requirements of Section 9-03.4, 9-03.4 or shall consist of other material approved by the Engineer. All other provisions of Section 5-02 pertaining to New Construction bituminous surface treatments shall apply to this preparation Work, except as hereinafter modified.

The prime coat shall be applied over the full length of the project. HMA shall not be placed until the prime coat has cured for 5-days unless otherwise approved by the Engineer.

Should any holes, breaks, or irregularities develop in the Roadway surface after the prime coat has been applied, they shall be patched, as described in Section 5-04.3(5)A, before placement of the HMA pavement. The Contractor shall maintain the completed prime coat by blading or brooming with equipment and procedures approved by the Engineer, until the HMA pavement is placed.

After the maintenance, patching or repair Work has been completed and immediately prior to placing the HMA, the surface of the prime coat shall be swept clean of all dirt, dust, or other foreign matter.

When the prime coat application is not specified in the Special Provisions or shown in the Plans, the Contractor shall prepare the untreated Roadway as described above and shall omit the prime coat treatment. The HMA shall be constructed on the prepared Subgrade.

The Contractor shall prepare untreated Shoulders and traffic islands by blading and compacting to provide a sound base for paving and shall omit the prime coat treatment. The HMA shall be constructed on the prepared Subgrade.

5-04.3(5)C Crack Sealing

When the Proposal includes a pay item for crack sealing, all cracks and joints ¼-inch and greater in width shall be cleaned with a stiff-bristled broom and compressed air and then shall be filled completely with sand slurry.

The sand slurry shall consist of approximately 20-percent CSS-1 emulsified asphalt, approximately 2-percent Portland cement, water (if required), and the remainder clean No. 4-0 paving sand. The components shall be thoroughly mixed and then poured into the cracks and joints until full. The following day, any cracks or joints that are not completely filled shall be topped off with additional sand slurry. After the sand slurry is placed, the filler shall be struck off flush with the existing pavement surface and allowed to cure. The HMA overlay shall not be placed until the slurry has fully cured. The requirements of Section 1-06 will not apply to the Portland cement and paving sand used in the sand slurry.

5-04.3(5)D Soil Residual Herbicide

Where shown in the Plans, the Contractor shall apply one application of an approved soil residual herbicide. The requirements of Section 8-02.3(2)A shall apply to this application. Paving shall begin within 24-hours after application of the herbicide.

The material to be used shall be registered with the Washington State Department of Agriculture for use under pavement. Before use, the Contractor shall obtain approval of the material to be used and the proposed rate of application from the Project Engineer. The following information shall be included in the request for approval of the material:

1. Brand Name of the Material;
2. Manufacturer;
3. Environmental Protection Agency (EPA) Registration Number;
4. Material Safety Data Sheet; and
5. Proposed Rate of Application.

5-04.3(5)E Pavement Repair

The Contractor shall excavate pavement repair areas and shall backfill these with HMA in accordance with the details shown in the Plans and as staked. The Contractor shall conduct the excavation operations in a manner that will protect the pavement that is to remain. Pavement not designated to be removed that is damaged as a result of the Contractor's operations shall be repaired by the Contractor to the satisfaction of the Project Engineer at no cost to the Contracting Agency. The Contractor shall excavate only within one lane at a time unless approved otherwise by the Project Engineer. The Contractor shall not excavate more area than can be completely finished during the same shift.

The Project Engineer will determine the excavation depth, which may vary up to a total depth of 1-foot. The determination will depend on the location of material suitable for support of the pavement. The minimum width of any pavement repair area shall be 3-feet unless shown otherwise in the Plans. Before any excavation, the existing pavement shall be sawcut or shall be removed by a pavement grinder. Excavated materials will become the property of the Contractor and shall be disposed of in a Contractor-provided site off the Right of Way or used in accordance with Sections 2-02.3(3) or 9-03.21. Asphalt for tack coat shall be required as specified in Section 5-04.3(5)A. A heavy application of tack coat shall be applied to all surfaces of existing pavement in the pavement repair area. Placement of the HMA backfill shall be accomplished in lifts not to exceed 0.35-foot compacted depth. Each lift shall be thoroughly compacted by a mechanical tamper or a roller.

5-04.3(6) Vacant

5-04.3(7) Preparation of Aggregates

The aggregates shall be stockpiled according to the requirements of Section 3-02. Sufficient storage space shall be provided for each size of aggregate. The aggregates shall be removed from stockpile(s) in a manner to ensure a minimum of segregation when being moved to the HMA plant for processing into the final mixture. Different aggregate sizes shall be kept separated until they have been delivered to the HMA plant.

5-04.3(7)A Mix Design

5-04.3(7)A1 General

The Contractor shall develop a mix design prior to the initial production of HMA and prior to the production of HMA each calendar year thereafter. The mix design aggregate structure and asphalt binder content shall be determined in accordance with WSDOT Standard Operating Procedure 732 and meet the requirements of Sections

9-03.8(2) and 9-03.8(6). Mix designs that were developed during the calendar year prior to the current year's production of HMA that have been issued a WSDOT mix design report will be accepted provided the Contractor submits a certification letter stating that the aggregate and asphalt binder have not changed. Changes to aggregate that may require a new mix design include the source of material or a change in the percentage of material from a stockpile greater than 5-percent. Changes to asphalt binder that may require a new mix design include the source of the crude petroleum supplied to the refinery, the refining process, and additives or modifiers in the asphalt binder.

5-04.3(7)A2 Statistical or Nonstatistical Evaluation

Mix designs for HMA accepted by statistical and nonstatistical evaluation shall be submitted to the Project Engineer on DOT form 350-042. For a mix design that was originally developed for another WSDOT contract, the Contractor shall also submit DOT form 350-041 and include all changes to the job mix formula that have been approved on other contracts.

The Contractor shall submit representative samples of the mineral materials that are to be used in the HMA production. The Contracting Agency will use these samples to conduct verification testing of the mix design in accordance with WSDOT Standard Operating Procedure 732 and to determine anti-strip requirements, if any, in accordance with WSDOT test method T 718. Verification testing of HMA mix designs proposed by the Contractor that include RAP will be completed without the inclusion of the RAP. Submittal of RAP samples is not required. A mix design report will be provided within 25-calendar days after a mix design submittal has been received in the State Materials Laboratory in Tumwater. No paving shall begin prior to issuance of the mix design report or reference mix design report for that year.

5-04.3(7)A3 Commercial Evaluation

Mix designs for HMA accepted by commercial evaluation shall be submitted to the Project Engineer on DOT form 350-042; only the first page is required.

Verification of the mix design by the Contracting Agency is not required. The Project Engineer will determine anti-strip requirements for the HMA. Paving shall not begin before the anti-strip requirements have been provided to the Contractor. For commercial HMA, the Contractor shall select a class of HMA and design level of Equivalent Single Axle Loads (ESAL's) appropriate for the required use.

5-04.3(8) Mixing

After the required amounts of mineral materials and asphalt binder have been introduced into the mixer the HMA shall be mixed until a complete and uniform coating of the particles and a thorough distribution of the asphalt binder throughout the mineral materials is ensured.

When discharged, the temperature of the HMA shall not exceed the optimum mixing temperature by more than 25°F as shown on the mix design or reference mix design report or as approved by the Engineer. Also, when a WMA additive is included in the manufacture of HMA, the discharge temperature of the HMA shall not exceed the maximum recommended by the manufacturer of the WMA additive. A maximum water content of 2-percent in the mix, at discharge, will be allowed providing the water causes no problems with handling, stripping, or flushing. If the water in the HMA causes any of these problems, the moisture content shall be reduced as directed by the Project Engineer.

Storing or holding of the HMA in approved storage facilities will be permitted during the daily operation but in no event shall the HMA be held for more than 24-hours. HMA held for more than 24-hours after mixing shall be rejected. Rejected HMA shall be disposed of by the Contractor at no expense to the Contracting Agency. The storage facility shall have an accessible device located at the top of the cone or about the third point. The device shall indicate the amount of material in storage. No HMA shall be accepted from the storage facility when the HMA in storage is below the top of the cone of the storage facility, except as the storage facility is being emptied at the end of the working shift.

Recycled asphalt pavement (RAP) utilized in the production of HMA shall be sized prior to entering the mixer so that a uniform and thoroughly mixed HMA is produced. If there is evidence of the recycled asphalt pavement not breaking down during the heating and mixing of the HMA, the Contractor shall immediately suspend the use of the RAP until changes have been approved by the Project Engineer.

5-04.3(8)A Acceptance Sampling and Testing—HMA Mixture

5-04.3(8)A1 General

Acceptance of HMA shall be as provided under statistical, nonstatistical, or commercial evaluation.

Acceptance of HMA by statistical evaluation is administered under the provisions of Section 5-04.5(1) Quality Assurance Price Adjustments. Statistical evaluation will be used for a class of HMA when the Proposal quantities for that class of HMA exceed 4,000-tons.

Nonstatistical evaluation will be used for the acceptance of HMA when the Proposal quantities for a class of HMA are 4,000-tons or less.

Commercial evaluation will be used for Commercial HMA and for other classes of HMA in the following applications: sidewalks, road approaches, ditches, slopes, paths, trails, gores, prelevel, and pavement repair. Other nonstructural applications of HMA accepted by commercial evaluation shall be as approved by the Project Engineer. Sampling and testing of HMA accepted by commercial evaluation will be at the option of the Project Engineer. The Proposal quantity of HMA that is accepted by commercial evaluation will be excluded from the quantities used in the determination of statistical and nonstatistical evaluation.

The mix design will be the initial JMF for the class of HMA. The Contractor may request a change in the JMF. Any adjustments to the JMF will require the approval of the Project Engineer and may be made in accordance with Section 9-03.8(7).

5-04.3(8)A2 Aggregate

For HMA accepted by statistical evaluation, the gradation of aggregates will be included in the statistical calculations. The acceptance criteria for aggregate properties of sand equivalent, uncompacted void content, and fracture will be their conformance to the requirements of Section 9-03.8(2). These properties will not be included in the statistical evaluation. Sampling and testing of aggregates accepted by commercial evaluation will be at the option of the Project Engineer.

5-04.3(8)A3 Sampling

The random sampling of HMA will be by WSDOT Test Method T 716. Samples for acceptance testing shall be obtained by the Contractor when ordered by the Engineer. The Contractor shall sample the HMA mixture in the presence of the Engineer and in accordance with WSDOT FOP for WAQTC AASHTO T 168.

5-04.3(8)A4 Definition of Sampling Lot and Sublot

A lot is represented by randomly selected samples that will be tested for acceptance with a maximum of 15 sublots per lot; the final lot may be increased to 25 sublots. All of the test results obtained from the acceptance samples from a given lot shall be evaluated collectively. If the Contractor requests a change to the JMF that is approved, the material produced after the change will be evaluated on the basis of the new JMF for the remaining sublots in the current lot and for acceptance of subsequent lots. For a lot in progress with a CPF less than 0.75, a new lot will begin at the Contractor's request after the Project Engineer is satisfied that material conforming to the Specifications can be produced.

Sampling and testing for statistical and nonstatistical evaluation shall be performed on the frequency of one sample per sublot. The sublots shall be approximately uniform in size with a maximum sublot size of 800-tons. The quantity of material represented by the final sublot for either statistical or nonstatistical evaluation may be increased to a maximum of two times the sublot quantity calculated. Should a lot accepted by statistical evaluation contain fewer than three sublots, the HMA will be accepted in accordance with nonstatistical evaluation.

5-04.3(8)A5 Test Results

The results of all acceptance testing performed in the field and the Composite Pay Factor (CPF) of the lot after three sublots have been tested will be available to the Contractor through WSDOT's website.

The Contractor may request a sublot be retested. To request a retest, the Contractor shall submit a written request within 7-calendar days after the specific test results have been posted to the website. A split of the original acceptance sample will be sent for testing to either the Region Materials Laboratory or the State Materials Laboratory as determined by the Project Engineer. The split of the sample will not be tested with the same equipment or by the same tester that ran the original acceptance test. The sample will be tested for a complete gradation analysis, asphalt binder content, and Va, and the results of the retest will be used for the acceptance of the HMA in place of the original sublot sample test results. The cost of testing will be deducted from any monies due or that may come due the Contractor under the Contract at the rate of $250 per sample.

5-04.3(8)A6 Test Methods

Testing of HMA for compliance of Va will be by WSDOT Standard Operating Procedure SOP 731. Testing for compliance of asphalt binder content will be by WSDOT FOP for AASHTO T 308. Testing for compliance of gradation will be by WAQTC FOP for AASHTO T 27/T 11.

5-04.3(8)A7 Test Section – HMA Mixtures

For each class of HMA accepted by statistical evaluation, the Contractor may request a test section to determine whether the mixture meets the requirements of Section 9-03.8(2) and 9-03.8(6). The test section shall be constructed at the beginning of paving and will be at least 600-tons and a maximum of 1,000-tons or as approved by the Project Engineer. No further wearing or leveling HMA will be paved the day of or the day following the construction of the test section. The mixture in the test section will be evaluated as a lot with a minimum of three sublots required.

5-04.3(9) Spreading and Finishing

The mixture shall be laid upon an approved surface, spread, and struck off to the grade and elevation established. HMA pavers complying with Section 5-04.3(3) shall be used to distribute the mixture. Unless otherwise directed by the Engineer, the nominal compacted depth of any layer of any course shall not exceed the following:

HMA Class 1"	0.35-feet
HMA Class ¾" and HMA Class ½"	
wearing course	0.30-feet
other courses	0.35-feet
HMA Class ⅜"	0.10-feet

On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impractical, the paving may be done with other equipment or by hand.

When more than 1 JMF is being utilized to produce HMA, the material produced for each JMF shall be placed by separate spreading and compacting equipment. The intermingling of HMA produced from more than 1 JMF is prohibited. Each strip of HMA placed during a work shift shall conform to a single JMF established for the class of HMA specified unless there is a need to make an adjustment in the JMF.

5-04.3(10) Compaction

5-04.3(10)A General

Immediately after the HMA has been spread and struck off, and after surface irregularities have been adjusted, the mix shall be thoroughly and uniformly compacted. The completed course shall be free from ridges, ruts, humps, depressions, objectionable marks, and irregularities and shall conform to the line, grade, and cross-section shown in the Plans. If necessary, the JMF may be altered in accordance with Section 9-03.8(7) to achieve desired results.

Compaction shall take place when the mixture is in the proper condition so that no undue displacement, cracking, or shoving occurs. Areas inaccessible to large compaction equipment shall be compacted by mechanical or hand tampers. Any HMA that becomes loose, broken, contaminated, shows an excess or deficiency of asphalt, or is in any way defective, shall be removed and replaced with new hot mix that shall be immediately compacted to conform to the surrounding area.

The type of rollers to be used and their relative position in the compaction sequence shall generally be the Contractor's option, provided the specified densities are attained. An exception shall be that pneumatic tired rollers shall be used for compaction of the wearing course beginning October 1st of any year through March 31st of the following year. Coverages with a vibratory or steel wheel roller may precede pneumatic tired rolling. Unless the Project Engineer has approved otherwise, vibratory rollers shall not be operated in the vibratory mode when the internal temperature of the mix is less than 175°F. Regardless of mix temperature, a vibratory roller shall not be operated in a vibratory mode when checking or cracking of the mat occurs. Rollers shall only be operated in static mode on bridge decks.

5-04.3(10)B Control

5-04.3(10)B1 General

HMA mixture accepted by statistical or nonstatistical evaluation that is used in traffic lanes, including lanes for ramps, truck climbing, weaving, and speed change, and having a specified compacted course thickness greater than 0.10-foot, shall be compacted to a specified level of relative density. The specified level of relative density shall be a Composite Pay Factor (CPF) of not less than 0.75 when evaluated in accordance with Section 1-06.2, using a minimum of 91.0-percent of the reference maximum density as determined by WSDOT FOP for AASHTO T 209. The specified level of density attained will be determined by the statistical evaluation of tests taken in accordance with FOP for WAQTC TM 8 and WSDOT SOP T 729 on the day the mix is placed (after completion of the finish rolling).

Each compaction lot will be divided into sublots with a maximum of 15 sublots per lot; the final lot may be increased to 25 sublots. Sublots will be uniform in size with a maximum of approximately 80-tons per sublot; the final sublot of the day may be increased to 120-tons. The sublot locations within each density lot will be determined by the stratified random sampling procedure conforming to WSDOT Test Method

T 716. For a lot in progress with a CPF less than 0.75, a new lot will begin at the Contractor's request after the Project Engineer is satisfied that material conforming to the Specifications can be produced.

HMA mixture accepted by commercial evaluation and HMA constructed under conditions other than those listed above shall be compacted on the basis of a test point evaluation of the compaction train. The test point evaluation shall be performed in accordance with instructions from the Project Engineer. The number of passes with an approved compaction train, required to attain the maximum test point density, shall be used on all subsequent paving.

HMA for preleveling shall be thoroughly compacted. HMA that is used for preleveling wheel rutting shall be compacted with a pneumatic tire roller unless otherwise approved by the Engineer.

5-04.3(10)B2 Cyclic Density

The Project Engineer may also evaluate the HMA for low cyclic density of the pavement in accordance with WSDOT SOP 733. 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. Any area tested for density under Section 5-04.3(10)B1 will be included in this evaluation. 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.

5-04.3(10)B3 Longitudinal Joint Density

The Project Engineer will evaluate the HMA wearing surface for low density at the longitudinal joint in accordance with WSDOT SOP 735. Low density is defined as less than 90.0-percent of the reference maximum density. 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.

5-04.3(10)B4 Test Results

The nuclear moisture-density gauge results of all compaction acceptance testing and the CPF of the lot after three sublots have been tested will be available to the Contractor through WSDOT's website. Determination of the relative density of the HMA with a nuclear moisture-density gauge requires a correlation factor and may require resolution after the correlation factor is known. Acceptance of HMA compaction will be based on the statistical evaluation and CPF so determined.

For a sublot that did not meet the minimum of 91.0-percent of the reference maximum density in a compaction lot with a CPF below 1.00 and thus subject to a price reduction or rejection, the Contractor may request that a core be used for determination of the relative density of the sublot. The relative density of the core will replace the relative density determined by the nuclear moisture-density gauge for the sublot and will be used for calculation of the CPF and acceptance of HMA compaction lot. When cores are taken by the Contracting Agency at the request of the Contractor, they shall be requested by noon of the next workday after the test results for the sublot have been provided or made available to the Contractor. The core will be taken at approximately the same location as the nuclear moisture-density gauge test in the compaction sublot being challenged. Traffic control shall be provided by the Contractor as requested by the Project Engineer. Failure by the Contractor to provide the requested traffic control will result in forfeiture of the request for cores. When the CPF for the lot based on the results of the HMA cores is less than 1.00, the cost for the coring will be deducted from any monies due or that may become due the Contractor under the Contract at the rate of $200 per core and the Contractor shall pay for the cost of the traffic control.

5-04.3(11) Reject Work

5-04.3(11)A General

Work that is defective or does not conform to Contract requirements shall be rejected.

5-04.3(11)B Rejection by Contractor

The Contractor may, prior to sampling, elect to remove any defective material and replace it with new material. Any such new material will be sampled, tested, and evaluated for acceptance.

5-04.3(11)C Rejection Without Testing

The Project Engineer may, without sampling, reject any batch, load, or section of Roadway that appears defective. Material rejected before placement shall not be incorporated into the pavement. Any rejected section of Roadway shall be removed.

No payment will be made for the rejected materials or the removal of the materials unless the Contractor requests that the rejected material be tested. If the Contractor elects to have the rejected material tested, a minimum of three representative samples will be obtained and tested. Acceptance of rejected material will be based on conformance with the statistical acceptance Specification. If the CPF for the rejected material is less than 0.75, no payment will be made for the rejected material; in addition, the cost of sampling and testing shall be borne by the Contractor. If the CPF is greater than or equal to 0.75, the cost of sampling and testing will be borne by the Contracting Agency. If the material is rejected before placement and the CPF is greater than or equal to 0.75, compensation for the rejected material will be at a CPF of 0.75. If rejection occurs after placement and the CPF is greater than or equal to 0.75, compensation for the rejected material will be at the calculated CPF with an addition of 25-percent of the unit Contract price added for the cost of removal and disposal.

5-04.3(11)D Lots and Sublots

5-04.3(11)D1 A Partial Sublot

In addition to the random acceptance sampling and testing, the Project Engineer may also isolate from a normal sublot any material that is suspected of being defective in relative density, gradation or asphalt binder content. Such isolated material will not include an original sample location. A minimum of 3 random samples of the suspect material will be obtained and tested. The material will then be statistically evaluated as an independent lot in accordance with Section 1-06.2(2).

5-04.3(11)D2 An Entire Sublot

An entire sublot that is suspected of being defective may be rejected. When a sublot is rejected a minimum of 2 additional random samples from this sublot will be obtained. These additional samples and the original sublot will be evaluated as an independent lot in accordance with Section 1-06.2(2).

5-04.3(11)D3 A Lot in Progress

The Contractor shall shut down operations and shall not resume HMA placement until such time as the Project Engineer is satisfied that material conforming to the Specifications can be produced:

a. When the Composite Pay Factor (CPF) of a lot in progress drops below 1.00 and the Contractor is taking no corrective action, or

b. When the Pay Factor (PF) for any constituent of a lot in progress drops below 0.95 and the Contractor is taking no corrective action, or

c. When either the PFi for any constituent or the CPF of a lot in progress is less than 0.75.

5-04.3(11)D4 An Entire Lot

An entire lot with a CPF of less than 0.75 will be rejected. The designated percentage reduction as defined in Section 1-06.2(2)B under Financial Incentive Paragraph 1, Item 3, shall be 25-percent.

5-04.3(12) Joints

5-04.3(12)A Transverse Joints

The Contractor shall conduct operations such that the placing of the top or wearing course is a continuous operation or as close to continuous as possible. Unscheduled transverse joints will be allowed and the roller may pass over the unprotected end of the freshly laid mixture only when the placement of the course must be discontinued for such a length of time that the mixture will cool below compaction temperature. When the Work is resumed, the previously compacted mixture shall be cut back to produce a slightly beveled edge for the full thickness of the course.

A temporary wedge of HMA constructed on a 50H:1V shall be constructed where a transverse joint as a result of paving or planing is open to traffic. The HMA in the temporary wedge shall be separated from the permanent HMA by strips of heavy wrapping paper or other methods approved by the Engineer. The wrapping paper shall be removed and the joint trimmed to a slightly beveled edge for the full thickness of the course prior to resumption of paving.

The material that is cut away shall be wasted and new mix shall be laid against the cut. Rollers or tamping irons shall be used to seal the joint.

5-04.3(12)B Longitudinal Joints

The longitudinal joint in any one course shall be offset from the course immediately below by not more than 6-inches nor less than 2-inches. All longitudinal joints constructed in the wearing course shall be located at a lane line or an edge line of the Traveled Way.

On one-lane ramps a longitudinal joint may be constructed at the center of the traffic lane, subject to approval by the Project Engineer, if:

1. The ramp must remain open to traffic, or
2. The ramp is closed to traffic and a hot-lap joint is constructed.
    a. If a hot-lap joint is allowed at the center of the traffic lane, two paving machines shall be used; a minimum compacted density in accordance with Section 5-04.3(10)B shall be achieved throughout the traffic lane; and construction equipment other than rollers shall not operate on any uncompacted mix.

When HMA is placed adjacent to cement concrete pavement, the Contractor shall construct longitudinal joints between the HMA and the cement concrete pavement. The joint shall be sawed to the dimensions shown on Standard Plan A-40.10-00 and filled with joint sealant meeting the requirements of Section 9-04.2.

5-04.3(13) Surface Smoothness

The completed surface of all courses shall be of uniform texture, smooth, uniform as to crown and grade, and free from defects of all kinds. The completed surface of the wearing course shall not vary more than ⅛-inch from the lower edge of a 10-foot straightedge placed on the surface parallel to the centerline. The transverse slope of the completed surface of the wearing course shall vary not more than ¼-inch in 10-feet from the rate of transverse slope shown in the Plans.

When deviations in excess of the above tolerances are found that result from a high place in the HMA, the pavement surface shall be corrected by one of the following methods:

1. Removal of material from high places by grinding with an approved grinding machine, or
2. Removal and replacement of the wearing course of HMA, or
3. By other method approved by the Project Engineer.

Correction of defects shall be carried out until there are no deviations anywhere greater than the allowable tolerances.

Deviations in excess of the above tolerances that result from a low place in the HMA and deviations resulting from a high place where corrective action, in the opinion of the Project Engineer, will not produce satisfactory results will be accepted with a price adjustment. The Project Engineer shall deduct from monies due or that may become due to the Contractor the sum of $500.00 for each and every section of single traffic lane 100-feet in length in which any excessive deviations described above are found.

When Portland cement concrete pavement is to be placed on HMA, the surface tolerance of the HMA shall be such that no surface elevation lies above the Plan grade minus the specified Plan depth of Portland cement concrete pavement. Prior to placing the Portland cement concrete pavement, any such irregularities shall be brought to the required tolerance by grinding or other means approved by the Project Engineer.

When utility appurtenances such as manhole covers and valve boxes are located in the Traveled Way, the Roadway shall be paved before the utility appurtenances are adjusted to the finished grade.

5-04.3(14) Planing Bituminous Pavement

Planing shall be performed in such a manner that the underlying pavement is not torn, broken, or otherwise damaged by the planing operation. Delamination or raveling of the underlying pavement will not be construed as damage due to the Contractor's operations. Pavement outside the limits shown in the Plans or designated by the Engineer that is damaged by the Contractor's operations shall be repaired to the satisfaction of the Engineer, at the Contractor's expense.

For mainline planing operations, the equipment shall have automatic controls, with sensors for either or both sides of the equipment. The controls shall be capable of sensing the grade from an outside reference line, or a mat-referencing device. The automatic controls shall have a transverse slope controller capable of maintaining the mandrel at the desired transverse slope (expressed as a percentage) within plus or minus 0.1-percent.

The planings and other debris resulting from the planing operation shall become the property of the Contractor and be disposed of in accordance with Section 2-03.3(7)C. The planings may be utilized as RAP, within the requirements of Section 5-04.2 or 9-03.21.

5-04.3(15) HMA Road Approaches

HMA approaches shall be constructed at the locations shown in the Plans or where staked by the Project Engineer. The Work shall be performed in accordance with Section 5-04.

5-04.3(16) Weather Limitations

HMA for wearing course shall not be placed on any Traveled Way beginning October 1st through March 31st of the following year without written approval from the Project Engineer.

Asphalt for prime coat shall not be applied when the ground temperature is lower than 50°F without written approval of the Project Engineer.

HMA shall not be placed on any wet surface, or when the average surface temperatures are less than those specified in the following table, or when weather conditions otherwise prevent the proper handling or finishing of the bituminous mixtures:

Surface Temperature Limitation		
Compacted Thickness (Feet)	Wearing Course	Other Courses
Less than 0.10	55°F	45°F
0.10 to 0.20	45°F	35°F
More than 0.20	35°F	35°F

5-04.3(17) Paving Under Traffic

When the Roadway being paved is open to traffic, the requirements of this section shall apply.

The Contractor shall keep on-ramps and off-ramps open to traffic at all times except when paving the ramp or paving across the ramp. During such time, and provided that there has been an advance warning to the public, the ramp may be closed for the minimum time required to place and compact the mixture. In hot weather, the Project Engineer may require the application of water to the pavement to accelerate the finish rolling of the pavement and to shorten the time required before reopening to traffic.

Before closing a ramp, advance warning signs shall be placed and signs shall also be placed marking the detour or alternate route. Ramps shall not be closed on consecutive interchanges at the same time.

During paving operations, temporary pavement markings shall be maintained throughout the project. Temporary pavement markings shall be installed on the Roadway prior to opening to traffic. Temporary pavement markings shall be in accordance with Section 8-23.

All costs in connection with performing the Work in accordance with these requirements, except the cost of temporary pavement markings, shall be included in the unit Contract prices for the various Bid items involved in the Contract.

5-04.3(18) Vacant

5-04.3(19) Sealing of Pavement Surfaces

Where shown in the Plans, the Contractor shall apply a fog seal. The fog seal shall be constructed in accordance with Section 5-02.3. Unless otherwise approved by the Project Engineer, the fog seal shall be applied prior to opening to traffic.

5-04.3(20) Anti-Stripping Additive

When directed by the Project Engineer, an anti-stripping additive shall be added to the HMA in accordance with Section 9-02.4.

5-04.3(21) Vacant

5-04.4 Measurement

HMA Cl. ___ PG ___, HMA for ___ Cl. ___ PG ___, and Commercial HMA will be measured by the ton in accordance with Section 1-09.2, with no deduction being made for the weight of asphalt binder, blending sand, mineral filler, or any other component of the mixture. If the Contractor elects to remove and replace mix as allowed by Section 5-04.3(11), the material removed will not be measured.

Preparation of untreated roadway will be measured by the mile once along the centerline of the main line Roadway. No additional measurement will be made for ramps, Auxiliary Lanes, service roads, Frontage Roads, or Shoulders. Measurement will be to the nearest 0.01-mile.

No specific unit of measure will apply to the force account item of crack sealing.

Soil residual herbicide will be measured by the mile for the stated width to the nearest 0.01-mile or by the square yard, whichever is designated in the Proposal.

Pavement repair excavation will be measured by the square yard of surface marked prior to excavation.

Asphalt for prime coat will be measured by the ton in accordance with Section 1-09.2.

Prime coat aggregate will be measured by the cubic yard, truck measure, or by the ton, whichever is designated in the Proposal.

Asphalt for fog seal will be measured by the ton, as provided in Section 5-02.4.

Longitudinal joint seals between the HMA and cement concrete pavement will be measured by the linear foot along the line and slope of the completed joint seal.

Planing bituminous pavement will be measured by the square yard.

Temporary pavement marking will be measured by the linear foot as provided in Section 8-23.4.

Removing temporary pavement marking will be measured by the linear foot as provided in Section 8-23.4.

Water will be measured by the M gallon as provided in Section 2-07.4.

No specific unit of measure will apply to the calculated item of anti-stripping additive.

No specific unit of measure will apply to the calculated item of job mix compliance price adjustment.

No specific unit of measure will apply to the calculated item of compaction price adjustment.

No specific unit of measure will apply to the calculated item of cyclic density price adjustment.

No specific unit of measure will apply to the calculated item of longitudinal joint density price adjustment.

5-04.5 Payment

Payment will be made in accordance with Section 1-04.1, for each of the following Bid items that are included in the Proposal:

"HMA Cl. ___ PG ___", per ton.

"HMA for Approach Cl. ___ PG ___", per ton.

"HMA for Preleveling Cl. ___ PG ___", per ton.

"HMA for Pavement Repair Cl. ___ PG ___", per ton.

"Commercial HMA", per ton.

The unit Contract price per ton for "HMA Cl. ___ PG ___", "HMA for Approach Cl. ___ PG ___", "HMA for Preleveling Cl. ___ PG ___", "HMA for Pavement Repair Cl. ___ PG ___", and "Commercial HMA" shall be full compensation for all costs incurred to carry out the requirements of Section 5-04 except for those costs included in other items which are included in this sub-section and which are included in the Proposal.

"Preparation of Untreated Roadway", per mile.

The unit Contract price per mile for "Preparation of Untreated Roadway" shall be full pay for all Work described under Section 5-04.3(5)B, with the exception, however, that all costs involved in patching the Roadway prior to placement of HMA shall be included in the unit Contract price per ton for "HMA Cl. ___ PG ___" which was used for patching. If the Proposal does not include a Bid item for "Preparation of Untreated Roadway", the Roadway shall be prepared as specified, but the Work shall be included in the Contract prices of the other items of Work.

"Crack Sealing", by force account.

"Crack Sealing" will be paid for by force account as specified in Section 1-09.6. For the purpose of providing a common Proposal for all Bidders, the Contracting Agency has entered an amount in the Proposal to become a part of the total Bid by the Contractor.

"Soil Residual Herbicide ____ ft. Wide," per mile, or

"Soil Residual Herbicide", per square yard.

The unit Contract price per mile or per square yard for "Soil Residual Herbicide" shall be full payment for all costs incurred to obtain, provide and install herbicide in accordance with Section 5-04.3(5)D.

"Pavement Repair Excavation Incl. Haul", per square yard.

The unit Contract price per square yard for "Pavement Repair Excavation Incl. Haul" shall be full payment for all costs incurred to perform the Work described in Section 5-04.3(5)E with the exception, however, that all costs involved in the placement of HMA shall be included in the unit Contract price per ton for "HMA for Pavement Repair Cl. ___ PG ___", per ton.

"Asphalt for Prime Coat", per ton.

The unit Contract price per ton for "Asphalt for Prime Coat" shall be full payment for all costs incurred to obtain, provide and install the material in accordance with Section 5-04.3(5)B.

"Prime Coat Agg.", per cubic yard, or per ton.

The unit Contract price per cubic yard or per ton for "Prime Coat Agg." shall be full pay for furnishing, loading, and hauling aggregate to the place of deposit and spreading the aggregate in the quantities required by the Engineer.

"Asphalt for Fog Seal", per ton.

Payment for "Asphalt for Fog Seal" is described in Section 5-02.5.

"Longitudinal Joint Seal", per linear foot.

The unit Contract price per linear foot for "Longitudinal Joint Seal" shall be full payment for all costs incurred to perform the Work described in Section 5-04.3(12).

"Planing Bituminous Pavement", per square yard.

The unit Contract price per square yard for "Planing Bituminous Pavement" shall be full payment for all costs incurred to perform the Work described in Section 5-04.3(14).

"Temporary Pavement Marking", per linear foot.

Payment for "Temporary Pavement Marking" is described in Section 8-23.5.

"Removing Temporary Pavement Marking", per linear foot.

Payment for "Removing Temporary Pavement Marking" is described in Section 8-23.5.

"Water", per M gallon.

Payment for "Water" is described in Section 2-07.5.

"Anti-Stripping Additive", by calculation.

"Anti-Stripping Additive" will be paid for in accordance with Section 1-09.6 except that no overhead, profit or other costs shall be allowed. Payment shall be made only for the invoice cost of the additive. The quantity of asphalt binder shall not be reduced by the quantity of anti-stripping additive used. For the purpose of providing a common Proposal for all Bidders, the Contracting Agency has entered an amount in the Proposal to become a part of the total Bid by the Contractor.

"Job Mix Compliance Price Adjustment," by calculation.

"Job Mix Compliance Price Adjustment" will be calculated and paid for as described in Section 5-04.5(1).

"Compaction Price Adjustment," by calculation.

"Compaction Price Adjustment" will be calculated and paid for as described in Section 5-04.5(1).

"Cyclic Density Price Adjustment," by calculation.

"Cyclic Density Price Adjustment" will be calculated and paid for as described in Section 5-04.3(10)B item 1A.

"Longitudinal Joint Density Price Adjustment" by calculation.

"Longitudinal Joint Density Price Adjustment" will be calculated and paid for as described in Section 5-04.3(10)B.

5-04.5(1) Quality Assurance Price Adjustments

All HMA will be subject to price adjustments. Price adjustments for HMA mixture will be based on the requirements of 5-04.3(8). Price adjustments for HMA compaction will be based on the requirements in 5-04.3(10). For the purpose of providing a common Proposal for all Bidders, the Contracting Agency has estimated a calculated amount for all price adjustment items and has entered these amounts in the Proposal to become a part of the total Bid by the Contractor. Statistical analysis of the HMA will be performed in accordance with Section 1-06.2.

5-04.5(1)A Price Adjustments for Quality of HMA Mixture

Statistical analysis of quality of gradation and asphalt content will use the following price adjustment factors:

Table of Price Adjustment Factors	
Constituent	**Factor "f"**
All aggregate passing: 1½", 1", ¾", ½", ⅜" and No.4 sieves	2
All aggregate passing No. 8 sieve	15
All aggregate passing No. 200 sieve	20
Asphalt binder	40
Air Voids (Va)	20

A pay factor will be calculated for each sieve listed that is equal to or smaller than the maximum allowable aggregate size (100-percent passing sieve) asphalt binder and percent air voids (Va).

1. **Statistical Evaluation.** For each lot of HMA produced under Statistical Evaluation, a Job Mix Compliance Incentive Factor (JMCIF) will be determined. The JMCIF equals the algebraic difference of CPF minus 1.00 multiplied by 60-percent. The Job Mix Compliance Price Adjustment will be calculated as the product of the JMCIF, the quantity of HMA in the lot in tons, and the unit Contract price per ton of mix.
2. **Nonstatistical Evaluation.** Each lot of HMA produced under Nonstatistical Evaluation and having all constituents falling within the tolerance limits of the job mix formula shall be accepted at the unit Contract price with no further evaluation. When one or more constituents fall outside the nonstatistical tolerance limits in Section 9-03.8(7), the lot shall be evaluated in accordance with Section 1-06.2 to determine the appropriate CPF. The nonstatistical tolerance limits will be used in the calculation of the CPF and the maximum CPF shall be 1.00. When less than three sublots exist, backup samples of the existing sublots or samples from the Roadway shall be tested to provide a minimum of three sets of results for evaluation.

3. **Commercial Evaluation.** If sampled and tested, HMA produced under Commercial Evaluation and having all constituents falling within the tolerance limits of the job mix formula shall be accepted at the unit Contract price with no further evaluation. When one or more constituents fall outside the commercial tolerance limits in Section 9-03.8(7), the lot shall be evaluated in accordance with Section 1-06.2 to determine the appropriate CPF. The commercial tolerance limits will be used in the calculation of the CPF and the maximum CPF shall be 1.00. When less than three sublots exist, backup samples of the existing sublots or samples from the street shall be tested to provide a minimum of three sets of results for evaluation.

For each lot of HMA produced under Nonstatistical or Commercial Evaluation when the calculated CPF is less than 1.00, a Nonconforming Mix Factor (NCMF) will be determined. The NCMF equals the algebraic difference of CPF minus 1.00 multiplied by 60-percent. The Job Mix Compliance Price Adjustment will be calculated as the product of the NCMF, the quantity of HMA in the lot in tons, and the unit Contract price per ton of mix.

If a constituent is not measured in accordance with these Specifications, its individual pay factor will be considered 1.00 in calculating the Composite Pay Factor (CPF).

5-04.5(1)B Price Adjustments for Quality of HMA Compaction

For each compaction control lot with one or two sublots, having all sublots attain a relative density that is 91.0-percent of the reference maximum density the HMA shall be accepted at the unit Contract price with no further evaluation. When a sublot does not attain a relative density that is 91.0-percent of the reference maximum density, the lot shall be evaluated in accordance with Section 1-06.2 to determine the appropriate CPF. Additional testing by either a nuclear moisture-density gauge or cores will be completed as required to provide a minimum of three tests for evaluation.

For each compaction control lot with three or more sublots, a Compaction Incentive Price Adjustment Factor (CIPAF) will be determined. The CIPAF equals the algebraic difference of the CPF minus 1.00 multiplied by 40-percent. The Compaction Price Adjustment will be calculated as the product of CIPAF, the quantity of HMA in the compaction control lot in tons, and the unit Contract price per ton of mix.

9-02 BITUMINOUS MATERIALS

9-02.1 Asphalt Material, General

Asphalt furnished under these Specifications shall not have been distilled at a temperature high enough to injure by burning or to produce flecks of carbonaceous matter, and upon arrival at the Work, shall show no signs of separation into lighter and heavier components.

The Asphalt Supplier of Performance Graded Asphalt Binder (PGAB) and Cationic Emulsified Asphalt shall have a Quality Control Plan (QCP) in accordance with WSDOT QC 2 "Standard Practice for Asphalt Suppliers That Certify Performance Graded and Emulsified Asphalts." The Asphalt Supplier's QCP shall be submitted and approved by the WSDOT State Materials Laboratory. Any change to the QCP will require a new QCP to be submitted. The Asphalt Supplier of PGAB and Cationic Emulsified Asphalt shall certify through the Bill of Lading that the PGAB or Cationic Emulsified Asphalt meets the Specification requirements of the Contract.

9-02.1(1) Vacant

9-02.1(2) Vacant

9-02.1(3) Vacant

9-02.1(4) Performance Graded Asphalt Binder (PGAB)

PGAB meeting the requirements of AASHTO M 320 Table 1 of the grades specified in the Contract shall be used in the production of HMA. The Direct Tension Test (AASHTO T 314) of M 320 is not a Specification requirement.

9-02.1(4)A Vacant

9-02.1(5) Vacant

9-02.1(6) Cationic Emulsified Asphalt

See table 9-02.1(6).

Table 9-02.1(6) - Cationic Emulsified Asphalt

Grade	Type AASHTO Test Method	Rapid Setting				Medium Setting						Slow Setting				Special Tack	
		CRS-1		CRS-2		CMS-2S		CMS-2		CMS-2h		CSS-1		CSS-1h		STE-1	
		Min.	Max	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Tests on Emulsions																	
Viscosity Saybolt Furol S @ 77°F (25 °C)	T 59	—	—	—	—	—	—	—	—	—	—	20	100	20	100	—	30
Viscosity Saybolt																	
Furol S @ 122°F (50 °C)	T 59	20	100	150	400	50	450	50	450	50	450	—	—	—	—	—	—
Storage stability test 1 day %	T 59	—	1	—	1	—	1	—	1	—	1	—	1	—	1	—	1
Demulsibility 35 ml																	
0.8% sodium dioctyl																	
sulfosuccinate, %[a]	T 59	40	—	40	—	—	—	—	—	—	—	—	—	—	—	25	—
Coating ability & water resistance:																	
Coating, dry aggregate	T 59	—	—	—	—	Good	—	Good	—	Good	—	—	—	—	—	—	—
Coating, after spraying	T 59	—	—	—	—	Fair	—	Fair	—	Fair	—	—	—	—	—	—	—
Coating, wet aggregate	T 59	—	—	—	—	Fair	—	Fair	—	Fair	—	—	—	—	—	—	—
Coating, after spraying	T 59	—	—	—	—	Fair	—	Fair	—	Fair	—	—	—	—	—	—	—

Table 9-02.1(6) - Cationic Emulsified Asphalt (Continued)

Grade	Type AASHTO Test Method	Rapid Setting				Medium Setting						Slow Setting				Special Tack	
		CRS-1		CRS-2		CMS-2S		CMS-2		CMS-2h		CSS-1		CSS-1h		STE-1	
		Min.	Max	Min.	Max	Min.	Max	Min.	Max	Min.	Max	Min.	Max	Min.	Max	Min.	Max
Particle charge test	T 59	Pos		Pos		Pos		Pos		Pos		Pos[b]		Pos[b]		Pos	
Sieve Test, %	T 59	—	0.10	—	0.10	—	0.10	—	0.10	—	0.10	—	0.10	—	0.10	—	0.10
Cement mixing test, %	T 59	—	—	—	—	—	—	—	—	—	—	—	2.0	—	2.0	—	—
Distillation:																	
Oil distillate by vol. of emulsions %	T 59	—	3	1.5	3	—	20	—	12	—	12	—	—	—	—	—	5
Residue, %	T 59	60	—	65	—	60	—	65	—	65	—	57	—	57	—	45	—
Tests on residue from distillation tests:																	
Penetration, 77°F (25° C)	T 49	100	250	100	250	100	250	100	250	40	90	100	250	40	90	100	200
Ductility, 77°F (25° C) 5 cm/min., cm	T 51	40	—	40	—	40	—	40	—	40	—	40	—	40	—	40	—
Solubility in trichloroethylene, %	T 44	97.5	—	97.5	—	97.5	—	97.5	—	97.5	—	97.5	—	97.5	—	97.5	—

a The demulsibility test shall be made within 30 days from date of shipment.
b If the particle charge test for CSS-1 and CSS-1h is inconclusive, material having a maximum pH value of 6.7 will be acceptable.

9-02.1(6)A Polymerized Cationic Emulsified Asphalt CRS-2P

The asphalt CRS-2P shall be a polymerized cationic emulsified asphalt. The polymer shall be milled into the asphalt or emulsion during the manufacturing of the emulsion. The asphalt CRS-2P shall meet the following Specifications:

	AASHTO Test Method	Specifications	
		Minimum	Maximum
Viscosity @122°F, SFS	T 59	100	400
Storage Stability 1 day %	T 59	—	1
Demulsibility 35 ml. 0.8% Dioctyl Sodium Sulfosuccinate	T 59	40	—
Particle Charge	T 59	positive	—
Sieve Test %	T 59	—	0.30
Distillation			
Oil distillate by vol. of emulsion %	T 59 note 1	0	3
Residue	T 59 note 1	65	—
Test on the Residue From Distillation			
Penetration @77°F	T 49	100	250
Torsional Recovery %	note 2	18	—
or			
Toughness/Tenacity in-lbs	note 3	50/25	—

note 1 Distillation modified to use 200 grams of emulsion heated to 350°F ± 9°F and maintained for 20 minutes.
note 2 The Torsional Recovery test shall be conducted according to the California Department of Transportation Test Method No. 332. The residue material for this test shall come from California Department of Transportation Test Method No. 331.
note 3 Benson method of toughness and tenacity; Scott tester, inch pounds at 77°F, 20 in. per minute pull. Tension head 7/8 in. diameter.

At the option of the supplier the Benson Toughness/Tenacity test can be used in lieu of Torsional Recovery based on type of modifier used. If the Benson Toughness/Tenacity method is used for acceptance the supplier must supply all test data verifying Specification conformance.

9-02.1(7) Vacant

9-02.1(8) Flexible Bituminous Pavement Marker Adhesive

Flexible bituminous pavement marker adhesive is a hot melt thermoplastic bituminous material used for bonding raised pavement markers and recessed pavement markers to the pavement.

The adhesive material shall conform to the following requirements:

Property	Test Method	Requirement
Penetration, 77°F, 100g, 5 sec. dmm	AASHTO T 49	30 Max.
Softening Point, F	AASHTO T 53	200 Min
Rotational Thermosel Viscosity, cP, #27 spindle, 20 RPM, 400°F	AASHTO T 316	5000 Max.
Ductility, 77°F, 5 cm/minute, cm	AASHTO T 51	15 Min.
Ductility, 39.2°F, 1 cm/minute, cm	ASTM D 51	5 Min.
Flexibility, 1", 20°F, 90 deg. Bend, 10 sec., ⅛"× 1" × 6" specimen	ASTM D 3111 NOTE 1	Pass

Flexible bituminous adhesive shall develop bond pull-off strength greater than 50 psi when tested in accordance with WSDOT T-426.

Note 1: Flexibility test is modified by bending specimen through an arc of 90 degrees at a uniform rate in 10 seconds over a 1-inch diameter mandrel.

9-02.1(9) Coal Tar Pitch Emulsion, Cationic Asphalt Emulsion Blend Sealer

Bituminous asphalt seal coat material shall be a blend of 20 percent Coal Tar Pitch Emulsion, and 80 percent Cationic Asphalt Emulsion, together with specified additives, minerals and sand aggregate.

The Coal Tar Pitch Emulsion component shall conform to all requirements of Federal Specification RP-355E. The emulsion shall be prepared from straight run, high temperature, coke oven tar meeting the requirements of Federal Specification RC 1424.

The Cationic Emulsified Asphalt component shall be CSS-1h grade emulsion, meeting the requirements of Section 9-02.1(6), Cationic Emulsified Asphalt.

The blended emulsion shall be homogeneous and shall show no separation or coagulation of components that cannot be overcome by moderate stirring. It shall be capable of being applied completely by squeegee, brush, or other approved mechanical methods to the surface of bituminous pavements when spread at the specified rates.

9-02.2 Sampling and Acceptance

9-02.2(1) Certification of Shipment

Bituminous materials may be accepted by the Engineer based on the asphalt binder supplier's Certification of Compliance incorporated in their Bill of Lading. The Certification will include a statement certifying Specification compliance for the product shipped. Failure to provide this Certification with the shipment shall be cause for rejection of the material. The following information is required on the Bill of Lading:

1. Date
2. Contract Number and/or Project Name
3. Grade of Commodity and Certification of Compliance
4. Anti-strip Type
5. Percent Anti-strip
6. Mass (Net Tons)
7. Volume (Gross Gallons)
8. Temperature of Load (F)
9. Bill of Lading Number
10. Consignee and Delivery Point
11. Signature of Supplier's Representative
12. Supplier (Bill of Lading Generator)
13. Supplier's Address
14. Refiner
15. Refiner's Location

The Bill of Lading shall be supplied at the time of shipment of each truck load, truck and trailer, or other lot of asphalt binder. In addition to the copies the Contractor requires, one copy of the Bill of Lading including the Certification Statement shall be sent with the shipment for agency use.

9-02.2(2) Samples

When requested by the Engineer, the asphalt supplier shall ship, by prepaid express or U.S. mail, samples of asphalt that represent current production.

9-02.3 Temperature of Asphalt

The temperature of paving asphalts in storage tanks when loaded for transporting shall not exceed the maximum temperature recommended by the asphalt binder manufacturer.

9-02.4 Anti-Stripping Additive

When directed by the Engineer, heat-stable anti-stripping additive shall be added to the asphalt mix. At the option of the Contractor, the anti-stripping additive can be either added to the liquid asphalt or sprayed on the aggregate on the cold feed. Once the process and type of anti-stripping additive proposed by the Contractor have been approved by the State Materials Laboratory, the process, brand, grade, and amount of anti-stripping additive shall not be changed without approval of the Engineer.

When liquid anti-stripping additive is added to the liquid asphalt, the amount will be designated by the Engineer, but shall not exceed 1 percent by weight of the liquid asphalt.

When polymer additives are sprayed on the aggregate, the amount will be designated by the Engineer, but shall not exceed 0.67 percent by weight of the aggregate.

The use of another process or procedure for adding anti-stripping additive to the asphalt mix will be considered based on a proposal from the Contractor.

9-02.5 Warm Mix Asphalt (WMA) Additive

Additives for WMA shall be approved by the Engineer.

WARM MIX ASPHALT SUBMITTAL

In accordance with WSDOT Standard Specifications Section 5-04.2 this submittal must be approved by the Engineer prior to production of WMA.

Contract Information

- Contract number
- HMA tons per bid item
  - WMA tons per bid item
  - HMA mix design ID number(s) to be used for production of WMA

Warm Mix Asphalt

- WMA technology description; organic additive, chemical additive and equipment used
  - Manufacturer’s technical information
    - Recommendations for production of WMA
    - Material safety data sheets (MSDS) for additive if used
  - Contractor’s target rate for water or additive
- Mixing temperature @ discharge
  - Manufacturer of the WMA technology
    - Recommended mixing temperature
    - Maximum mixing temperature
  - Mix design
    - Optimum mixing temperature
      - The optimum mixing temperature is provided on the mix design report
    - Maximum mixing temperature
      - The maximum temperature is the optimum mixing temperature +25°F (+14°C) per Section 5-04.3(8)
  - Contractor’s mixing temperatures
    - Target mixing temperature
    - Maximum mixing temperature
      - The Contractor’s maximum mixing temperature cannot exceed the manufacturer’s maximum mixing temperature or the mix design maximum mixing temperature
- Target temperature for WMA @ paver laydown

Asphalt plant

- Location, type & model
- Equipment and/or modifications for WMA production

- RAP percentage (20% max.)
- Production rate

Truck Ticket

- The truck ticket shall identify the material produced as HMA or WMA

APPENDIX D - SELECTED SPECIFICATIONS AND LIST OF APPROVED WMA TECHNOLOGIES OF OTHER STATES

D1. California

CALTRANS APPROVAL PROCESS FOR WARM-MIX ASPHALT TECHNOLOGIES

1. INTRODUCTION

Warm Mix Asphalt (WMA) encompasses a range of technologies that allows a reduction in traditional hot mix asphalt production, placement and compaction temperatures. The California Department of Transportation (Caltrans) is interested in the evaluation of WMA technologies for extending the paving season, potential increased pavement service life, environmental benefits, and worker safety. Consequently, Caltrans has been evaluating warm mix technologies under a variety of applications, including field test sections throughout the state, accelerated pavement testing, and associated laboratory testing. Federal and other state funded research has been, and continues to be followed closely.

A wide range of different warm-mix technologies is available. However, due to their relatively recent introduction, only limited longer-term performance data, especially on high traffic volume highways, has been collected. Consequently, Caltrans has instituted an approval process for all WMA technologies in the state to ensure that the way in which each works, and the potential benefits and risks of using them are fully understood, and that any performance related problems are correctly analyzed and explained. Information gained from assessing these approvals together with results from ongoing research will guide implementation of warm-mix asphalt in California in terms of where best to use it, and in making changes where required to specifications, mix design procedures, test methods, quality control procedures, material plant quality programs, and the use of recycled asphalt pavement.

2. APPROVAL PROCESS

The Caltrans WMA approval process requires that the WMA technology provider and/or approval requester submit a request for approval and brief report summarizing the results of laboratory and field testing undertaken on the technology to date and providing evidence that equal or better performance is achieved when compared to conventional hot-mix asphalt controls. The testing can be undertaken in any state. Caltrans will review this submittal and determine whether, based on the testing performed, the WMA technology should be approved or provisionally approved for use on Caltrans projects.

2.1 Summary Report Prepared by WMA Technology Provider

The summary report must be prepared by the WMA technology provider or a consultant appointed by the technology provider and should summarize the laboratory and field testing undertaken on the technology. The results must clearly indicate that the WMA performs equal or better to the level of the HMA (control) performance. Any laboratory testing cited should have been undertaken by an AASHTO accredited laboratory not directly affiliated with the WMA technology provider. The report should include the following:

- Chapter 1: Contact Details
  - WMA technology name.
  - WMA technology provider (company name, representative name, and contact information).
  - The name of the organization and lead investigator(s) undertaking laboratory and field testing (including AMRL certification number).
- Chapter 2: Technology Details
  - A brief overview of how the technology works
  - Details on required plant modifications to accommodate the technology
  - Details on how Caltrans Material Plant Quality Program (MPQP) requirements will be met
  - A copy of the Material Safety Data Sheet (MSDS)

- Chapter 3: Laboratory Test Results
  - Mix design (can be Hveem or SuperPave)
  - A summary of laboratory testing results, including tabulated mix properties, mix production details, and tabulated laboratory test results comparing the HMA and WMA supported by plots where appropriate. The results must provide evidence that the WMA mix performs equal to or better than the HMA control mix. Tests can be undertaken on specimens removed from a road or prepared in a laboratory. Testing should include the following:
    - Rutting performance
      (AASHTO T-320 [Repeated Simple Shear Test], AASHTO TP 63-03 [Asphalt Pavement Analyzer] or AASHTO TP 79 [Dynamic Modulus/Flow Number])
    - Cracking performance
      (AASHTO T-321 [Fatigue Beam] or Texas Overlay Tester)
    - Moisture sensitivity performance
      (AASHTO T-324 [Hamburg Wheel Track] and AASHTO T283 [Tensile Strength Retained] (or CT371 if tested in California))
    - Open-graded friction course durability
      (ASTM D-7064 [Part x2][Cantabro])
    - Binder testing (to determine effect on PG grading. AASHTO M-320)
- Chapter 4: Field Test Results
  A minimum of three experiments is required, one of which may include an accelerated loading test. Each test must include an HMA control. On field tests, the HMA control and WMA sections must be placed end-to-end in the same lane (not in adjacent lanes). Sections should have an AADT of at least 10,000 with at least 10% trucks. Each section should have been monitored after construction (as a baseline) and again after 12 months or longer (i.e., at least one year of traffic).
  Each project summary should include:
  - Experiment locations, experiment details (including traffic), and the monitoring program.
  - Mix design information (can be Hveem or SuperPave)
  - Mix production and construction data (include production and placement temperatures, summary of QC measurements, and any other documented observations).
  - Tabulated summary of observations from each visit. The reasons for any differences between the HMA and WMA sections should be explained.
  - Photographs at each monitoring visit showing all distresses. Photographs must show equal or better performance to HMA control.
- Chapter 5: Reference list of reports cited in the text and other reports prepared on the WMA technology.
- Chapter 6: List of State DOT contacts and associated documentation (e.g. project special provisions) applicable to the construction of the test sections.

2.2 Approval

Caltrans will review the report and if satisfied with the information provided, the technology will be placed on the Caltrans "*Approved List of Warm-Mix Asphalt Technologies*". If insufficient field testing has been undertaken, the technology may be placed on the Caltrans "*Provisional Approved List of Warm-Mix Asphalt Technologies*", which allows experimental use on projects with a Traffic Index less than 11, until a revised summary report with the required field testing has been submitted and approved.

A copy of the approval checklist is attached.

Caltrans Warm Mix Asphalt Technology Approval

Company		Technology				
Contact		Date Reviewed				
Documents Submitted	Summary Report	Yes	No			
	Supporting Reports	Yes	No			
	Other	Yes	No			
MPQP adherence information		Yes	No	MSDS		
Name of organization doing testing						
Experiment designs		Yes	No			
Mix designs		Yes	No	Method		
Specimen preparation		Yes	No	LMLC	FMLC	FMFC
Rutting performance		Yes	No	Method		
Fatigue performance		Yes	No	Method		
Hamburg Wheel Track		Yes	No	Method		
Tensile Strength Retained		Yes	No	Method		
OGFC durability		Yes	No	Method		
Other		Yes	No	Method		
Other		Yes	No	Method		
Performance better or equal to HMA		Yes	No			
Number of states with tests			Number of tests in report			
Field test in California		Yes	No	Test with TI>11	Yes	No
Satisfactory evaluation		Yes	No			
Performance better or equal to HMA		Yes	No			
DoT contact names		Yes	No	Reference list	Yes	No
Recommendation		Approved		Provisional	[illegible]	
Reasons/comments						
Review Panel Chairperson						

Caltrans Approval Process for Warm Mix Asphalt Technologies
03/23/2011

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WARM MIX ASPHALT

LIST OF APPROVED TECHNOLOGIES FOR USE IN CONTRACTORS OPTION SPECIFICATION (2012 CONSTRUCTION SEASON)

Product Name	Supplier
Advera	PQ Corporation
Rediset WMX	AkzoNobel Surface Chemistry LLC
Evotherm DAT	MeadWestVaco
Sasobit	Sasol Wax North America

If you have any questions about the information, please call Kee Foo at 916-227-5436.

Date updated: May 16, 2011

D2. NorthCarolina

North Carolina Department of Transportation
Approved Products Listing

APPROVED WARM MIX ASPHALT (WMA) TECHNOLOGIES

Prior to any approval, the WMA technology manufacturer must submit documentation from a minimum of three (3) successfully constructed projects using the WMA technology that includes the following:

- Product Name & Supplier;
- Contact Name & Telephone Number;
- WMA Technology Material Safety Data Sheet (MSDS);
- Documentation from each successfully constructed project, including: project type, project owner, location, tonnage placed, mix design used, field density and performance data.

After the initial review process, the WMA technology can be given the following approval statuses based on the construction and performance of NCDOT-approved job mix formulas (JMFs) using the technology:

WMA Manufacturer	WMA Technology	Current Approval Status
Astec Industries	Double Barrel Green	Limited
Gencor Industries	Ultrafoam GX	Limited
Maxam Equipment	AQUABlack WMA	Trial
MeadWestvaco	Evotherm 3G	Trial
Meeker Equipment	Aqua Foam WMA	Trial
PQ Corporation	Advera	Trial
Sasol Wax	Sasobit	Trial
Terex Roadbuilding	Terex WMA	Trial

1) Trial Approval – one or more NCDOT-let projects have been successfully constructed using the WMA technology and monitored through a minimum of one Winter season.

- WMA technologies with **Trial** status may be used on NC and Secondary Routes.

2) Limited Approval – a minimum of 75,000 tons of mix using the WMA technology have been successfully constructed on NCDOT-let projects.

- WMA technologies with **Limited** status may be used on US, NC, and Secondary Routes.

Contact **Todd Whittington** of the Materials & Tests Unit at (919) 329-4060 for any information and current approval status.

D3. Pennsylvania

Standard Special Provision

Index or Category: Item Related
Status: Active
Sequence ID: 4111
District: CO
Version: B
Provision Name: c04111 ITEM 9411-____ (ITEM 9411-____) WARM MIX ASPHALT (WMA), PLANT-MIXED BITUMINOUS CONCRETE

Measurement: Dual
Edit Body: No
Edit Header: Yes
Edit Project Specific Details: No
Include on all projects: No
Include on all federally funded projects: No
Include on all 100% State funded projects: No

Instructions for Usage: Bid Warm-Mix Asphalt (WMA) bituminous concrete pavement courses in lieu of bidding Superpave Asphalt Mixture Design, HMA paving courses according to Strike-off Letter 421-11-##, dated May ##, 2011. Consider the additional material and/or plant processing modification requirements and associated costs, before bidding. Refer to the following website for more information on WMA: http://www.warmmixasphalt.com

Effective From: 05/01/2011
To: 01/01/2199

ITEM 9411-___ WARM MIX ASPHALT (WMA), PLANT-MIXED BITUMINOUS CONCRETE, _______ COURSE, PG__-__, _______ MILLION ESALS, ______ mm MIX, ___" DEPTH, SRL-__

I. DESCRIPTION - This work is the Standard and RPS construction of plant-mixed, dense-graded Warm Mix Asphalt (WMA) pavement course on a prepared surface using a volumetric asphalt mixture design developed with the Superpave Gyratory Compactor (SGC) using prescribed manufactured additives, modifiers and/or plant process modifications according to these specifications and the standard drawings. Use of reclaimed asphalt pavement (RAP) materials is permitted using current requirements and policy as specified for Hot-Mix Asphalt (HMA) pavement courses in Section 409 and Bulletin 27.

II. MATERIAL - Section 409.2 with additions and modifications as follows:

(a) Bituminous Material. Section 409.2(a) with additional subsections as follows:

3. WMA Technology Additives or Modifiers Blended at the Bituminous Material Supplier Refinery or Terminal. Provide refinery or terminally blended bituminous material modified with a WMA Technology additive or modifier from an approved manufacturer and source listed in Bulletin 15. Include in the bituminous material producer QC plan, the WMA Technology additive or modifier manufacturer name and source, dosage rates, blending method, QC testing, corrective action points, disposition of failed material, storage, handling shipping, and bill of lading information following the applicable requirements in Section 702. Include the WMA Technology Additive or Modifier and dosage rate on the bill of lading. Provide certification that the refinery or terminally blended bituminous material modified with the WMA Technology additive or modifier meets the requirements of Section 409.2(a)1 or Section 409.2(a)2 for the specified grade.

4. WMA Technology Additives or Modifiers Blended at the Bituminous Mixture Producer Plant. For WMA Technology additives or modifiers blended with the bituminous material at the bituminous mixture production plant, prepare a Producer QC Plan as specified in Section 106 and conforming to the additional Producer QC Plan requirements in Section 409.2(e)1.a and the additional Producer QC Plan requirements within this specification. Provide certification that the bituminous material blended with the WMA Technology additive or modifier at the bituminous mixture production plant meets the requirements of Section 409.2(a)1 or Section 409.2(a)2 for the specified grade.

(e) Composition of Mixtures. Section 409.2(e) with additions and modifications as follows:

1. Virgin Material Mixtures. Replace the first paragraph in Section 409.2(e)1 with the following:

Size, uniformly grade, and combine aggregate fractions, bituminous material, and either WMA technology additive(s), modifier(s) or no special additive(s) or modifier(s), if mixture temperature, workability, and compactability is achieved solely through plant mechanical modification to produce foamed asphalt, in proportions to produce a JMF that conforms to the material, gradation, and volumetric Superpave Asphalt Mixture Design requirements as specified in Bulletin 27, Chapter 2A, for the specified nominal maximum aggregate size and design ESALs except as procedurally modified by the WMA Technology Technical Representative or manufacturer to address laboratory procedures when preparing, compacting and testing WMA mixtures and to achieve a uniform blend. Develop a hot mix asphalt (HMA) JMF according to Section 409.2 and incorporate the WMA technology additive, modifier, or process into that JMF during production. Do not develop a volumetric WMA JMF based on incorporating the WMA technology additive, modifier or process during the volumetric asphalt mixture design process. For all WMA mixture JMFs, perform moisture sensitivity analysis on laboratory mixed and laboratory compacted specimens that include the WMA Technology additive, modifier, or process as required in Bulletin 27, Chapter 2A for HMA using the same mixing, compaction and conditioning criteria used during the development of the volumetric asphalt mixture design for the HMA JMF and ensure the WMA Technology additive modifier, or process is not detrimental to the moisture resistance of the mixture.

1.a.2. Testing Plan with Action Points. Section 409.2(e)1.a.2 and add the following additional bullets:

- Blended bituminous material lot size/quantity and lot designation method.
- List of all tests to be performed on the blended bituminous material.
- Testing and certification of the blended bituminous material and WMA Technology additive or modifier for conformance to Section 409.4(a)1 or Section 409.2(a)2.
- Frequency of testing of the blended bituminous material.
- List action points to initiate corrective procedures for the blended bituminous material.
- Recording method to document corrective procedures for the blended bituminous material.
- Handling and disposition of blended bituminous material failing to meet the bituminous material specification requirements.

1.a.3. Materials Storage and Handling. Section 409.2(e)1.a.3 and add the following additional bullets:

- WMA Technology additive or modifier manufacturer name and source as listed in Bulletin 15.
- WMA Technology additive or modifier storage and handling prior to blending.
- All measuring, conveying and blending devices for the WMA Technology and anti-strip additive (if required), including calibration procedures.
- WMA Technology additive or modifier and anti-strip additive (if required) method of introduction, dosage rates, blending with the bituminous material and method of automation, recordation and print outs.
- Storage and handling of the blended bituminous material with the WMA Technology additive or modifier.
- WMA Production and Laboratory Mixture Temperature Range and Target
- WMA Laboratory Compaction Temperature Range and Target

1.c. Annual JMF Verification. Section 409.2(e)1.c and add the following to the end of the subsection.

Perform the annual JMF Verification for the WMA mixture JMF even if the equivalent HMA mixture JMF was previously annually verified.

1.d. Production. Section 409.2(e)1.d and add the following:

Prepare and test WMA mixtures, including SGC specimens for quality control using the same test methods, procedures and frequencies as specified for HMA, except as modified by the WMA Technology Technical Representative and the Producer QC Plan. Maintain records of the testing of WMA and make available for review by the Representative when directed.

1.d.6 Degree of Particle Coating. Add new subsection to Section 409.2(e)1.d as follows:

For all WMA mixtures, sample the mixture according to PTM No. 1 and at the frequency in the producer QC Plan. Determine the degree of particle coating of the completed WMA mixture according to AASHTO T 195. Produce a WMA mixture with percent coated particles ≥ 95.0%, except ≥ 85.0% for WMA mixtures containing slag aggregate. Increase the plant mixing time or make other plant adjustments if the required percent of coated particles is not met. Produce a WMA mixture capable of being handled, placed and compacted without stripping the bituminous material from the aggregate.

Table A
Job-Mix Formula
Composition Tolerance Requirements of the Completed Mix
Section 409, Table A, Except Revise the Temperature of Mixture (°F) as follows:

Class of Material	Type of Material	Minimum*	Maximum*
PG 58-28	Asphalt Cement	215	285
PG 64-22	Asphalt Cement	220	295
PG 76-22	Asphalt Cement	240	305
All other PG Binders	Asphalt Cement	215	(Max Temperature as specified in Bulletin 25 minus

			25°F)
* The minimum and maximum temperatures shown in Table A for each Class of Material are a master temperature range for a completed WMA mixture. The Producer must include a smaller completed mixture temperature range and compaction temperature range that does not exceed 50°F and that does not fall outside the master temperature range in the Producer QC Plan. The Producer is required to produce the completed mixture within the smaller temperature range in the Producer QC Plan. The Producer is required to compact the completed mixture in the SGC for QC volumetric analysis at the midpoint of the compaction temperature range in the Producer QC Plan. The Producer QC Plan mixture temperature range and compaction temperature range are to follow the guidelines provided by the WMA Technology Technical Representative or Manufacturer.			

(g) WMA Technologies (Additive(s), Modifier(s), or Processes) and WMA Manufacturers. Add new subsection to Section 409.2 as follows:

Produce the WMA mixture using approved or provisionally approved WMA technologies including additives, modifiers or processes from manufacturers listed in Bulletin 15. If blending WMA additives or modifiers with bituminous material, provide bituminous material modified with the WMA additive or modifier according to Section II (a)3 or Section II (a)4 within this specification. For WMA technology additives or modifiers blended with the bituminous mixture at the bituminous mixture production plant, prepare a QC Plan as specified in Section 106 and also conforming to the additional Producer QC Plan requirements within this specification. Submit the QC plan to the District Materials Engineer/District Materials Manager (DME/DMM) annually at least 3 weeks before the planned start of blending WMA Technologies with bituminous material and do not start blending until the DME/DMM reviews the QC plan.

For more information on the approved WMA technologies listed in Bulletin 15, refer to the Internet website http://www.warmmixasphalt.com/WmaTechnologies.aspx.

(h) Anti-Strip Additives. Add new subsection to Section 409.2 as follows:

Add a compatible liquid anti-strip additive at a minimum dosage rate of 0.25% by mass (weight) of the total bituminous material or, higher as needed, to WMA mixtures using WMA Technology that is categorized as a mechanical foaming process.

(i) WMA Technology Technical Representative. Add new subsection to Section 409.2 as follows:

If directed by the Department at the preconstruction conference, ensure that a Technical Representative, from the manufacturer of the approved WMA Technology used to produce the WMA mixture, is present during initial production and placement of the specified WMA pavement course. If the Department directs that a Technical Representative is not required to be present during initial production, provide the name and telephone number of a Technical Representative who can be on-call and in direct verbal contact with the Producer, Contractor and a Department Representative within a maximum 2 hour period after initial contact. Ensure that the Technical Representative is knowledgeable in the storage, handling, blending, mixture production, mixture QC testing, placement and compaction using the WMA Technology. The Department will expect a WMA Technology Technical Representative to be present during initial production, placement and compaction when the Producer is using a WMA Technology for the very first time. Submit any proposed deviations to this requirement in writing to the Representative for approval either before or at the preconstruction conference. After initial production of the specified WMA pavement course in a sufficient quantity to place 1 mile without any technical issues affecting the production, placement and compaction of the WMA pavement course, as determined by the Department Representative upon review of the plant and field QC testing, the Department Representative will release the Technical Representative from being present. Upon release of the Technical Representative from being present, provide the name and telephone number of a Technical Representative who can be on-call and in direct verbal contact with the Producer, Contractor and a Department Representative within a maximum 2 hour period after initial contact.

III. CONSTRUCTION - Section 409.3 with additions and modifications as follows.

(a) Paving Operation QC Plan: Section 409.3(a) and add the following:

Prepare and submit additional information specifically related to all aspects of the field control of WMA concrete paving operations to the Representative as part of the paving operation QC Plan that addresses all recommendations and direction from the WMA Technology Technical Representative. Describe the construction equipment and methods necessary to control the WMA paving operations including the testing, delivery, placement, compaction, and protection of the WMA concrete courses for all placement applications including handwork as specified in Section 409.3.

(c) Bituminous Mixing Plant. Section 409.3(c) and add the following:

Make any plant modifications needed to introduce the WMA Technology additives, modifiers, or processes according to specific recommendations and direction from the WMA Technology Technical Representative or process manufacturer to achieve a uniform blend of the WMA Technology additive, modifier or foaming process and produce a WMA mixture meeting these specifications.

1. Batch Plant. Section 409.3(c)1 and add the following:

Dry the aggregate(s) according to the specific recommendations and direction from the WMA Technology Technical Representative and heat to a suitable temperature so that the resulting completed mixture temperature is within the mixture temperature range established in the Producer QC Plan and recommended or directed by the WMA Technology Technical Representative or manufacturer and that is within the master minimum and maximum temperature range in Table A within this specification. Ensure that the aggregate is free of unburned fuel oil when delivered to the pug mill.

2. Drum mixer Plant. Section 409.3(c)2 and add the following:

Produce a completed mixture that is within the mixture temperature range established in the Producer QC Plan and recommended or directed by the WMA Technology Technical Representative or manufacturer and that is within the master minimum and maximum temperature range in Table A within this specification. Ensure that the aggregate and completed mixture is free of unburned fuel oil.

(h) Spreading and Finishing. Section 409.3(h) with additions as follows.

1.a Placing. Section 409.3(h)1.a and add the following to the end of the subsection.

At the beginning of each day's paving, up to 3 hauling equipment loads of WMA mixture are permitted to exceed the maximum temperature of mixture in Table A within this specification. This is to assist with warming the paver screed and other equipment in order to prevent dragging and sticking of WMA mixture to the equipment. For these loads, do not exceed the maximum temperature of mixture specified for HMA in Section 409, Table A.

IV. MEASUREMENT AND PAYMENT - Section 409.4 except replace HMA with WMA as follows:

(a) Standard WMA Construction

1. WMA Courses.

1.a Warm Mix Asphalt (WMA), Wearing Course. Square Yard or Ton
1.b Warm Mix Asphalt (WMA) Wearing Course (Scratch). Ton
1.c Warm Mix Asphalt (WMA) Wearing Course (Leveling). Ton
1.d Warm Mix Asphalt (WMA) Binder Course. Square Yard or Ton
1.e Warm Mix Asphalt (WMA) Binder Course (Leveling). Ton

(b) RPS WMA Construction. Section 409.4(b), except replace HMA with WMA. Square Yard or Ton

pennsylvania
DEPARTMENT OF TRANSPORTATION

DATE:

SUBJECT: Design and Use Guidelines for Warm Mix Asphalt (WMA) Pavement Courses and Revised Standard Special Provisions (SSPs) for WMA Base Courses and WMA Binder and Wearing Courses

TO: **ALL DISTRICT EXECUTIVES**

FROM: Rebecca S. Burns, P.E., Acting Director
Bureau of Construction and Materials

This Strike-Off Letter is time neutral. It supersedes Strike-Off Letter 423-10-01. It includes new versions of the Item Related Standard Special Provisions for WMA Base Courses (I-c031111b) and WMA Binder and Wearing Courses (I-c041111b).

Goal: The Department has established an internal goal of 20% of its total asphalt mixture paving to be performed utilizing approved WMA Technologies or piloting non-approved WMA technologies during the calendar year 2011. The 20% goal will be evaluated based on the total tonnage of asphalt mixture material placed (not bid) during the 2011 calendar year for both construction and maintenance projects. Each District is strongly encouraged to take appropriate measures to meet this 20% goal. It is important that every District and County become familiar with WMA mixtures and to get experience paving with WMA, since it is possible that Hot Mix Asphalt (HMA) may be replaced by WMA for environmental or performance reasons within the next 5 years.

WMA Project Selection: For projects to be constructed in CY 2011 and beyond, the Districts may specify WMA pavement courses in lieu of Superpave Asphalt Mixture Design, HMA pavement courses on any project where they would consider specifying HMA pavement courses. This includes Federal Oversight, PennDOT Oversight NHS, PennDOT Oversight Non-NHS, and Non-Federal projects. An experimental project Work Plan is not required by FHWA on Federal Oversight, PennDOT Oversight NHS, or PennDOT Oversight Non-NHS projects.

Pavement Design: For pavement design, WMA pavement courses are to use the same pavement design procedures outlined in Publication 242 for Superpave Asphalt Mixture Design, HMA pavement courses including selection of Mixture Nominal Maximum Aggregate Size (NMAS), grade of PG-Binder, 20 year design ESALs, Standard or RPS construction, pavements depths, and SRL.

<u>WMA Standard Special Provisions and Construction Item Numbers</u>: To facilitate specifying WMA pavement courses, there are two (2) Item Related SSP's available for use in ECMS which have both been recently revised to Version B. The new Version B WMA SSPs include revised temperature ranges, weather restrictions, mixture composition requirements, and changes to the requirements for a WMA Technology Technical Representative. The two revised Version B WMA SSPs are attached for your reference and are also available in ECMS.

Attachment A provides required WMA construction item numbers and descriptions that are to be used when incorporating WMA pavement course construction items into project contracts. Additionally, Roadway Management System (RMS), Pavement History codes for pavement layers have been established for WMA pavement courses and are attached for your reference. WMA must be coded correctly in RMS using the appropriate WMA codes.

When electing to specify WMA pavement course construction items, it is recommended that all the pavement course construction items are WMA to increase uniformity, consistency and constructability during paving operations and to lower bid unit prices. If the District elects to specify a HMA control section, it should be at least 1 full lane width and one-half mile in length and a minimum of 500 tons and use the same Job Mix Formula (JMF) that was used to produce the WMA mixture to facilitate a good comparison.

<u>WMA Mix Designs</u>: For mix designs, WMA mixtures will continue to use an existing approved HMA mix design to which an approved WMA technology has been included to produce the mixture. Although NCHRP Project 9-43 will be proposing a recommended Appendix to AASHTO R 35 to properly prepare and evaluate WMA mixtures for Superpave Volumetric Mix Designs, it is anticipated that these recommendations may be revised prior to their adoption by AASHTO. Therefore, these proposed recommendations will not be adopted by the Department at this current time. In the new Version B WMA SSPs, mixture production, delivery and compaction temperatures and temperatures for mixture quality control testing for the WMA Technology are established by the WMA Technology Technical Representative, but within the master temperature ranges established in the two new Version B WMA SSPs. The two new Version B WMA SSPs also require that mix designs containing WMA Technology modifiers, additives or processes be verified by moisture sensitivity analysis to ensure the WMA Technology is not detrimental to the moisture resistance of the WMA mixture. In addition, the new Version B WMA SSPs require the use of anti-strip additives when producing WMA mixtures with WMA Technologies categorized as water foaming processes using mechanical plant foaming devices.

<u>Substitution of WMA for HMA Construction Items and Work Order Process</u>: On current projects, or projects that have been advertised or recently let, where only Superpave Asphalt Mixture Design, HMA Courses are specified, the Districts are encouraged to work with any Contractor who proposes to substitute WMA pavement courses for the HMA pavement courses. Districts should only agree to such proposals if the contractor agrees to perform the work in accordance with the WMA SSPs and the substitution is cost neutral, (i.e., results in a zero net change to the project) or results in a cost reduction. Districts may agree to the substitution of a limited quantity of paving or a portion of the project, (i.e., substitution of WMA for HMA on 1 or 2 lane miles of a planned 5 lane mile HMA pavement project). The substitution program is being encouraged to enable the Districts, Contractors, and Producers to continue to gain experience with existing WMA Technologies and pavement courses. The substitution program also allows exposure to other approved WMA Technology modifiers, additives or processes that are entering or expanding into the Pennsylvania market or helps gain experience with WMA Technologies and pavement courses on higher volume roadways. Agreed upon pavement construction item substitutions should follow current work authorization and work order processing procedures. One or both of the WMA SSPs should be attached to the required Authorization for Contract Work, as appropriate, and acknowledged by the Contractor. The associated Work Order should be processed in the 'Additional / Extra Work' category and the 'Field Change(s) Directed by the Engineer' change type selected. In addition to establishing the necessary WMA construction item(s) as Extra Work, the work order should include a corresponding reduction in quantity for the original HMA contract construction item(s). Even though material substitutions are to be cost neutral or result in a cost reduction, cost justification in the form of an Engineering Analysis will be required for the WMA pavement course construction item or items being incorporated into the project. As a reminder, the use of an Engineering Analysis for cost justification purposes must be coordinated with the Bureau of Construction and Materials prior to work order approval.

Use of Non-Approved WMA Technology Additives, Modifiers or Processes: When an HMA producer proposes to use a non-approved WMA Technology modifier, additive or process, and the Engineering District is willing to allow the Producer to use the non-approved WMA Technology and to participate in the evaluation of the non-approved WMA Technology, the District must contact Timothy L. Ramirez, P.E., at (717) 783-6602 or by e-mail at tramirez@state.pa.us for additional requirements to properly evaluate the WMA Technology. Additional requirements will include, but not be limited to, mandatory inclusion of a HMA pavement course control section of the same JMF, collection of raw component material samples, collection of plant produced loose mixture samples, and collection and preparation of plant produced-laboratory compacted specimen samples to conduct various additional testing for the evaluation and comparison of the WMA vs HMA using the non-approved WMA Technology. Additional information is also required to be collected from the WMA Technology manufacturer and use of the WMA Technology on the project.

WMA Performance & Cost Monitoring: The Bureau of Construction and Materials will be working with the Districts, along with the Bureau of Maintenance and Operations, to monitor use, costs, and further analyze WMA pavement courses.

If there are any questions regarding this policy, please contact Scott Nazar, Chief, Pavement Materials Section, Roadway Management Division at (717) 425-7640.

Attachments

2930/4210/TLR/lgb

CC: R. S. Christie, P.E., Deputy Secretary for Highway Administration
All Central Office Hwy. Admin. Bureau Directors
All Assistant District Executives for Design
All Assistant District Executives for Construction
All District Materials Engineers/Managers
All District Pavement Management Engineers/Managers
BOCM Division/Section Chiefs
D. Cough, P.E., FHWA
Z. Siddiqui, FHWA
Associated Pennsylvania Constructors
Pennsylvania Turnpike Commission
Source File
Reading File

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Supplemental Technical Specification for **April 1, 2011**

Warm Mix Asphalt (WMA)

SCDOT Designation: SC-M-408 (04/11)

1. SCOPE

1.1 This is a specification intended for use in placing Warm Mix Asphalt (WMA) on primary and secondary routes with ADT less than 10,000 and truck volumes less than 15 percent.

This work consists of an asphalt mixture composed of mineral aggregate, aggregate screening, natural sand, asphalt binder, and hydrated lime mixed in an accepted asphalt hot mix plant. The mixtures will be produced in a SCDOT qualified asphalt plant that has been equipped with a foaming system or uses additives listed on Qualified Product List No. 77 to produce Warm Mix Asphalt (WMA). All foaming asphalt plants and additives used for this type of technology must be accepted by the Asphalt Materials Manager prior to production of this product. The asphalt mixes must be placed on a prepared surface in accordance with these Supplemental Specifications, applicable sections of the Standard Specifications, other appropriate Special Provisions and in conformity with the plans. WMA will use the same acceptance criteria for conventional hot mix asphalt mixes.

2. REFERENCED DOCUMENTS

2.1 SCDOT Standard Specifications

2.1.1 Division 300, Division 400, SC-M-401, SC-M-402, and SC-M-407

2.2 AASHTO Standards

2.2.1 AASHTO M303 and M320

2.3 SCDOT Test Methods

2.3.1 SC-T-70, SC-T-75, SC-T-80, and SC-T-84

3. MATERIALS

3.1 Aggregate: Ensure that aggregates used in the production of Warm Mix Asphalt (WMA) meet the requirements found in the 2007 Standard Specifications section 401.2.2 and in SC-M-407 without exception.

3.2 Asphalt Binder: Ensure that the binder is a neat asphalt binder that complies with the requirements of the SCDOT Standard Specifications section 401.2.1.1 using only PG64-22. Additives used in the production of the WMA may be pre-blended with the PG Binder at the asphalt terminal or introduced into the plantwith other metering equipment as stated in section 5.6. PG binders that have chemical additives added at the terminal or at the asphalt plant must be heat and storage stable and continue to meet AASHTO M 320.

3.3 Anti-Strip Additives: Ensure that hydrated lime is incorporated into all mixes and meets the requirements of AASHTO M 303 Type 1 regardless of mix type. Ensure that the hydrated lime is blended with the damp aggregate at a rate of

1.0% +/- 0.1 % by weight of dry aggregate. Ensure that blending of the hydrated lime is accomplished according to subsection 401.2.1.3.

3.4 Water. Ensure that potable water is used in water injection systems for foaming the asphalt binder.

4. MIX DESIGN

4.1 Warm mix designs utilize the same asphalt binder grade, aggregate and RAP sources, and material gradations as identically-formulated hot mix asphalt (HMA), although it may be in a HMA Contractor's benefit to provide additional equipment in their mix design laboratories to establish or simulate the foaming process to set optimum binder content and volumetric properties. WMA mix designs utilizing additives will use asphalt that may be pre-blended from the asphalt terminal or may be introduced by adding the correct dosage of additives to establish mix design volumetric properties. Additional equipment may be required by the WMA additive manufacturer in the design process to ensure the proper dosage and to achieve a homogenous mixture. Additive manufacturers will provide documentation of proper mixing and compaction temperatures to produce and compact WMA mixtures. Ensure that WMA mixtures comply with SC-M-402.

Design WMA job mix formulas in accordance with SC-T-80. Ensure that all designs are accepted by the Materials and Research Engineer prior to use on SCDOT work. Ensure that mix designs are prepared in a laboratory approved by the Asphalt Materials Manager and by technicians certified as a SCDOT Level 2, HMA Job Mix Technician. Ensure that technicians are trained on the use of foaming equipment if necessary to provide mix designs that will comply with all specifications herein and in the applicable Standard Specifications, Supplemental Specifications, andSpecial Provisions.

5. FIELD REQUIRMENTS

5.1 Ensure that all WMA Systems or Additives used are listed on QPLNo. 77. WMA foaming systems and additives are used to allow lower asphalt mix temperature. Use foaming equipment or an additive that is compatible with the asphalt plant and acceptable to the Asphalt Materials Manager in producing WMA, and ensure that asphalt plant conforms to SC-M-401 after any modification. Ensure that the burner in the aggregate dryer is properly adjusted so that there is no burner fuel in the WMA.

5.2 Ensure that on any WMA foaming system, or when any new metering equipment is installed on a contractors plant, that a trial run is done so all plant controls and metering equipment can be verified to be working accurately prior to production. Prior to full production of WMA mixtures for the Department, the contractor's quality control manager will be responsible for verifying that all acceptance properties are within job mixtolerances as well as tensile strength ratio requirements during the trial run.

5.3 Ensure that all WMA mixtures are stored a maximum of 8 hours in a separate storage silo from conventional HMA mixtures. Extended overnight storage of WMA mixtures will notbe permitted.

5.4 Ensure that only one WMA foaming system or WMA additive is used during a day of production of WMA mixtures.

5.5 **Water Injection Foaming Systems**

5.5.1 The use of a water injection system is not permitted on an asphalt batch plant.

5.5.2 Ensure that the foaming system manufacturer can provide technical assistance to the WMA producer by having a representative on site in the event of issues arising during use of the system within 24 hours of identifying problem.

5.5.3 Ensure that injection equipment is tied into the computer in the plant control room so that metering of the injected water can be continuously monitored by the plant operator.

5.5.4 Ensure that injection systems have variable water injection that is automatically controlled by the plant production rate. Do not allow water injection system to exceed 2.0% water by weight of asphalt binder.

5.5.5 Ensure that the water injection rate cannot be manually overridden by the plant operator once established in the plant's computer.

5.5.6 Ensure that in the event of control or equipment failure in the injection system occurs or if the injection equipment stops water flow the computer system immediately notifies the plant operator and all WMA production is stopped until the water injection system is repaired and checked by the contractor's quality control manager before WMA production resumes.

5.5.7 Ensure that the water injects into the asphalt binder flow before the asphalt binder spray makes contact with aggregate. Do not allow water to come in contact with aggregate prior to binder spray.

5.5.8 Ensure that the injection equipment includes water storage and a pump control that is tied into the injection computer controls.

5.5.9 Ensure that the water flow alarm is installed in the control room to indicate a shortage of water in the storage tank, or a disruption in the water flow equipment.

5.5.10 Provide an additional asphalt binder sampling valve at the injection equipment to sample binder prior to the spray system.

5.5.11 Heat and prepare the materials in a manner that produces a warm mixture that, when discharged, is at a mixture temperature that can be maintained from **220°F F - 285°F (no exceptions).** Use SC-T-84 to measure mix temperature at the asphalt plant and on the road in the delivery trucks.

5.6 **WMA Additives**

5.6.1 Ensure that if the additive has been pre-blended at theasphalt terminal, it has been documented on the Bill of Lading (BOL) coming from the binder supplier. Ensure that the percent additive added to the PG 64-22 is printed on the BOL. Store the binder in a storage tank without any contamination from previous loads of virgin PG 64-22. Label binder storage tanks noting the addition of WMA additives. All other WMA additives must be clearly identified at the asphalt plant and the WMA producer must have all documentation for the additives readily available for review at the asphalt plant.

5.6.2 Ensure that the WMA additive and or metering equipment manufacturer can provide technical assistance to the WMA producer by having a representative on site in the event of issues arising during use of the system within 24 hours of identifying problem.

5.6.3 Ensure that the additive metering equipment is tied into the computer in the plant control roomso that metering of the non-terminally blended additives can be continuously monitored by the plant operator.

5.6.4 Ensure that metering systems can vary the amount of additives introduced into the asphalt plant and are automatically controlled by the plant production rate. Do not allow the WMA additive rate to go outside of the manufacturer's recommendations as stated in the WMA QC Plan, as stated in section 6. The recommendations should include a target dosage for the additives and upper and lower tolerance limits.

5.6.5 Ensure that if the additive equipment stops flow or if a control or equipment failure in occurs, the computer system immediately notifies the plant operator and all WMA production is stopped until the system is repaired and checked.

5.6.6 Heat and prepare the materials in a manner that produces a warm mixture that, when discharged, is at a mixture temperature that can be maintained from **220 °F - 285°F (no exceptions).** Use SC-T-84 to measure mix temperature at the asphalt plant and on the road in the delivery trucks.

6. QUALITY CONTROL

6.1 Provide the Asphalt Materials Manager, at least 30 days prior to starting production, a QC Plan to document the manufacturer's suggestions for target production rates when using water injection equipment in foaming systems or when usingchemical additives, and produce an outline with acceptable variationsthe asphalt plant and acknowledge that the mixture will remain within 220 °F- 285°F at all times.

6.2 Ensure that laboratory compaction ranges are established in the QC Plan used for making gyratory specimens for mix acceptance.

6.3 Ensure that all WMA samples taken for field determination of binder content are dried to constant weight if necessary prior to running SC-T-75as outlined in the WMA QCPlan.

6.4 When using Intermediate Type C, Surface Type CM or Surface Type C mix types, perform Indirect Tensile Strength (ITS) testing using SC-T-70 at least one time during the first day's production, then at least once every 30 days thereafter. Forward the results by e-mail to the Asphalt Materials Manager immediately upon completion. Failure to comply with Section 401.2.3.4 of the standard specifications will cause Asphalt Materials Manager to immediately suspend production. Redesign will be required for any job mix formula which fails to meet Tensile Strength Ratio (TSR) field requirements.

7. CONSTRUCTION

7.1 Seasonal and Ambient Air Temperatures. Ensure that ambient air temperatures and seasonal restrictions during placement of WMA follow the requirements set forth in subsection 401.4.4 of the Standard Specifications without exception.

7.2 Failure to comply with WMA mix temperature requirements as stated in the section 6.1 and the Contractors QC plan will result in mix being rejected as directed by the Asphalt Materials Manager.

8.	**FIELD ACCEPTANCE**

8.1 During the production and quality control of WMA, make all necessary provisions to ensure that plant unit operations comply with SCDOT specifications regarding the production of HMA as stipulated in Division 310 and Division 401

9. MEASUREMENT

9.1 Measure and accept WMA mixtures by the ton or square yard placed.

10. PAYMENT

10.1 WMA Mixtures will be paid for at the contract unit price which will be for full compensation for furnishing all materials, equipment, and labor. Payment will be made under:

Item No.	Pay Item	Unit
4110320	WMA Base Course Type B	TON
41103XX	WMA Base Course Type C	TON
41103XX	WMA Base Course Type D	TON
411XXX	WMA Shoulder Widening Course	TON
4112330	WMA Intermediate Course Type C	TON
4113XX	WMA Surface Course Type CM	TON
4113340	WMA Surface Course Type C	TON
4113350	WMA Surface Course Type D	TON
4113XX	WMA Surface Course Type E	TON
4113XX	WMA Preventative Maintenance Course	SY

APPENDIX E - LIST OF WMA REPORTS PUBLISHED BY TARGET STATES

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Buss, A. F. (2011). Investigation of Warm-Mix Asphalt Using Iowa Aggregates, Iowa State University.

Crews, E. (2008). Extended Season Paving in New York City Using Evotherm Warm Mix Asphalt.

Hurley, G. C. (2010). Missouri Field Trial of Warm Mix Aphalt Technologies: Construction Summary.

Hurley, G. C., B. D. Prowell, et al. (2009). Michigan Field Trial of Warm Mix Asphalt Technologies: Construction Summary, Michigan Department of Transportation.

Kasozi, A. M. (2011). Properties of warm mix asphalt from two field projects: Reno, Nevada and Manitoba, Canada, UNIVERSITY OF NEVADA, RENO.

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MeadWestvaco (2009). Evotherm Warm Mix Asphalt in Crow Wing County, Minnesota: Eliminating Thermal Cracking at Reduced Cost, MeadWestvaco Asphalt Innovations.

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APPENDIX F - LIST OF WMA REPORTS PUBLISHED BY OTHER RESOURCES

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Bonaquist, R. (2011). NCHRP Report 691, Mix Design Practices for Warm Mix Asphalt.

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Cheng, D. X., R. G. Hicks, et al. (2011). Assessment of Warm Mix Technologies for Use with Asphalt Rubber Paving Applications.

Chowdhury, A. and J. W. Button (2008). "A Review of Warm Mix Asphalt." Texas A&M University System.

D'Angelo, J. A., E. E. Harm, et al. (2008). Warm-Mix Asphalt: European Practice.

Diefenderfer, S. D., A. J. Hearon, et al. (2010). Performance of Virginia's Warm-Mix Asphalt Trial Sections, Virginia Transportation Research Council.

Diefenderfer, S. D., K. K. McGhee, et al. (2007). Installation of Warm Mix Asphalt Projects in Virginia, Virginia Transportation Research Council.

Estakhri, C., J. Button, et al. (July 2010). "Field and Laboratory Investigation of Warm Mix Asphalt in Texas."

Hurley, G. C. and B. D. Prowell (2005). "Evaluation of Aspha-min® Zeolite for Use in Warm Mix Asphalt." NCAT 05-04.

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Hurley, G. C. and B. D. Prowell (2006). "Evaluation of Evotherm® for Use in Warm Mix Asphalt." NCAT 06-02.

Hurley, G. C. and B. D. Prowell (2006). "Evaluation of Potential Processes for Use in Warm Mix Asphalt." Journal of the Association of Asphalt Paving Technologists 75: 41-90.

Jones, D., C. D. o. Transportation, et al. (2009). Warm Mix Asphalt Study: Test Track Construction and First-level Analysis of Phase 1 HVS and Laboratory Testing, University of California Pavement Research Center.

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Prowell, B. D., G. C. Hurley, et al. (2011). Warm-Mix Asphalt: Best Practices, 2nd Edition, National Asphalt Pavement Association.

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Tsai, J. and J. Lai (June 2010). Evaluating Constructability and Properties of Warm Mix Asphalt.

APPENDIX G - SCHOLARLY PAPERS ON WMA

Evaluation of Low Temperature Binder Properties of Warm Mix Asphalt, Extracted and Recovered RAP and RAS, and Bioasphalt

Zhanping You et al. studied the effect of effect of adding Sasobit and using reclaimed asphalt pavement (RAP) and reclaimed asphalt shingle (RAS) and Bioasphalt on low temperature performance of asphalt modified with these materials. They used two methods of testing: bending beam rheometer and asphalt binder cracking device (ABCD). For WMA, the tests were carried on binders modified with 0.5, 1.5, and 3.5% Sasobit. For RAS they used 5% and 10% recovered RAS and RAP at 50% and 100%. The analysis of results suggests that all four materials have to the potential to enhance the low temperature performance of asphalt pavements. Considering WMA, the results show that adding Sasobit beyond a certain percentage could potentially compromise the low temperature cracking performance and the researchers suggest a framework to set a maximum for the use of Sasobit.

Evaluating the Effect of Warm Mix Asphalt Technologies on the Moisture Characteristics of Asphalt Binders and Mixtures

Mogawer et al. evaluated four different types of WMA technologies to see the effect on the moisture susceptibility of the mix and the adhesion characteristic of the binder used. They evaluated Advera, Evotherm, Sasobit and SonneWarmix. Hamburg wheel tracking device (HWTD) was used to test moisture susceptibility of the mixtures at three aging times and three aging temperatures. Also, a pull-off test was used to evaluate the effect of the WMA technology on the binder adhesion, by the bitumen bond strength (BBS) test. The results of their research showed that moisture resistance of all mixtures had significant improvement with increasing aging time or temperature. For samples failing HWTD, liquid anti-strip and hydrated lime was added. Addition of anti-strip improved the HWTD results. Out of the four technologies, only Sasobit had a significant effect on the pull off tensile strength of the binder.

Influence of Anti-stripping Additives on Moisture Susceptibility of Warm Mix Asphalt Mixtures

Xiao et al. studied the effect of anti-stripping additives (ASA) on moisture susceptibility of WMA mixtures. They tested 36 types of mixtures (6 of each type) where they had 3 different types of aggregates, four different types of anti-stripping additives (ASA, lime, and two liquid ASA, as well as the control [no additive]), one binder grade (PG 64-22), and three types of WMA additives (virgin, Asphamin, and Sasobit). For each type of mixture, three samples were tested in dry condition and three in wet condition. The samples were evaluated based on indirect tensile strength (ITS), tensile strength ratio (TSR), toughness, and flow. The results show that hydrate lime exhibits the best moisture resistance for WMA mixtures, while the other two liquid ASA were weaker compared to lime, although they increased the ITS values of the mixtures. Also, the wet ITS values of the mixtures were lower when they contained WMA additives. There were no significant differences between the flows of different mixtures. Also, toughness values of specimens containing WMA additives are less than those of virgin mixtures.

Influence of Commercial Wax on Performance of Asphalt

Wei et al. studied the influence of addition of Sasobit on asphalt binder. The effects on rheological properties, chemical composition, and surface properties of the binder were investigated. The results showed that Sasobit had a stiffening effect on the binders, increasing the complex modulus and decreasing the phase angle. Investigation of the chemical effect of wax on the binder showed that there was no chemical interaction between the two when mixed at 135°C. Their research showed that addition of wax reduced the surface energy of the binder, which may result in increased wettability of the binder on the aggregate surfaces.

Influence of Production Temperature and Aggregate Moisture Content on the Performance of Warm Mix Asphalt

Bennert et al. studied the influence of mixing temperatures on the performance of WMA mixtures from rutting and fatigue viewpoints. They also evaluated the stripping potential by using pre-wetted aggregates. They used asphalt mixture performance tester (AMPT) and wet Hamburg wheel tracking tests to evaluate the performance of the mixtures, which clearly showed a decrease in rutting resistance and stiffness of the mixes. The magnitude of the stiffness change was not consistent and was dependent on the type of WMA additive. Fatigue resistance was tested by the Overlay Tester and this showed increase in cracking resistance. The moisture susceptibility was tested by TSR and wheel tracking test. The results clearly showed an increase in stripping, and this result was more serious when the aggregate blends have higher absorption properties.

Influence of WMA Additives and Reduced Aging on Rheology of Asphalt Binders with Different Natural Wax Contents

Arega et al. investigated the interaction between WMA additives and natural wax present in the asphalt binder. Natural wax refers to naturally crystallizable material in asphalt binders. Four asphalt binders were selected; two with high natural wax content and two with low content. The WMA additives used were Sasobit, Cecabase, Evotherm DAT, Evotherm 3G, and Rediset. The results of their testing showed that certain additives reduce the viscosity of short-term aged binder, especially when used with high natural wax content. Considering stiffness, WMA mixes are expected to have reduced stiffness and increased susceptibility to permanent deformation. Certain WMA additives compensate, while others aggravate the initial reduced stiffness of the binder. Binders with WMA additives that were subjected to short term aging followed by Pressure Aging Vessel (PAV) aging, and had similar or slightly reduced thermal cracking resistance.

Laboratory and Field Evaluations of Foamed WMA Projects

Granite Construction performed two WMA paving demonstration projects in 2008. The two projects were constructed with the free water method (Double Barrel Green). Based on these two demonstration projects, Wielinski et al. concluded that conventional mix design methods could be used for designing WMA with free-water technology. The Hveem and Marshall properties of HMA and WMA were similar. The WMA had lower initial stiffness, but WMA wet mix met the minimum mechanical properties. The researchers suggest requiring anti-strip agents by the public agencies. In both demonstration projects, the in-place densities for WMA and HMA were very close. There was also less variability of the in-place densities of WMA as compared to HMA.

Shanghai's Experience with WMA

Yan et al. studied the performance of 10 WMA projects constructed in Shanghai from 2006 to 2010. The major WMA technology being applied is Evotherm. Two major asphalt mixtures used in Shanghai are studied and laboratory performance of WMA is compared to HMA. For both types of mixtures, WMA had similar performance to HMA and satisfied the specification requirements. The performance criteria considered were air voids, Marshall Stability, TSR and dynamic stability. In the first two, WMA values were lower than HMA, while in the last two, they were higher than HMA.

Moisture Susceptibility and Stripping Resistance of Asphalt Mixtures Modified with Different Synthetic Waxes

Merusi et al. proposed a simple method to evaluate the influence of wax on stripping resistance and moisture susceptibility. Waxes with different chemical structures were used, namely paraffinic and polyamidic. Moisture susceptibility was tested by first the conventional method and then through the proposed method of using digital image analysis to identify the stripped surface in a quantitative way. Their results showed that enhanced performance (contradictory to expectation) could be obtained in the presence of wax modified binders, but this depends on the type of wax used.

Moisture Susceptibility of WMA Mixtures Containing Nano Sized Hydrated Lime

Super fine hydrated lime was produced from regular hydrated lime (RHL) by using LA abrasion machine. Tests conducted for moisture susceptibility were indirect tensile strength (ITS), tensile strength ratio (TSR), flow, and toughness. Two types of limes were used, nano-sized and regular-sized. Three different WMA additives were also used. The results of the tests showed that super fine hydrated lime has greater ITS and TSR values for WMA than with regular hydrated lime. Also, the anti-stripping properties of WMA mixtures containing super fine hydrated lime are dependent on the types of aggregates and additives used.

Utilization of Foaming Technology in WMA Mixtures Containing Moist Aggregates

Xia et al. performed an experimental design in which 42 different mixture types were used and indirect tensile strength (ITS), tensile strength ratio (TSR), rut depths of dry and conditioned specimens, and flow were measured. Design of the experiment utilized 2 aggregate sources, two aggregate moisture contents, two lime contents, one anti-stripping agent, and three foaming water contents (2, 3, and 4%). The results showed that rut depths of HMA mixtures were lower than other mixtures, and that, in general, rut depth was more related to aggregate sources, rather than moisture or lime content. According to their test results, aggregate source was responsible for ITS and rutting resistance. Hydrated lime showed little effect on rutting and moisture resistance. The anti-stripping agent used in the study was not recommended for use in foaming technology with moist aggregate, as long as it showed sensitivity to moisture. The effect of foaming water content was significant on rut depth and ITS, and the results showed that samples containing 2% water content were suitable for mixing.

Production, Placement, and Performance Evaluation of WMA in Texas

Estakhri et al. compared samples from a field trial placed by Texas DOT. The field trial was placed in 2006 using the emulsion based technology, Evotherm. In their study, field-mixed and lab compacted samples were evaluated for production density, moisture susceptibility, and cracking resistance. Hamburg wheel tracking tests and Texas Transportation Institute (TTI) overlay test were run on the cores taken from the field after one month and one year of service. No problems were observed in laydown or compaction operation. WMA samples taken after placement and after one month in service failed the Hamburg test requirements, but the cores taken at one year passed the requirements. In overlay test results, all of the lab-molded WMA mix specimens performed poorly, although there was a significant improvement after one month, which was gone after one year. Overall, the field performance of the WMA is comparable to HMA section after two years of service.

Laboratory Simulation of WMA Binder Aging Characteristics

Gandhi and Amirkhanian studied the effect of WMA additives on the binder aging process. Asphalt mixtures containing two different binder sources and three different WMA additives (Control, Asphamin, and Sasobit) were prepared and aged in the oven, and tests were run on the extracted binders. The results of their work indicates that binders extracted from WMA had lower aging indecies (viscosity of extracted binder to the original binder) compared to HMA, and they had aged significantly less than HMA binders. Regarding fatigue cracking, WMA additives had no significant effect on $G^*\sin\delta$ or the creep stiffness, although Asphamin increased the m-value of the binders.

Laboratory Evaluation of WMA Performance in Liaoning

Yanhai et al. studied the performance of WMA made by adding Sasobit. Four types of binder were tested, one control and three with additives. Rutting, bending at low temperatures, fatigue, and dynamic modulus tests were conducted. The results showed that adding 3% of Sasobit decreased the mixing temperature by 20°C and significantly increased the dynamic stability. Considering anti-cracking ability and fatigue resisting of the mixes, Sasobit had negative effect on the base asphalt, but positive on Styrene Butadiene Styrene (SBS) modified binder. Adding Sasobit improved the stability of mixes at high temperatures, as long as dynamic modulus of WMA with Sasobit increased significantly.

Analysis and Application of Relationships between Low-Temperature Rheological Performance Parameters of Asphalt Binders

In this work, Liu et al. tested the low temperature behavior of rubberized warm mix asphalt (RWMA) and investigated the possibility of formalizing a method by synthetically combining m-value and S-value. This is based on a physical equation between creep stiffness S (t) and creep rate m (t), where the binder with a larger m (t)/S (t) ratio value is considered a good low-temperature property material. The authors verified the adequacy of this method for selecting the best low-temperature performing RWMA binder among many binders by only comparing the m-value or S-value.

Effect of Sasobit and Aspha-Min on Wettability and Adhesion between Asphalt Binders and Aggregates

Wasiuddin, Zaman et al. explored the effect of Sasobit and Aspha-Min additions on wettability and adhesion between asphalt and aggregates by utilizing the surface free energy (SFE) method. Two selected asphalt binders, namely a PG 64-22 and a PG 70-28 were investigated, with the PG 70-28 binder modified with styrene-butadiene-styrene polymer. The SFE components of these binders were evaluated at three selected percentages of Sasobit (2%, 4%, and 8%) and Aspha-Min (1%, 4%, and 6%), based on the weight of the binder. The authors were able to correlate between the reduction of asphalt-aggregate adhesion and the increase in Sasobit percent. On the other hand, the effect of Aspha-Min on SFE, wettability, and adhesion could not be determined. This was attributed to the sample-making procedure that involved placing the asphalt-coated glass plates inside an oven at 150°C for 1min, a procedure that lead to the absence of water vapor at 150°C. An increase in wettability of PG 64-22 from 70.9 dyne/cm and 70.3 dyne/cm to 98.7 dyne/cm and 98.8 dyne/cm for limestone and sandstone, respectively, was recorded with the addition of 8% Sasobit. Better results were obtained for PG 70-28, giving a generally increasing trend in wettability with the increase in percent of Sasobit for both the binders. For moisture susceptibility (spontaneous change in free energy under water), a small or no reduction was observed in the case of PG 64-22, whereas Sasobit was found to greatly increase the moisture susceptibility of PG 70-28. An overall observation recorded by the authors was that Sasobit reduces the adhesion (free energy of adhesion) and increases the moisture susceptibility. For Aspha-Min, no trend was observed on increase or reduction of adhesion (free energy of adhesion). There was also no trend found for wettability in the case of PG 64-22, due to heating with Aspha-Min for 36 hours. For PG 70-28, Aspha-Min increases the adhesion (free energy of adhesion) and reduces the moisture susceptibility.

Warm Mix Asphalt using Sasobit® in Cold Region

The aim of this study was to present an overview of WMA for cold weather paving through a field experience, to evaluate the WMA's moisture susceptibility, as well as the rutting and fatigue potential through dynamic modulus testing and tensile strength ratio testing. WMA made with Sasobit added at a rate of 1.5% by mass of binder was utilized in this study. The same volumetric design was employed for placing both WMA and HMA (control). The mixing temperature used for WMA was 260°F (126.7°C) and HMA was 320°F (160°C). During the WMA production, emission was significantly reduced compared to HMA production. The recorded time needed for cooling down the WMA was significantly longer than HMA, about 27 minutes more than the time needed for HMA. The authors used this fact to verify that the use of WMA technology can significantly improve the cold weather paving by allowing an extended hauling distance and increasing the time required for cooling of the pavement. Tensile Strength Ratio (TSR) testing results for control and WMA mixtures showed that the TSR for WMA is comparable to the HMA (control mixture), which could indicate that there are no significant differences between WMA made with Sasobit and HMA, in terms of moisture damage. However, the authors found that the tensile strength of WMA is significantly lower than HMA, indicating that the fracture energy of WMA is lower than HMA, which may lead to having WMA made with Sasobit of higher fatigue cracking potential than HMA. The authors also found that WMA mixtures had higher dynamic modulus (E*) than those of HMA, a result that indicated that WMA has a lower rutting potential as compared to HMA.

Evaluation of Potential Processes for Use in Warm Mix Asphalt

In this research work, Hurley and Prowell investigated the performance of three warm mix asphalt processes, namely: Aspha-min, Sasobit, and Evotherm through a laboratory study. In this study, the applicability of these processes to typical paving operations and environmental conditions commonly found in the United States was examined. The compactability of mixtures was improved for all three processes. The mix temperatures were 160°F (71 °C); and in the field, laydown and compaction temperatures were 140°F (60°C). The addition of the Aspha-min zeolite reduced the design asphalt content by approximately 0.1 to 0.4%, while the addition of Sasobit or Evotherm reduced the design asphalt content by approximately 0.1 to 0.5%. The addition of zeolite, Sasobit, and Evotherm improved compaction over the control mixture for all binder, aggregate, and temperature combinations. Evotherm lowered the air void content the most, with Sasobit next, while zeolite was the least. Evotherm increased the measured resilient modulus the most, with zeolite next, whereas Sasobit decreased the measured resilient modulus. Evotherm lowered the rut depths the most (by an average of 1.8 mm); followed by 1.4 mm for Sasobit, while the zeolite decreased the value by an average of 0.2 mm. The strength gain experiment was conducted to evaluate the rutting potential immediately after construction; results indicated that although the strength varied over the different aging times, there was no change in strength for either the control mix or for the warm mix at a particular age time. This proved that there was no evidence to support the need for a cure time before traffic for asphalt mixtures containing such additives. Based on the results for the asphalt pavement analyzer (APA) rutting tests, Sasobit neither increased nor decreased the rutting potential, down to 230°F (110°C). On the other hand, there was a significant increase in the rutting results for both compaction temperatures in case of zeolite. The test results for the Evotherm revealed an increased potential for rutting at the 230°F (110°C) compaction temperature. Tensile strength ratio (TSR) results showed a decrease in the presence of zeolite, but still resulted in an acceptable value. Meanwhile, the Sasobit lowered the TSR value to an unacceptable value. On the other hand, Aspha-min exhibited a cohesive failure that was attributed by the authors as a result of the binder emulsification due to the moisture released from the Aspha- min. The authors suggested having a cure time that would dissipate the moisture in the binder, eliminating the potential of a cohesive failure. The authors utilized anti-stripping agents as a means to increase moisture resistance. ARMAZ LOF 6500 was used with the control and zeolite mixtures. For the control mixture, the liquid anti-strip reduced the adhesive failure and increased the unsaturated tensile strengths, while the saturated tensile strengths remained the same as the control mixture without liquid anti-strip. For the mixture with zeolite, the liquid anti-strip increased the unsaturated tensile strengths, but it decreased the saturated tensile strengths, thus resulting in a low TSR value (0.38). The authors attributed the decrease in the saturated tensile strength to a reduction in binder viscosity from the liquid anti-stripping agent. All processes improved the compactability of the mixtures. The resilient modulus of the investigated warm mix asphalt compared to mixtures having the same PG binder were the same, on the basis that the authors verified that there would not be any effect on pavement thickness design when using warm asphalt mixes. The addition of 1.5 percent hydrated lime resulted in improved cohesion and moisture resistance over the warm mixtures without hydrated lime. Hamburg wheel-tracking tests indicated good performance in terms of moisture susceptibility and rutting for the mixtures containing Sasobit. Hamburg results also suggested that the lime assisted in the rutting resistance of warm mixtures, with Aspha-min compacted at lower temperatures due to the lime stiffening of the asphalt binder. Superpave gyratory compactor results indicated that Aspha-min, Sasobit, and Evotherm may lower the optimum asphalt content.

Evaluation of Warm-Mix Asphalt Produced with the Double Barrel Green Process

Middleton and Forfylow evaluated the economic, environmental, and mixture performance of the Double Barrel Green process. WMA mixes containing reclaimed asphalt pavement and manufactured shingle modifier (MSM) produced with the Double Barrel Green System during field trials were examined in this study. According to the authors, transportation agencies and HMA producers are unlikely to adopt WMA technologies solely because the benefits involved in their utilization do not cover the associated increase in investment and additive costs. However, a minimization in the increased material costs identified with other WMA technologies can be attained by the utilization of the Double Barrel Green process for the production of WMA with a standard-grade asphalt binder, as it only involves a one-time mechanical plant modification. This modification is the installation of the foaming manifold over an existing asphalt injection system on the outer drum of the plant, and installation of corresponding asphalt binder and water feed lines into the manifold. The mixes employed in this study were a control, 15% RAP, 15% RAP and 5% MSM, and 50% RAP. A minimal impact on rutting susceptibility was recorded with increased RAP and MSM contents. The resilient modulus of the control mix showed an approximate 30% increase in the values obtained at 5°C and 25°C test temperatures, compared to the WMA mixes with RAP and MSM. A moisture content of less than 0.1% was recorded for the WMA as compared to that of HMA, indicating that retained moisture from the foaming process was not significant. In terms of emission, 10% reductions in carbon dioxide, carbon monoxide, and nitrogen oxides were determined for WMA over HMA. On the other hand, a slight increase in sulphur dioxide was identified. However, the authors attributed such increase to testing variances. A decrease in temperature of about 41°C was recorded for WMA compared to HMA, yielding a 24% reduction in energy consumption.

Warm-Mix Asphalt Technology to Incorporate High Percentage of Reclaimed Asphalt Pavement Material in Asphalt Mixtures

Mallick et al. investigated the feasibility of using a warm-mix asphalt (WMA) additive, Sasobit H8, in the recycling of hot-mix asphalt (HMA) with 75 % RAP at a lower temperature. The emphasis of the study was directed towards selecting the right grade of asphalt binder while taking into consideration that the temperature of recycling is 125°C, because this temperature is sufficiently lower than conventional mixing and compaction temperatures used for PG 64-28 in most of the northeastern United States. A control HMA was prepared with extracted aggregates and PG 64-28 binder at 150°C. Another HMA was produced with PG 52-28 binder at 135°C. Two WMA mixes were prepared with Sasobit H8 at 125° C, one with PG 52-28 and the other with PG 42-42 binder. For the RAP mix investigated in this study, the design (added) asphalt content was 1.5%. Sasobit H8 was added to asphalt at 1.5% (1.5% of the total binder which includes RAP binder and added binder). Sasobit H8 was used to facilitate mixing and compaction by attaining sufficient workability through decreasing the viscosity of the asphalt. The study concluded that it is possible to produce mixes with 75% RAP with similar air voids as virgin mixes at lower than conventional temperatures using 1.5% Sasobit. However, Sasobit had a slightly stiffening effect at low temperatures. On the other hand, the addition of Sasobit helped in producing uniform mixes. The production of a mix that is most comparable with a virgin mix was achieved through the addition of a significantly lower grade of binder, PG 42-42, at a rate of 1.5% by weight of mix.

Evaluation of Compactability and Mechanical Properties of Bituminous Mixes with Warm Additives, 2011

The effect of employing additives (chemical and organic) on the compactability and mechanical properties of asphalt mixes is studied in this work. The measurement of the degree of compactability was derived from the measurement of the compaction energy index (CEI) which compares the compaction of one mixture to another, while the traffic densification index (TDI) was utilized to give indication of the estimated densification produced by traffic, as it analyzes the effect of post-compaction due to the traffic loads during the pavement service life. Lower CEI values were displayed for mixes with WMA additives, indicating their ease of compaction compared to original binder and also the ability to reduce the working temperatures. The TDI values for WMA manufactured at 140 °C and at 120 °C were similar to original mix's value at 160 °C. The addition of WMA additives improved the sensitivity to water compared to original mix at the same temperature, and the stiffness modulus obtained was reduced. On the other hand, these moduli varied less with temperature than in original mix, while having all the WMA showing a higher stiffness modulus than original mix at 120 °C.

Rheology of Warm Mix Asphalt Binders with Aged Binders, 2011

This study addresses the rheological investigation of properties of warm mix asphalt (WMA) binders containing long-term aged binders. The recycled binders with the additives were produced using two (i.e., zeolite Aspha-min and wax Sasobit) of the available warm asphalt processes. The addition of Sasobit into the recycled binders seemed to increase the viscosity values of the binders at 60°C, suggesting better rutting resistance at a critical pavement temperature. The creep recovery test and the repeated creep recovery test indicated the least permanent deformation for the WMA binders. The temperature susceptibility was slightly improved for the WMA binders. The frequency sweep test indicated that the recycled binders containing Sasobit were observed to have lower phase angles and higher complex modulus than the other recycled binders, meaning better elastic properties.

Evaluation of the Potential of Sasobit to Reduce Required Heat Energy and CO_2 Emission in the Asphalt Industry, 2010

This paper evaluated the effects of different quantities of a WMA additive, Sasobit, on the required heat energy and the amount of CO_2 produced to increase the temperature of two aggregates from three sources and one binder from 25°C to the point of mixing. The results showed that incorporating 1% Sasobit can potentially reduce the required heat energy and amount of CO_2 produced by 2.8% and 3.0%, respectively, for all aggregate types and sources investigated. The paper also incorporated a design chart for appropriate Sasobit content to produce the most cost effective asphalt mixture with less environmental impact. Through this chart, 1.6% Sasobit content is the most suitable proportion to be blended into the asphalt binder, without compromising pavement resistance against fatigue failure.

Estimating Correlations between Rheological and Engineering Properties of Rubberized Asphalt Concrete Mixtures Containing Warm Mix Asphalt Additive, 2011

This paper investigated the mixture performance characteristics of rubberized warm asphalt mixtures, and their correlation with binder properties. The results of the experiments indicated that the use of crumb rubber and WMA additive in HMA can effectively improve the engineering properties of these mixes at lower mixing and compacting temperatures. The addition of Sasobit to rubberized, as well as virgin binders significantly reduced the viscosity of the binders. On the other hand, addition of Asphamin did not have any significant effect on the viscosity of the virgin and rubberized binders. WMA additives increased the high temperature performance ($G^*/\sin \delta$) values of the binders. Also, the addition of crumb rubber reduced $G^*\sin \delta$ and stiffness values after long-term aging, but the WMA additives do not significantly affect these values. The increase in the mixing and compaction temperatures, due to the addition of crumb rubber, can be offset by adding the warm asphalt additives, which lowers the mixing and compaction temperatures of rubberized mixtures comparable to those of conventional HMA.

Effects of Warm Mix Asphalt Additives on Performance Properties of Polymer Modified Asphalt Binders, 2010

This study presented an experimental evaluation for the performance properties of polymer modified asphalt (PMA) binders containing warm mix asphalt (WMA) additives (i.e., Aspha-min and Sasobit). The addition of Sasobit significantly decreased the viscosity of PMA binders at 135 °C. The viscosity of PMA binders containing Aspha-min increased due to the filling effect of the additive. PMA binders containing Aspha-min and Sasobit had higher failure temperature than the control PMA binders, suggesting better resistance on rutting at high temperature. The PMA binders containing the additives were observed to have higher G*sin δ values compared to the control PMA binders, meaning that the addition of the additives might result in the PMA binders being less resistant to fatigue cracking at intermediate temperatures. The warm PMA binders were found to have significantly higher stiffness values which relate to possible lower resistance on low temperature cracking. Also, the PMA binders with Sasobit showed significantly lower m-values than the control PMA binders.

Analysis of Rheological Properties of Rubberized Binders Containing Warm Asphalt Additives, 2010

This paper presented the data on rheological tests conducted on rubberized binders containing warm asphalt additives. Two of the available warm asphalt technologies, Asphamin and Sasobit, were used to produce the warm asphalt binders. The binders containing Sasobit had higher viscosities at 60°C, irrespective of the binder source, compared with binders containing Asphamin or no warm asphalt additive. The binders containing Sasobit had lower permanent deformation values, whereas, for the binders with Asphamin the permanent deformation was similar to binders without any warm asphalt additives. Binders modified with Sasobit showed lower phase angle compared with the binders without any warm asphalt additives, especially at lower temperatures, which suggests improved elasticity of the binders at lower temperatures. This increase in elasticity would help the binders to resist rutting and permanent deformation.

Investigation of Field Produced Warm Mix Asphalt Mixes in Iowa, 2010

This publication presents the results of the field study investigation of four field produced WMA mixes and four control mixes. The WMA technologies used in this study were Evotherm 3G, Revix, Sasobit, and foaming using the Double Barrel Green system. Reduced compaction temperatures were achieved with all WMA additives. For the Evotherm 3G, the HMA average peak load was greater than the peak load of the WMA samples. For the Revix, WMA had a slightly higher overall average for the indirect tensile strength tests (IDT) peak strength. On the other hand, the WMA had a greater loss of strength when subjected to moisture conditioning. For the Sasobit, The field compacted moisture conditioned WMA samples were the lowest performing samples. The tensile strength ratios (TSR) showed higher values for HMA. For the Double Barrel Green foaming, moisture conditioned samples had a lower peak loads than HMA ones.

Using Warm-Mix Asphalt Technology to Incorporate High Percentage of Reclaimed Asphalt Pavement Material in Asphalt Mixtures, 2008

This study investigated the feasibility of using a warm-mix asphalt (WMA) additive, Sasobit H8, in successfully recycling hot-mix asphalt (HMA) with 75% RAP at a lower temperature. The results obtained from this study indicated that it is possible to produce mixes with 75% RAP with similar air voids as virgin mixes at lower than conventional temperatures using 1.5% Sasobit (based on the weight of the total asphalt binder). The addition of Sasobit also helped in lowering the viscosity of the asphalt binder at higher temperatures; however it had a slightly stiffening effect at low temperatures. The addition of Sasobit helped in getting uniform mixes that had air voids compacted at lower than conventional temperature similar to air voids obtained in conventional mixes compacted at conventional temperatures.

Laboratory Evaluation of Warm Asphalt Binder Aging Characteristics, 2009

This paper presented the results of a study to evaluate the aging characteristics of WMA binders artificially aged in the rolling thin film oven (RTFO) and the pressure aging vessel (PAV). The outcome of the study showed that by reducing the mixing temperatures of WMA binders, the aging of the binders can be reduced. After artificial aging, binders containing Asphamin had significantly higher viscosities compared with the unmodified binders, and binders containing Sasobit had significantly lower viscosities compared with the unmodified binders. Binders containing Asphamin and Sasobit had higher $G^*/\sin\delta$ values compared with unmodified binders. Thus, adding the warm asphalt additives improved the rutting resistance of the binders. Addition of Asphamin and Sasobit did not seem to influence the fatigue resistance of the binders, as the $G^*\sin\delta$values for binders with and without the warm asphalt additives were not significantly different in most cases. Binders containing Asphamin and Sasobit had significantly higher creep stiffness values compared with unmodified binders. Thus, the authors concluded that adding the warm asphalt additives made the binders stiffer at low temperatures.

High Temperature Properties of Rubberized Binders Containing Warm Asphalt Additives, 2009

This paper presented the high temperature properties of rubberized binders containing warm asphalt additives (i.e. Aspha-min and Sasobit). The addition of warm asphalt additive Sasobit significantly decreased the high temperature viscosity, while the addition of Asphamin increased the viscosity due to the filling effect of the additive. Higher failure temperatures than the control rubberized binders were recorded for both WMA types, indicating better resistance on permanent deformation at high temperature.

Fatigue Behavior of Rubberized Asphalt Concrete Mixtures Containing Warm Asphalt Additives, 2009

This study explored the utilization of the conventional fatigue analysis approach in investigating the fatigue life of rubberized asphalt concrete mixtures containing the WMA additives (Asphamin and Sasobit). The results indicated that the fatigue life of the mixtures made with crumb rubber and WMA additive is greater than the control mixtures (no rubber and no WMA additive). The combination of the crumb rubber and WMA additive in asphalt binder is beneficial for improving the rheological properties of both the unaged and aged binders (e.g. increase $G^*\sin\delta$ and reduce $G^*/\sin\delta$ values). The increase in the mixing and compaction temperatures due to the addition of crumb rubber can be offset by adding the warm asphalt additives, which lowers the mixing and compaction temperatures of rubberized mixtures comparable to conventional HMA.

Effects of Compaction Temperature on Volumetric Properties of Rubberized Mixes Containing Warm-Mix Additives

This study investigated the effects of compaction temperature on rubberized mixes containing the warm mix additives (Asphamin and Sasobit). The authors found that the compaction temperatures of Crumb Rubber Modifier (CRM) mixtures containing the warm mix additives can be decreased to those of the control mixtures, with the target air void contents satisfied. In addition, Regardless of the compaction temperature, the addition of warm mix additives into CRM mixtures resulted in the increase of %VFA (Voids Filled with Asphalt Cement) values and the decrease of %VMA (Voids in the Mineral Aggregate) values.

Evaluation of Selected Warm-Mix Additives for Asphalt Recycling, 2010

This study evaluated the possibility of using WMA additives (Evotherm and Sasobit) for recycling recovered binder. The results of this study indicated that Evotherm was better than Sasobit for stiffness and viscosity reduction of the recycled binder, and also that Evotherm could be used to recycle up to 30% of the recovered binder without using rejuvenator at 135^{o}C. Therefore, it was concluded that the additive, Evotherm, could be efficiently used for WMA recycle without using rejuvenator, but Sasobit was better for normal binder WMA process than WMA recycle process.

APPENDIX H – RECOMMENDATIONS OF NCHRP AND OTHER STUDIES

Specimen Fabrication Procedures

"All of the WMA processes, including plant foaming processes, could be reasonably reproduced in the laboratory for mixture design and performance evaluation. The Draft Appendix to AASHTO R 35 includes process-specific specimen-fabrication procedures for the major categories of WMA processes."

Coating

"The type of mixer used to prepare laboratory mixtures of WMA significantly affects the coating of coarse aggregate particles. The Draft Appendix to AASHTO R 35 includes a note that the mixing times included in the appendix were developed using a mechanical planetary mixer with a wire whip. Mixing time for bucket mixers should be determined by preparing HMA mixtures using the viscosity-based mixing temperature from AASHTO T 312, and evaluating coating."

Workability

"Devices that measure the torque during mixing or the force to move a blade though loose mix could not detect differences between HMA and WMA mixtures at normal WMA production temperatures. Differences could be detected at lower temperatures associated with compaction."

Compactability

"The Draft Appendix to AASHTO R 35 includes evaluating the compactability of WMA mixtures by determining the number of gyrations to 92-percent relative density at the planned field compaction temperature and 54°F (30°C) below the planned field compaction temperature. A maximum increase in gyrations of 25 percent when the compaction temperature is reduced is recommended."

Moisture Sensitivity

"Moisture sensitivity, as measured by AASHTO T 283, will likely be different for WMA compared to HMA. Some WMA processes improve the resistance to moisture damage because they include anti-strip additives. Anti-strip dosage rates may be different for WMA compared to HMA. The Draft Appendix to AASHTO R 35 recommends that moisture sensitivity be evaluated and that appropriate anti-strip additives be used if needed."

Rutting Resistance

"The rutting resistance of all WMA processes except Sasobit, as measured by the flow number test on mixtures conditioned for 2 h at the planned field compaction temperature, is lower compared to HMA. Current criteria for the flow number test are based on mixtures that have been short-term conditioned for 4 h at 275°F (135°C). This conditioning represents the aging that occurs during construction as well as some time in service. A two-step conditioning process that includes 2 h at the compaction temperature followed by further loose mix aging at a representative service temperature appears feasible.

The Draft Appendix to AASHTO R 35 recommends performing flow number tests on laboratory prepared mixtures that have been conditioned 2 h at the planned field compaction temperature to simulate the effect of construction. The flow number criteria included in the Draft Appendix to AASHTO R 35 were adjusted to be 56 percent of the values recommended in NCHRP Project 09-33. This adjustment was made to account for the fact that the standard aging of 4 h at 275°F (135°C) used with HMA accounts for the stiffening that occurs during construction as well as some time in service."

Fatigue Resistance

"The fatigue resistance of WMA and HMA are similar for mixtures made from the same asphalt binders and aggregates and having the same volumetric properties. The draft standard practice for measuring properties of WMA for performance analysis using the MEPDG does not include a fatigue test since the calibrated fatigue relationship in the MEPDG should also apply to WMA mixtures."