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Regional Implementation of Warm Mix Asphalt

by

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16. Abstract

Asphalt is used in over 94 percent of all paved roadways in the United States. The ability to reduce its cost and emissions while improving its performance has benefits that could potentially change the direction the asphalt industry moves toward in the future. Warm-mix asphalt (WMA) technology is becoming more prevalent in routine roadway construction across the country. It provides many benefits over conventional hot-mix asphalt (HMA).

There are three groups of technologies currently being used to achieve these lower temperatures. They are chemical additive, organic additive (wax), and water additive (foamed). Each of these technologies is different, yet they all function on the same basic concept. They each decrease the viscosity of the liquid binder, thus allowing the binder to more easily coat the aggregate at a cooler temperature.

In the last decade, WMA has increasingly been used across the country. Many states have developed special provisions or have modified their standard specifications to accommodate the use of WMA. In an attempt to quantify the use of WMA technology in the southeastern region of the United States, this study was initiated with the following objectives.

1. To inform research agencies of the work that is ongoing, as well as the work that has already been done.
2. To provide a document that can be used to educate and inform contractors from an unbiased perspective of the costs and benefits associated with the different types of warm mix asphalt.
3. To assist government agencies in establishing acceptance criteria for warm mix asphalt, thus allowing it as a suitable replacement for hot mix asphalt.

A survey was sent to 12 southeastern states to attempt to answer the questions listed above. Also, internet searches were conducted to determine specification and policy changes that were made in the subject states to accommodate WMA technology.

Results of the research indicated that WMA technology is being used in all of the southeastern states and that all of the states have made changes in standard specification and special provisions to permit the use of WMA. The most significant change made in specifications is the permission to allow the mixing and placing of WMA at cooler temperatures.

Although more long-term performance data is needed, it appears that at this time the performance of WMA technology is comparable to that of conventional HMA. The cost between HMA and WMA does not currently appear to be significant.

WMA appears to be a viable technology, and its use is expected to increase in the immediate future.

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SOUTHEASTERN TRANSPORTATION CONSORTIUM
SYNTHESES OF RESEARCH RESULTS

Regional Implementation of Warm Mix Asphalt

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EXECUTIVE SUMMARY

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There are three groups of technologies currently being used to achieve these lower temperatures: chemical additive, organic additive (wax), and water additive (foamed). Each of these technologies is different, yet they all function on the same basic concept. They each decrease the viscosity of the liquid binder, thus allowing the binder to more easily coat the aggregate at a cooler temperature.

In the last decade, WMA has increasingly been used across the country. Many states have developed special provisions or have modified their standard specifications to accommodate the use of WMA. In an attempt to quantify the use of WMA technology in the southeastern region of the United States, this study was initiated with the following objectives:

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5. To provide a document that can be used to educate and inform contractors from an unbiased perspective of the costs and benefits associated with the different types of warm mix asphalt.

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A survey was sent to 12 southeastern states to attempt to answer the questions listed above. Also, internet searches were conducted to determine specification and policy changes that were made in the subject states to accommodate WMA technology.

Results of the research indicated that WMA technology is used in all of the southeastern states and that all of the states have made changes in standard specifications and special provisions to permit the use of WMA. The most significant change made in specifications is the permission to allow the mixing and placing of WMA at cooler temperatures.

Although more long-term performance data is needed, it appears that at this time the performance of WMA technology is comparable to that of conventional HMA. The cost between HMA and WMA does not currently appear to be significant.

WMA appears to be a viable technology, and its use is expected to increase in the immediate future.

CHAPTER 1: INTRODUCTION

Asphalt is used in over 94 percent of all paved roadways in the United States. The ability to reduce its cost and emissions while improving its performance has benefits that could potentially change the direction the asphalt industry moves in the future. Warm-mix asphalt (WMA) technology is becoming more prevalent in routine roadway construction across the country. It provides many benefits over conventional hot-mix asphalt (HMA). Some of these benefits are a decrease in mixing and placement temperatures, a decrease in fuel consumption, reduced emissions, a safer work environment and higher densities with lower compactive effort.

There are three groups of technologies currently being used to achieve these lower temperatures: chemical additive, organic additive (wax), and water additive (foamed). Each of these technologies is different, yet they all function on the same basic concept. They each decrease the viscosity of the liquid binder, thus allowing the binder to more easily coat the aggregate at a cooler temperature. This decrease in temperature results in lower energy costs for the producer, as well as a decrease in emissions that are harmful to workers and the environment. The decrease in binder viscosity can also lead to achieving greater in-place densities with less compactive effort.

In the last decade, WMA has increasingly been used across the country. Many states have developed special provisions or have modified their standard specifications to accommodate the use of WMA. As stated above, a number of different WMA technologies are being used by the various state agencies.

OBJECTIVES:

The objectives of this study were:

- To inform research agencies of the work that is ongoing, as well as the work that has already been done. In doing so, this study will enable researchers to more-effectively spend research dollars on areas of WMA research that have been underfunded.

- To provide a document that can be used to educate and inform contractors from an unbiased perspective of the costs and benefits associated with the different types of warm mix asphalt. This document will assist in educating the industry, further enabling contractors to make fully-informed decisions based on the full body of knowledge.

- To assist government agencies in establishing acceptance criteria for warm mix asphalt, thus allowing it as a suitable replacement for hot mix asphalt. Some states already have warm mix specifications in place, and by quantifying the effectiveness of these specifications, this document will provide valuable assistance to government agencies.

METHODOLOGY:

Literature Review:

A literature search and review was conducted on available articles and papers using library and Internet sources. Information was collected on the use, properties, methods of construction, advantages and disadvantages, construction problems, long-term performance, cost, and other variables of WMA.

Survey:

A 25-question survey was sent to materials personnel in 12 southeastern states:

Alabama
Arkansas
Florida
Georgia
Kentucky
Louisiana
Mississippi
North Carolina
South Carolina
Tennessee
Virginia
West Virginia

The survey is included in the appendix.

Research on Specification Changes:

Information on specification changes or special provisions that were made or written to accommodate WMA in each southeastern state was obtained by extensive Internet searches.

Research on Approval Process or Procedures:

As in the previous section, much of the information on the approval process or procedure used in each state to approve WMA was available on the Internet. However, a considerable amount of information was obtained by personal conversations with materials personnel in a number of southeastern states.

CHAPTER 2: LITERATURE REVIEW

INTRODUCTION

To help understand the state of practice in the use of WMA, a literature survey and review was conducted. Various databases were searched to obtain a sizable number of publications describing the current research on WMA and the extent of use of WMA by various agencies across the country. It appears most, if not all, state agencies have used or have implemented the use of WMA (some on an experimental basis only).

WMA can be made in a number of different ways. These include organic chemicals (usually waxes) that reduce the viscosity of the asphalt binder. Mineral additives (such as zeolite) are also used. WMA can also be produced by the injection of a small amount of water into the hot binder (foaming technology). The more common WMA technologies currently used are listed in the following table.

It appears that the general consensus across most agencies is that there are a number of advantages to using WMA. The following list shows the most commonly discussed and assumed advantages of WMA:

1. Ability to pave at lower temperatures,
2. Lower temperatures increase mix durability,
3. Ability to increase haul distances,
4. Reduced plant emissions,
5. Savings on energy costs,
6. Help in eliminating premature ageing of the asphalt binder,
7. Easier compaction,
8. Reduced volatile organic compounds (VOC), and
9. Increased RAP usage.

The most commonly expressed concerns with WMA are

1. Susceptibility to moisture,
2. Rutting,
3. Stiffness,

4. Dynamic modulus,

5. Cracking in all forms, and

6. Long-term performance.

WMA technologies that are currently being used in the paving industry are listed in table 1.

Table 1. WMA technologies

WMA Technology	Process
Double Barrel Green	**Foaming**
Evotherm	**Chemical Additive**
Low Energy Asphalt (LEA)	**Foaming**
Rediset WMX	**Chemical Additive**
Sasobit	**Organic Additive**
Synthetic Zeolite	**Foaming**
WAM-Foam	**Foaming**

It appears that the asphalt foaming process is one of the more popular methods currently being used.

The literature review indicated that a considerable amount of laboratory research has been conducted and is currently ongoing concerning WMA. However, there is far less information available as related to field studies. Some field studies are in progress, but with little final definitive conclusions published. As a result, there appears to be very little long-term performance data comparing WMA with conventional HMA. The information that is available is more anecdotal than statistical.

In addition, laboratory data can appear to be contradictory when comparing the results of one study with another. Variables such as locally available aggregates, local binder sources, and testing protocols have large influences on the final results. Consequently, extrapolating data or attempting to use the results from one laboratory study to a different set of laboratory conditions and materials would appear to be questionable.

COMPARISON OF WMA WITH CONVENTIONAL HMA

The following sections list a number of conclusions and comments from various research agencies that compare WMA with conventional HMA as related to different forms of pavement distress.

Moisture Susceptibility

- AASHTO T 283 testing indicated an increase in moisture damage potential for WMA technologies (*Hurley, 2009*).
- Results indicate that most WMA mixtures tend to be relatively more moisture sensitive as compared to a similar HMA mixture (*Agrega, 2012*).
- Similar resistance to moisture damage as HMA (*Kasozi, 1012*).
- Super fine hydrated lime helps the moisture susceptibility of WMA (*Leng, 2011*).
- Laboratory Tensile Strength Ratio (TSR) results indicate similar performance with regard to moisture susceptibility for both the WMA and HMA (*Jones, 2011*).
- Nebraska uses hydrated lime in their mixes. Evothrem WMA additive did not perform well with the hydrated lime in the mix and had greater moisture susceptibility (*Townsend, 2013*).
- Performance testing indicated the WMA test mixes were slightly more susceptible to moisture damage than the HMA control mix (*Aschenbrener, 2010*).
- The test results indicated that the aggregate source did not show a remarkable effect on moisture susceptibility of mixture in this study (*Xiao, 2011*).

Rutting

- The WMA pavements are comparable to their corresponding HMA control pavements in terms of rutting and roughness (*Bower, 2012*).
- In general, the asphalt mixture prepared with Sasobit® technology and the control HMA mixture measured higher rutting than those prepared with the other WMA technologies (*Zelelew, 2013*).

- Sasobit had the longest amount of time to stripping, but had greatest rutting (*Alexander, 2012*).
- After 13 months in service, the HMA and WMA sections exhibited similar field performance. Both sections have virtually no rutting (*Jones, 2011*).
- The test results indicated that the aggregate source significantly affects the Indirect Tensile Strength (ITS) and rutting resistance regardless of the foaming water content, aggregate source approval (ASA), and aggregate moisture content (*Xiao, 2011*).

Cracking

- The WMA pavements show less reflective transverse cracking than their corresponding HMA control pavements (*Bower, 2012*).
- To date, the overall short-term performance of WMA pavements is comparable to that of HMA pavements, except that WMA mixes seem to be more resistant to the early stages of reflective cracking than HMA mixes in the field (*Bower, 2012*).
- In the context of using WMA in combination with reclaimed asphalt pavement (RAP), in most cases the use of RAP with WMA does not offer any significant improvement in the resistance to low temperature cracking after long-term aging as compared to the use of RAP with a conventional HMA (*Bower, 2012*)
- Better thermal cracking resistance than HMA (*Kasozi, 2012*).
- Sasobit had the greatest cracking in the field (*Alexander, 2012*).
- No adverse low-temperature cracking issues were detected (*Saboundjian, 2011*).

Long-Term Field Performance

- After 13 months in service, the HMA and WMA sections exhibited similar field performance. Both sections have virtually no rutting or cracking, but they had an appreciable amount of raveling. Tests on cores taken from the WMA and HMA pavements had very similar characteristics (*Jones, 2011*).
- The HMA control section exhibited minor longitudinal cracking after approximately 2.9 million equivalent single axle load (ESALs). No cracking was observed in the WMA certification section (*Powell, 2012*).
- After three years of field evaluations, the performance of the WMA test sections was comparable to the HMA control sections in regards to rutting,

cracking, and raveling (*Aschenbrener, 2010*).

• The field performance was excellent (*Aschenbrener, 2010*).

Summary Comments

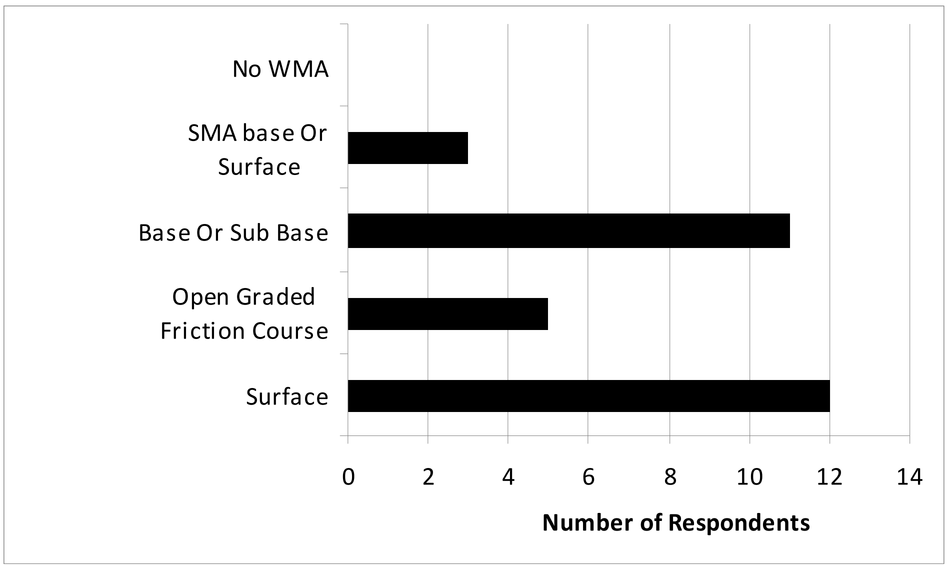
As can be seen from the previous comments and conclusions, results from the various research agencies vary considerably, indicating that there are many other factors that enter into the behavior of WMA mixtures. It also appears that transferring or extrapolating data from one study to another is not possible because of the wide variability of factors that control WMA behavior. Also, from the above comments and conclusions, it appears that each WMA mixture must be designed individually using local aggregates and binders.

Although more long-term field performance is needed, it appears that WMA is a viable technology and will probably increase in use in the future.

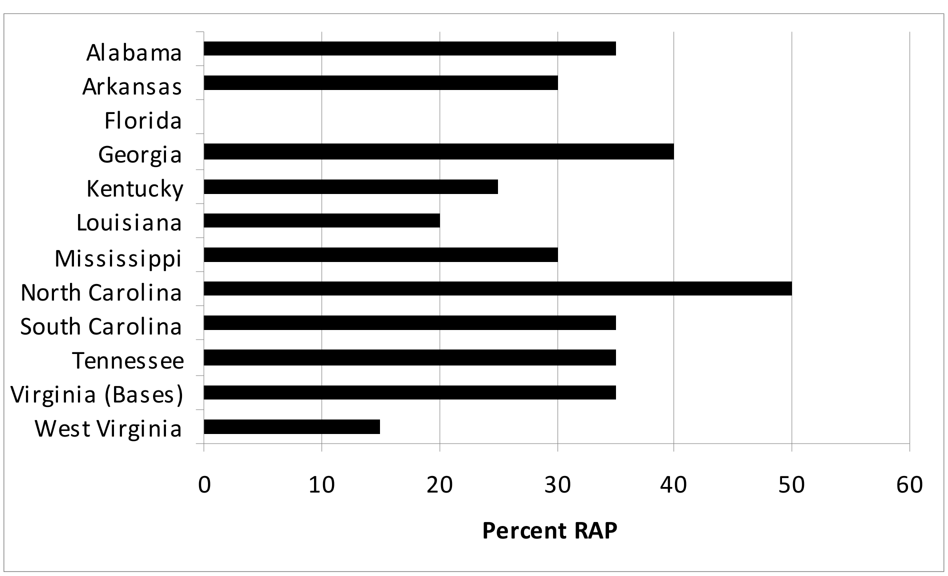
CHAPTER 3: RESULTS OF SURVEY

To determine the extent of implementation of warm-mix asphalt in the southeast region of the United States, a survey was conducted. A series of 25 questions were sent to 12 states in the southeast. All states responded. The questions and responses are given below.

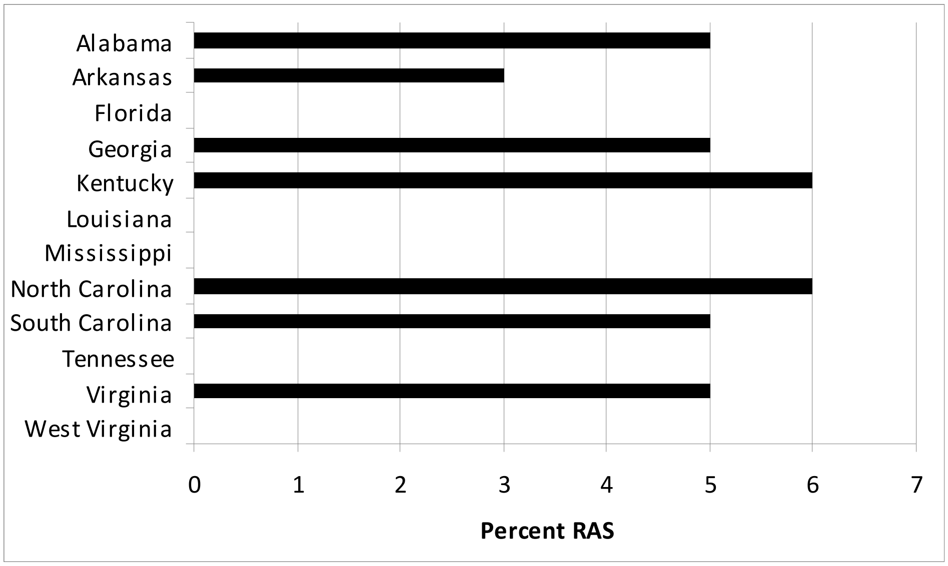
<u>Question No. 1</u>: Identify the Types of mixes where Warm-Mix Asphalt is used by your agency.



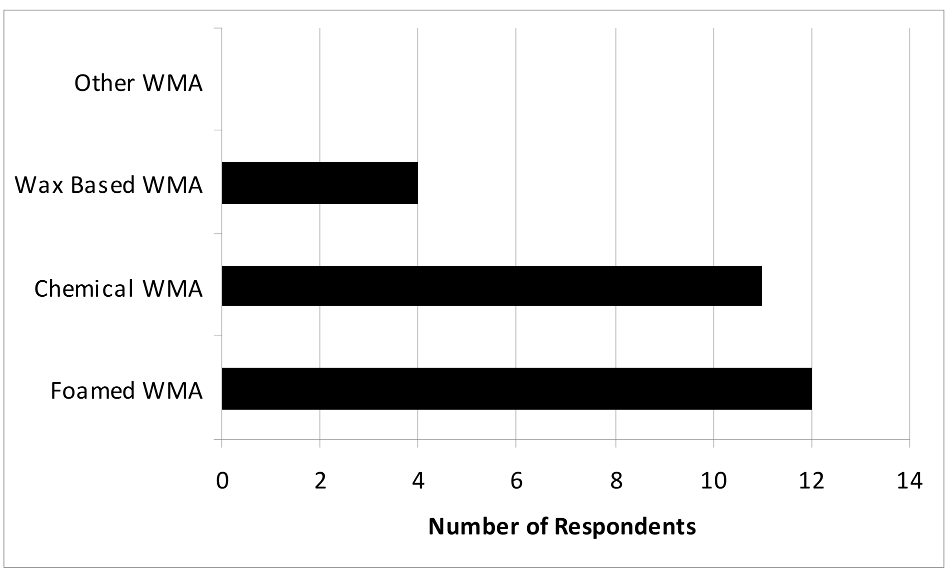
<u>Question No. 2</u>: Do you use RAP in your WMA? Eleven Respondents answered Yes. *What percent is allowed?*



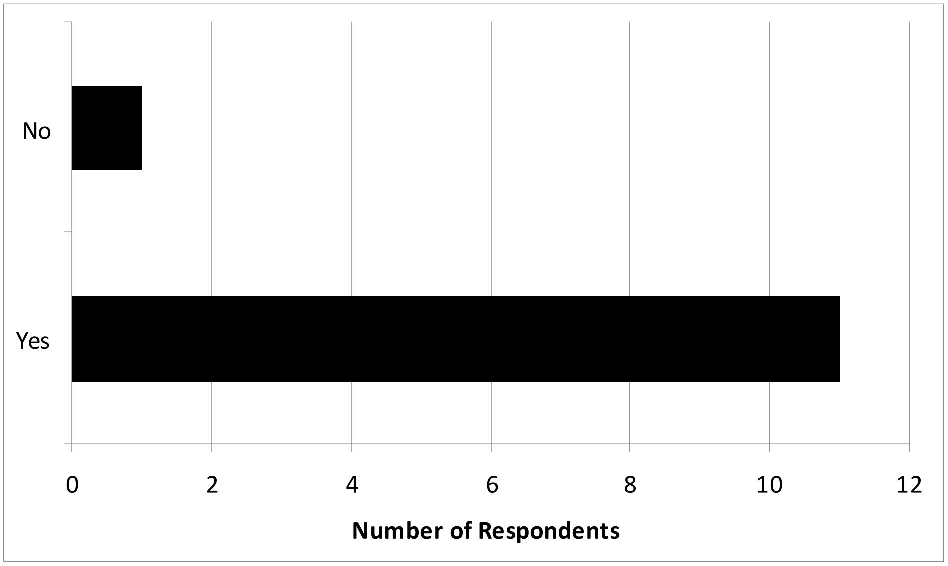
Question No. 3: *Do you use RAS in your WMA?* Seven respondents answered Yes. *What percent is allowed?*



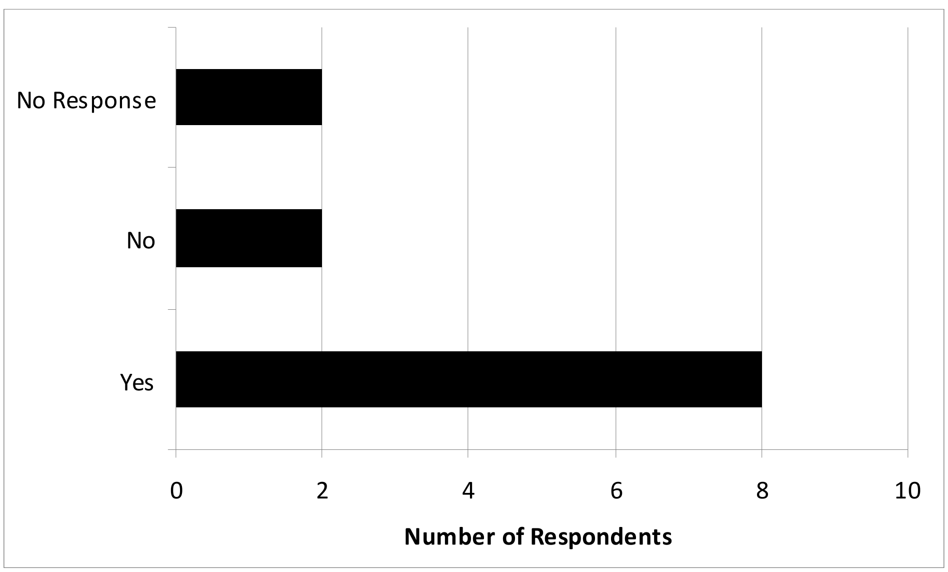
Question No. 4: *What Type of WMA have You Utilized?*



Question No. 5: Have you modified your standard specifications to allow WMA?



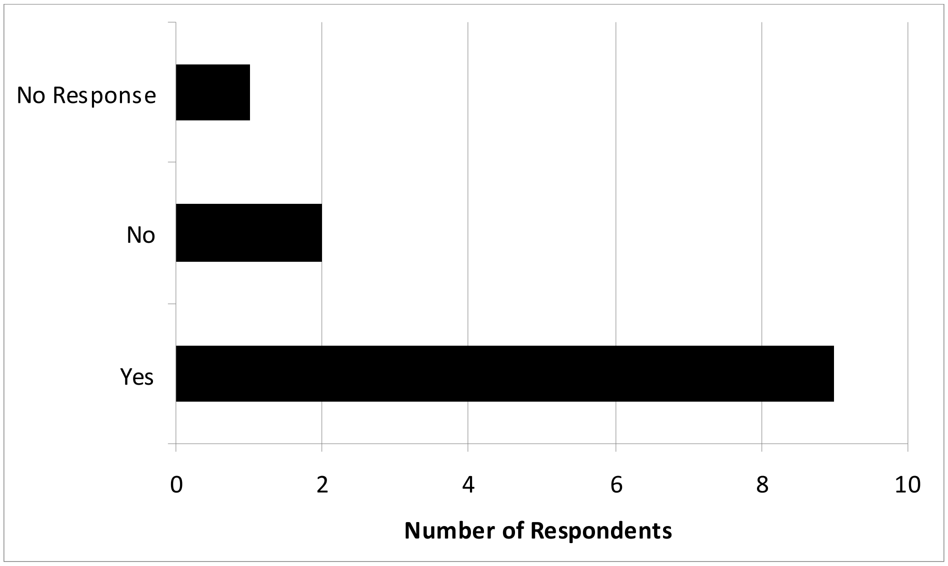
Question No. 6: Is WMA permitted on an experimental basis?



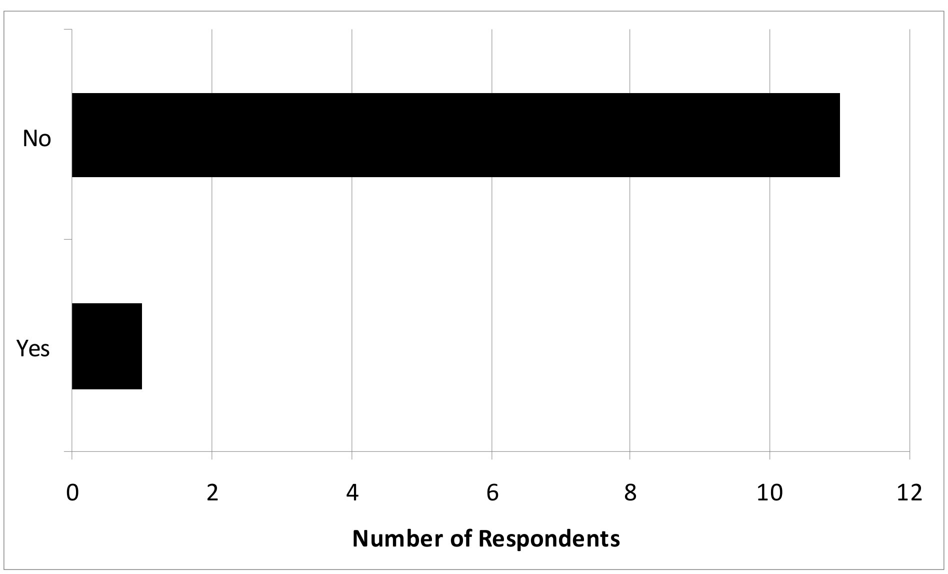
<u>Question No. 7</u>: Does your state have an approved list for allowing the different WMA technologies?

There was no response from any respondent.

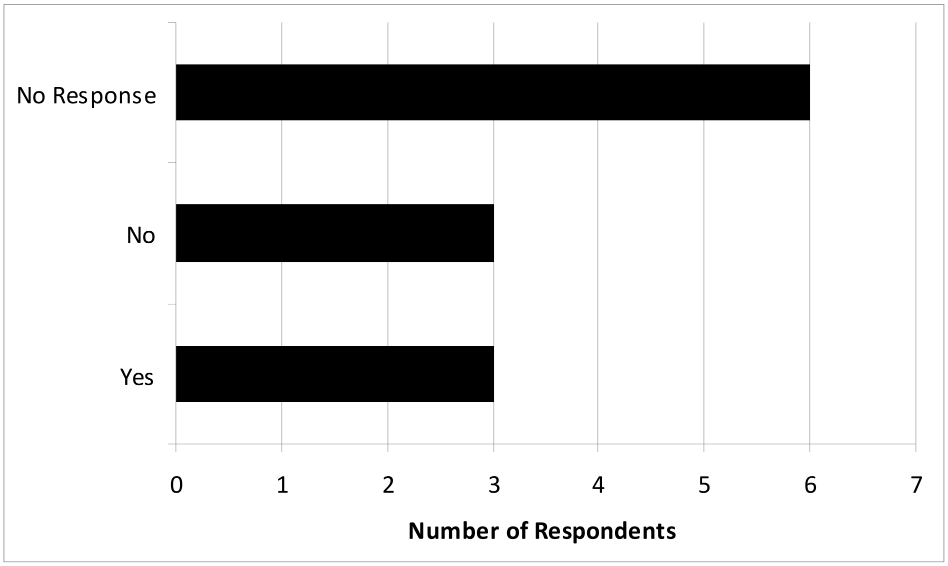
<u>Question No. 8</u>: Does your state have an approved procedure for allowing the different WMA technologies?



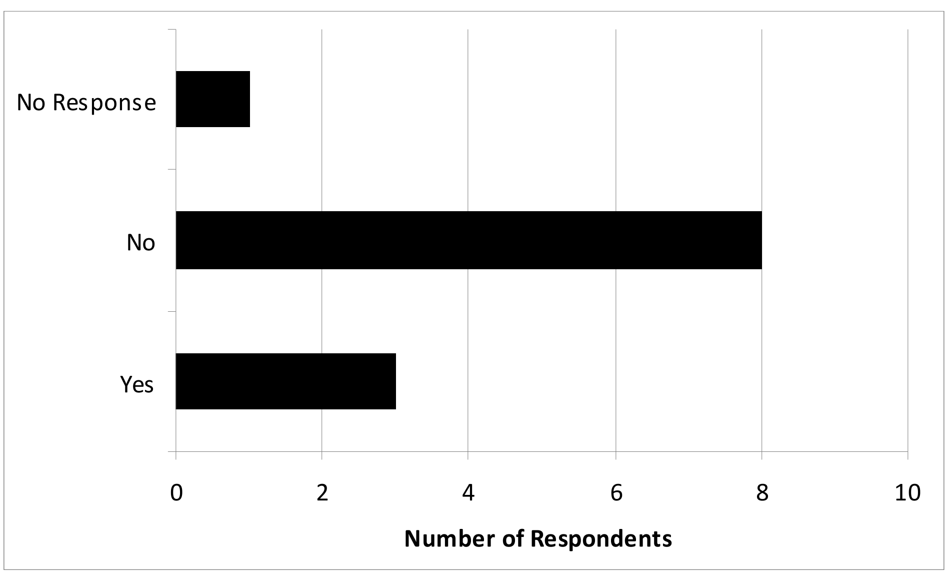
<u>Question No. 9</u>: Have you modified your mix design procedures to facilitate the use of WMA?



<u>Question No. 10</u>: Compared to the conventional HMA, is WMA more or less expensive in your state?



<u>Question No. 11</u>: Has the use of WMA created more competition among bidders on projects due to the ability to haul mix further prior to placement?



<u>Question No. 12</u>: List any positive constructability issues associated with WMA.

We have limited experience, but have not seen any real positive constructability issues so far. *(Georgia)*

It's not as hot. *(Arkansas)*

Have generally been able to achieve desirable density ranges with less compactive effort. *(West Virginia)*

It was easier to get compaction. *(Louisiana)*

WMA can be used as a compaction aid. *(Kentucky)*

Mixtures appear to be more consistent. *(Tennessee)*

The ability of the contractor to achieve density seems to be better. Most asphalt contractors now have the ability to produce WMA. *(Mississippi)*

WMA has been used at higher production temperatures in extended haul situations to extend workability. *(Virginia)*

The mix seems to be less prone to segregation and helps produce a more consistent surface. We have generally been able to achieve desirable density ranges with less compactive effort. We have seen generally 20-30 degrees F lower temperatures during production as compared to same mix without foaming, by water injection. *(West Virginia)*

We are able to have longer haul distances. *(Alabama)*

<u>Question No. 13</u>: List any negative constructability issues associated with WMA.

On very limited test sections, with placement of a couple of WMA additives, we experienced placement issues of pulling and tearing behind the paver which is typically associated with cool or cold mix. *(Georgia)*

Handwork can be problematic. *(Arkansas)*

We have heard complaints about workability. It can be difficult for the finishing roller to do a good job. *(Tennessee)*

A standard process for determination of proper production and placement temperatures is still up in the air. *(Mississippi)*

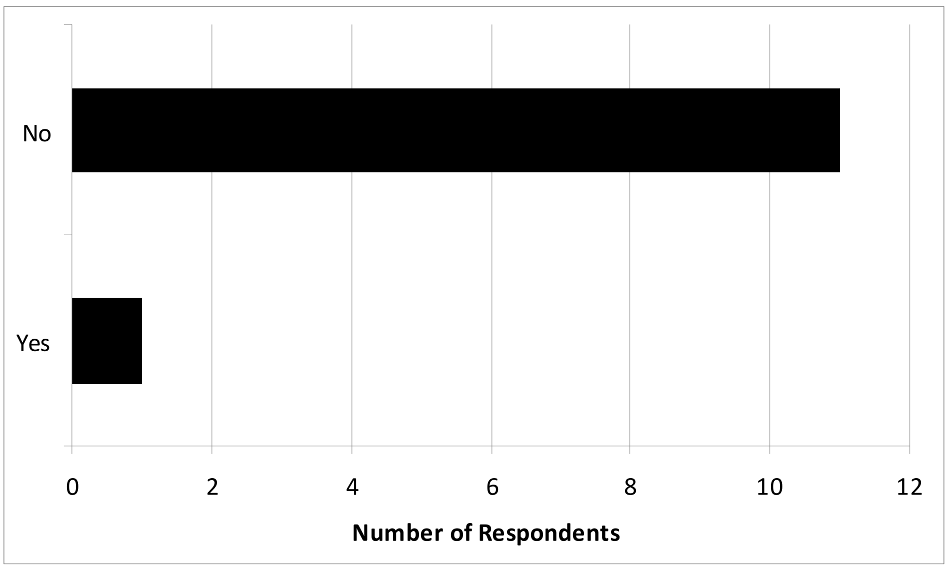
None have been noted. *(Florida and Virginia)*

Local Governments want HMA, not WMA, and contractors do not like switching from warm mix to hot mix. Therefore, many stay with HMA. *(West Virginia)*

We have seen some negatives on WMA projects, but not necessarily anything that would point directly to the use of WMA, as compared to traditional HMA. *(Louisiana)*

Contractors sometimes try to run too cold*. (Alabama)*

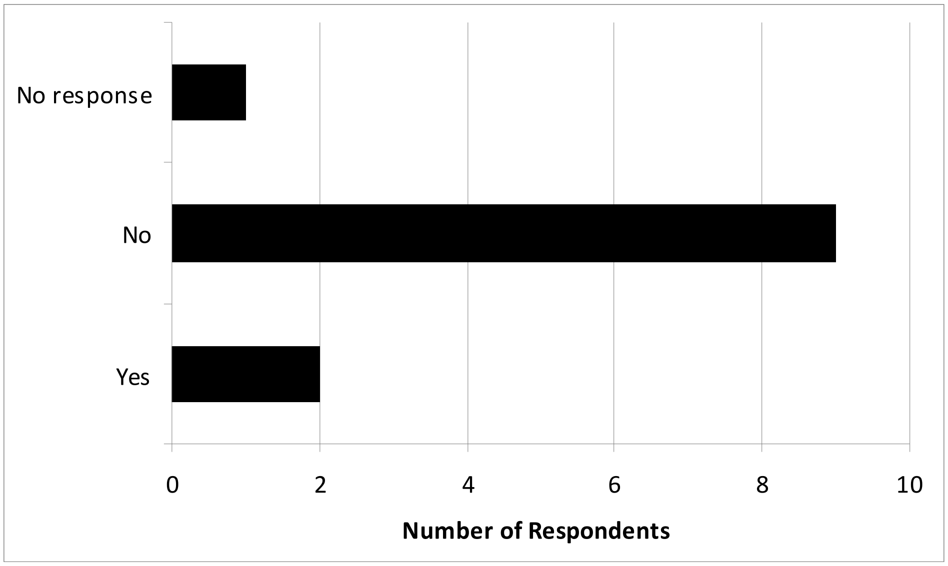
<u>Question No. 14</u>: Has WMA allowed you to extend the construction season in your state?



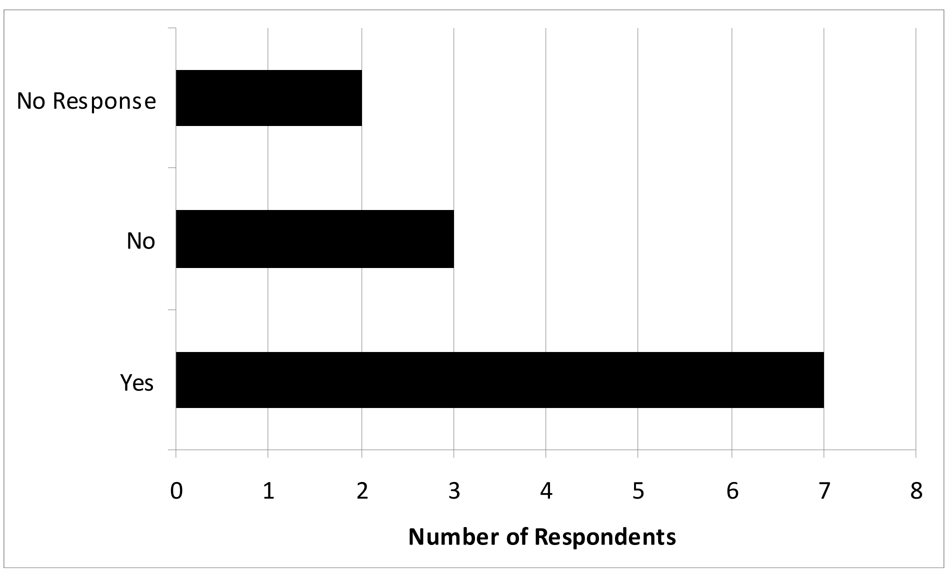
If YES, by how Much?

- One-to-two months. (Florida)
- Lower ambient air temperature by five degrees F. (West Virginia)
- Still evaluating. (Louisiana)

Question No. 15: Have you increased in-place density on projects Where WMA has been utilized?



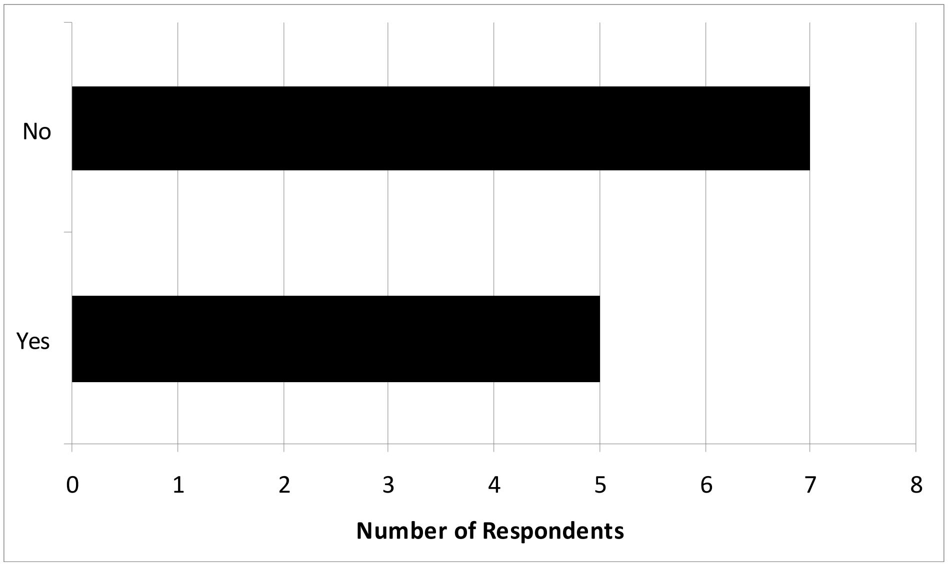
Question No. 16: Are any contractors using less compactive effort to achieve the same in-place density as HMA?



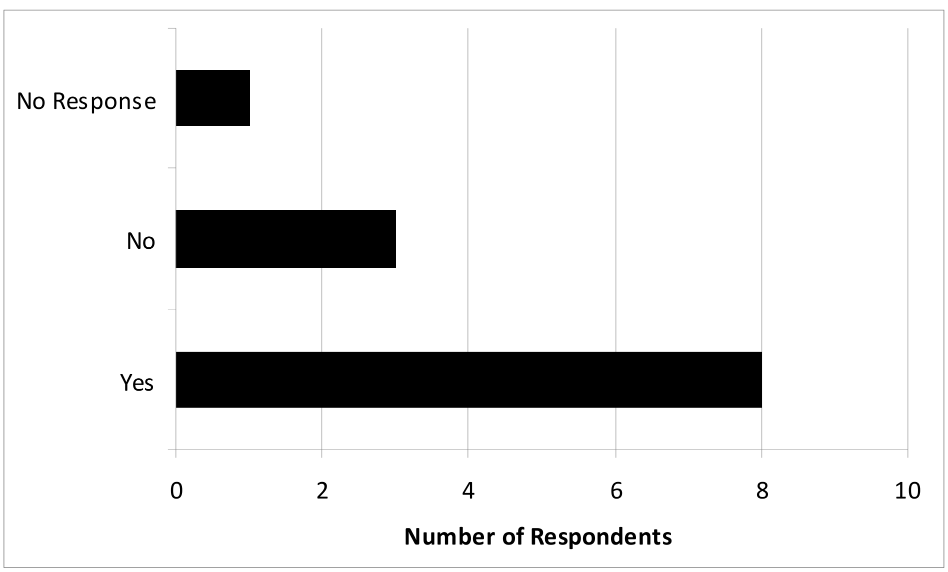
Question No. 17: Estimate the quantities of the following that have been used in your state.

The results reported by the states could not be interpreted.

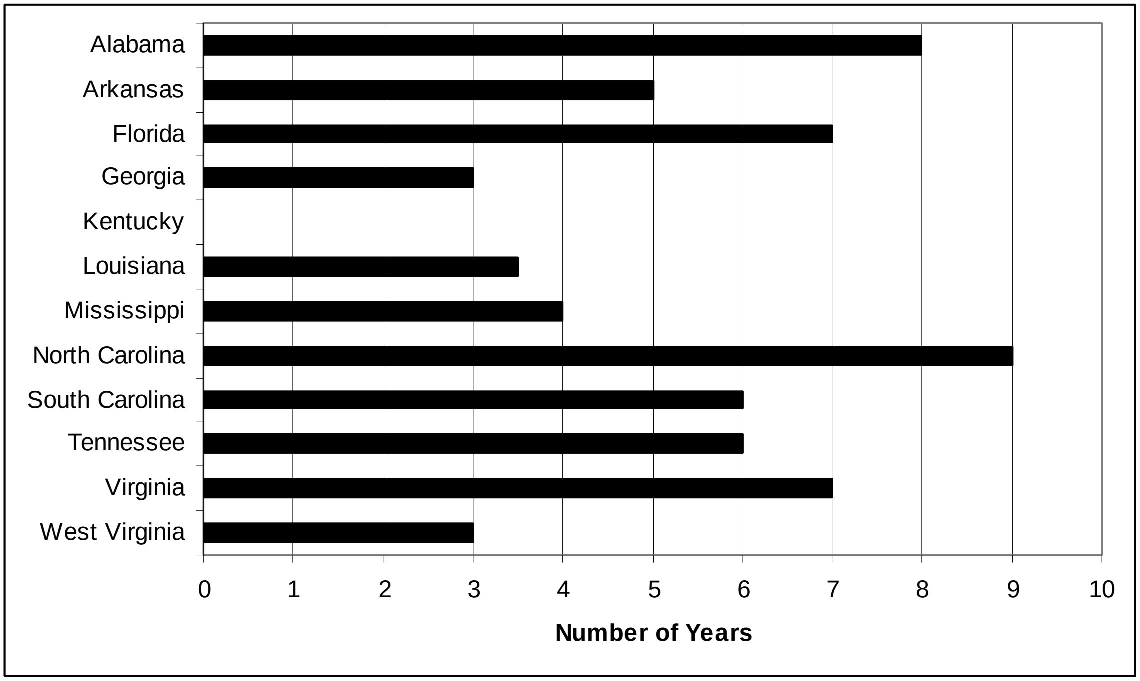
Question No. 18: Have you observed any constructability differences among the different types of WMA technologies?



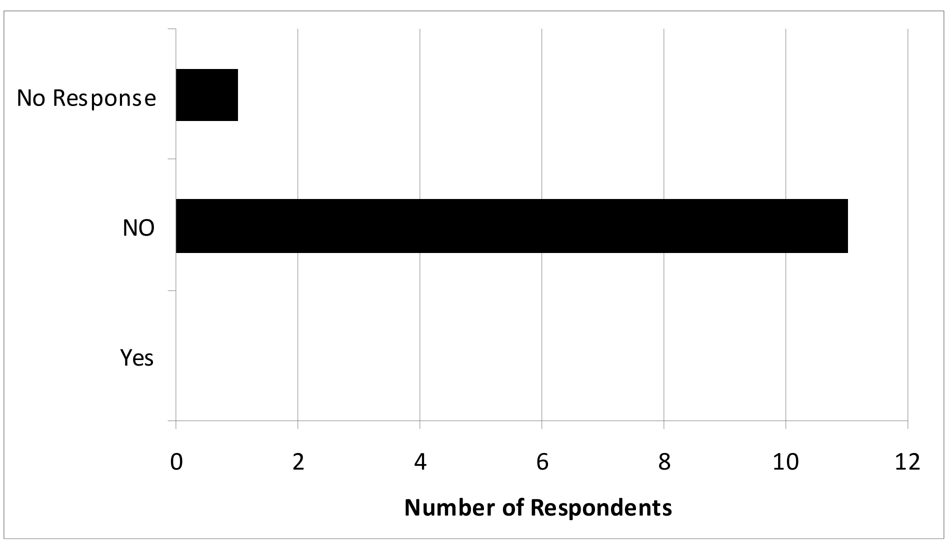
Question No. 19: Has your agency modified their construction specifications to specifically address WMA?



<u>Question No. 20</u>: *How long has your oldest WMA project been in service?*



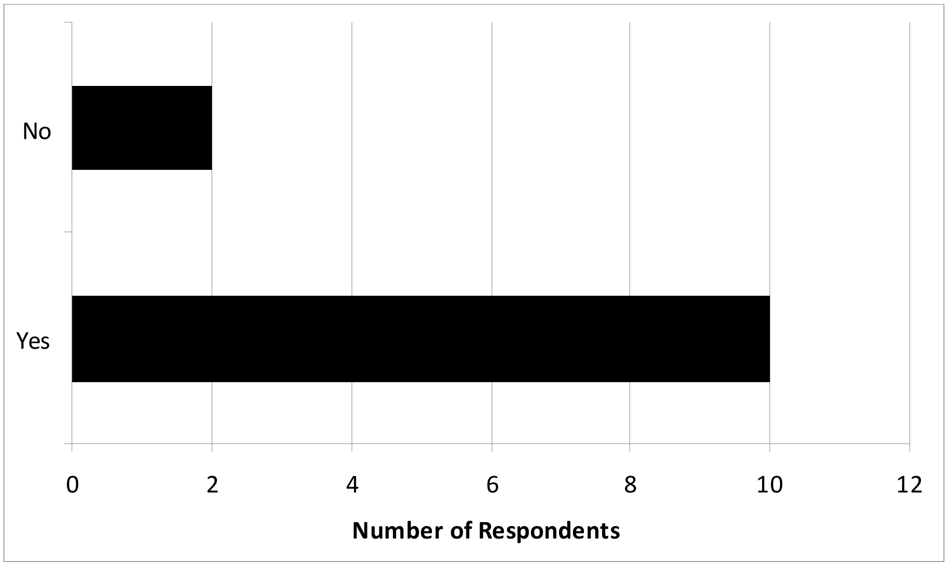
<u>Question No. 21</u>: *Have you observed any performance differences Between conventional HMA and WMA?*



Question No. 22: Are there particular distresses that seem more prevalent in WMA versus HMA pavements?

All respondents replied no.

Question No. 23: Are you currently monitoring any specific WMA sections for long-term performance?



Question No. 24: Has your agency completed any research projects in any of the following areas, if so are there research reports or summaries available?

	Yes	No	No Response
WMA constructability	**1**		**9**
Constructability Report or Summary Available?		**5**	**5**
WMA Mix Design	**1**		**9**
Mix Design Available?		**5**	**5**
WMA Performance	**3**		**7**
Performance Available?	**1**	**7**	**2**

<u>Question No. 25</u>: Do you currently have research underway related to WMA?

	Yes	No	No Response
Constructability Underway			**10**
Mix Design Underway	**2**		**8**
Performance Underway	**5**		**5**

The following general observations and comments are based upon a review of the previous responses to the survey questions.

- WMA is used mostly in surfaces and bases or sub bases.
- All 12 states allow RAP in WMA mixes, ranging from a high of 50 percent to a low of 15 percent.
- Only seven of the 12 states allow RAS in WMA mixes, ranging from six percent to three percent.
- WMA mixes that are foamed or contain chemical additives are the most popular.
- Eleven of the 12 states have modified their standard specifications to permit WMA.
- Eight states permit WMA on an experimental basis.
- Nine states do have an approved procedure for permitting various WMA technologies.
- Only one state has modified their mix design procedure to accomadate the use of WMA.
- The question of the cost of WMA as compared to convential HMA has not been definitively determined.
- It appears that, generally speaking, competition between bidders has not increased as a result of using WMA.
- Eleven states indicated that the construction season has not been extended as a result of using WMA.
- Nine states indicated that in-place density has not increased as a result of using WMA.
- Seven of the 12 states are apparently using less compactive energy to achive target densities when using WMA, as compared to conventional HMA.
- The question of whether there are constructability differences between the various WMA technologies appears to be fairly evenly divided among the states (six indicated *no,* four indicated *yes,* and two had no response).
- Eight states *have* modified their *construction* specifications to address WMA.

- It appears that most WMA projects have been in service from three to six years, with one project in service for approximately nine years.
- Eleven states said that they have observed no difference in performance between WMA and conventional HMA. One state did not respond to that question.
- All twelve states responded that there appeared to be no difference between WMA and HMA so far as any particular distress or distresses.

CHAPTER 4: SPECIFICATION CHANGES

Of the states that were surveyed in this study, all have made changes in their standard specifications or have issued special provisions/procedures. It appears that these changes began to be made in 2010 and have continued through the present. All surveyed states now permit WMA technology in at least one form or another.

Specifications and procedures for the production and acceptance of WMA are generally the same as for conventional HMA. A statement in the supplemental specification issued by Arkansas summarizes this quite well, "All provisions for the production and placement of conventional HMA mixtures….are applicable [for WMA] except as noted…." The most notable exception is that lower production temperatures and placement temperatures are permitted. This exception holds true in all 12 survey states.

The table 2 below shows how each state approached specification changes in order to include WMA technology.

Table 2. Specification approach to include WMA technology

Revised Standard Specifications	Issued Supplemental Specifications	Issued Special Provisions/Procedures
Florida	Arkansas	Alabama
Kentucky	Louisiana	Georgia
North Carolina	South Carolina	Mississippi
West Virginia	Tennessee	
	Virginia	
	West Virginia	

The following table lists the detailed changes or revisions that were made by each state in their specifications or special provisions/procedures.

Table 3. Summary of Specification Changes

Summary of Specification Changes by State to Accommodate Warm Mix Asphalt

State	*Standard Specification Section*	*Special Provision/Supplemental Specification or Specification Revision Warm-Mix Asphalt*	*Date*
Alabama	**Section 410 (2012 Edition)**	**ALDOT Procedures - ALDOT-436-09 - Warm Mix Asphalt Process/Product Approval** **Subsection 410.02 (e) 5. a.** - *Contractor Proposed Design with Increased RAP and RAS Content* **Subsection 410.03(b) 3.** - *Cold Weather restrictions* **Subsection 410.03 (d) 3. a.** - *Mixing Temperature*	**10/25/2010**
Arkansas	**Section 410 (2003 Edition)**	**DESCRIPTION**: The Department will allow the use of *Warm Mix Asphalt (WMA)*. All provisions for the production and placement of conventional HMA mixtures as stipulated in **Section 410** Construction Requirements and Acceptance of Asphalt Concrete Plant Mix Courses of the Standard Specifications for Highway Construction, Edition 2003, are applicable except as noted below. Section 410 Construction Requirements and Acceptance of Asphalt Concrete Plant Mix Courses of the Standard Specifications for Highway Construction, Edition of 2003, is hereby amended as follows: **Section 410.03:** Replace the third sentence with *"WMA production temperatures at the plant shall be according to the Contractor's approved mix design, but may be adjusted based on recommendations of the WMA additive/process manufacturer."* Add the following paragraph: *"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.* **Section 410.07:** Replace the last sentence of the first paragraph with *"Spreading and finishing temperatures shall be according to the Contractor's approved mix design, but in no case shall the WMA be placed at a temperature less than 220° F."*	**6/2/2011**
Florida	**Section 320 (2013 Edition)**	**Section 320 - SUBARTICLE 320-6.3.2 (Page 246 – 247) is deleted and the following substituted:** **320-6.3.2 Test Frequency:** The normal frequency for taking asphalt mix temperatures will be for each day, for each design mix on the first five loads and one out of every five loads thereafter. Take the temperature of the asphalt mix at the plant and at the roadway before the mix is placed at the normal frequency. Record the temperature on the front of the respective delivery ticket. The Engineer shall review the plant and roadway temperature readings and may take additional temperature measurements at any time. If any single load at the plant or at the roadway is within the master range shown in Table 320-2 but does not meet the criteria shown in Table 320-3 (for single measurements or the average of five consecutive measurements), the temperature of every load will be monitored until the temperature falls within the specified tolerance range in Table 320-3; at this time the normal frequency may be resumed. *For warm mix asphalt, the Contractor may produce the first five loads of the production day at a hot mix asphalt temperature not to exceed 330°F for purposes of heating the asphalt paver. For this situation, the upper tolerances of Tables 320-2 and 320-3 as applied to the warm mix asphalt mix design do not apply.*	**Revised 5/10/2013**
	Section 330 (2013 Edition)	**SECTION 330 HOT MIX ASPHALT - GENERAL CONSTRUCTION REQUIREMENTS** **330-1 Description.** This Section specifies the basic equipment and construction requirements for hot mix asphalt *(including warm mix asphalt)* pavements and bases. Establish and maintain a quality control system that provides assurance that all materials, products and completed construction submitted for acceptance meet Contract requirements.	**2013**

Table 3. Summary of Specification Changes (cont'd)

State	Standard Specification Section	Special Provision/Supplemental Specification or Specification Revision Warm-Mix Asphalt	Date
Georgia	Special Provisions 400, 402, 410, 828	***Standard Operating Procedure (SOP) 43-A*** **Title: Approval of Warm Mix Asphaltic Concrete Water Injection Foaming Systems** References are made to Special Provisions 400, 402, 410, 828	**Revised** **2/22/2013**
Kentucky	Section 400 (2012 Edition)	**WMA included in the 2012 Edition of the Standard Specifications** **(Referred to in the following subsections)** **401.02.04 (G) -** *Special Requirements for Dryer Drum Plants - Subsection (G) - Water Injection System* **401.03.01 -** *Preparation of Mixtures* **402.01 -** *Control and Acceptance of Asphalt Mixtures - Description* **402.01.01 -** *Warm Mix Asphalt (WMA) Evaluation and Approval* **402.05.02 -** *Asphalt Mixtures, HMA and WMA, Including Mixtures With Reclaimed Material* **403.03.04 -** *Transporting material* **409.01 -** *Asphalt Materials Using Reclaimed Materials - Description*	**2012**
Louisiana	Section 502 (2006 Edition)	**Supplemental Specifications: Superpave Asphaltic concrete Mixtures (01/11)** ***Subsection 502.02 (b) Additives***, is amended as follows. Subheading (4) is adeded. *(4) WMA (Warm Mix Asphalt) additives: Any chemical additive used to lower the mixing and compaction temperature shall be approved by the Materials Engineer.* ***Subsection 502.03, Design of Asphaltic Mixtures, Job Mix Formula (JMF)***, is amended as follows. Add the following at the end of the fourth paragraph. *When the contractor elects to use a water injection system (foaming device) to produce WMA (Warm Mix Asphalt) mixtures, the contractor shall provide a new JMF number and designate the design mix temperature. The WMA mixtures shall meet all other mix requirements of this section. When chemical additives are used to produce WMA mixtures to reduce mix temperatures, the chemical additive name, dosage and design temperature shall be placed on the JMF.* ***Subsection 502.04, Job Mix Formula Validation.*** The following new paragraph shall be added at the end of this subsection. *Validation will not be required for WMA mixtures when a previously validated and approved JMF is used. However, a new JMF number shall be assigned to designate the new mix temperatures.*	**Revised** **2011**

Table 3. Summary of Specification Changes (cont'd)

State	Standard Specification Section	Special Provision/Supplemental Specification or Specification Revision Warm-Mix Asphalt	Date
Mississippi	Sections 406, 1030, 1102	**Special Provision - Warm Mix Asphalt (the following articles in the Standard Specifications are revised)** Article 1030.02 (h) - *Materials* Article 1102.01 - *Equipment* Article 1102.01(a) - *Equipment* Article 1030.04(d) - *Mix Design Verification* Article 1030.06(a) - *Production* Article 1030.05(d)(2)c - *Production* Article 1030.05(d)(2)a - *Quality Control/Quality Assurance Testing* Article 406.06(b)(1) - *Construction Requirements*	Revised 11/1/2012
North Carolina	Sections 609, 610 (2012 Edition)	**WMA included in the following Standard Secifications Sections** Subsection 609-3 - *Field Verification of Mixture and Job Mix Formula* **Asphalt Concrete Plant Mix Pavements** Subsection 610-1 - *Description* Subsection 610-2 - *Materials* Subsection 610-3 - *Construction of Mixture (Mix Design and Job Mix Formula)* (B) Mix design Criteria (C) Job Mix Formula (JMF)	2012
South Carolina	Divisions 300 and 400 (2007 Edition)	**Supplemental Technical Specification:** **Warm Mix Asphalt (WMA)** SCDOT Designation: SC-M-408 (04/11)	4/1/2011
Tennessee	Sections 300, 400 and 900 (2006 Edition)	**Supplemental Specification - Section 400** (the following subsections were revised) Subsection 407.02 - *Materials* Subsection 407.04a(12) - *Bituminous Mixing Plant* 12. Warm Mix Asphalt process equipment Subsection 407.11 - *Preparation of Bituminous Materials* (B) Warm Mix Asphalt (WMA) **Supplemental Specification - Section 900** (the following subsections were revised) Subsection 918.09(B) - *Chemical Additives* (3) Warm Mix Asphalt (WMA) Additives	Revised 6/12/2013 Revised 6/12/2013

Table 3. Summary of Specification Changes (cont'd)

State	Standard Specification Section	Special Provision/Supplemental Specification or Specification Revision Warm-Mix Asphalt	Date
Virginia	Section 211 (2007 Edition)	**Supplemental Section 211 - Asphalt concrete** Section 211.01 - *Description* Section 211.02 (k) - *Materials* Section 211.03 (f) - *Job Mix Formula* Section 211.15 (a) - *Initial Production*	Revised 1/9/2013
West Virginia	Section 400 (2010 Edition)	**Included in the 2010 Edition of the Standard Specifications for Roads and Bridges** Subsection 401.4.2.1 - *Warm Mix Asphalt*	2010
		Included in 2013 Supplemental Specifications Subsection 401 - Asphalt Base, Wearing, and Patching and Leveling courses Subsection 401.14 - *Pay Items (in the table)*	2013

CHAPTER 5: POLICIES, PROCEDURES OR METHODS OF APPROVAL OF WMA

Although the researchers were unable to determine the procedure or process in all of the southeast states, it appeared from the states that responded that the process or procedure for approving WMA varied considerably from one state to another. Some states have a written formal policy or procedure that clearly delineates the steps in the approval process while other states used a more informal procedure to approve WMA technology. The following paragraphs briefly outline the procedure used in each individual state.

Alabama - The procedure used in Alabama is titled "*Warm Mix Asphalt Process/Product Approval*" (ALDOT-436-09). There are two possible procedures that can be used in Alabama. The first procedure is a two-phased procedure with the first phase being the *Trial Production Mix* phase and the second phase being the *Field Demonstration and Evaluation* phase. The document that outlines this first procedure (ALDOT-436-09) lists eight major items or steps in the process:

1. *Scope* -
   This lists the two-phase process mentioned above.
2. *Referenced Documents-*
   This lists all pertinent documents regarding testing.
3. *Procedure for Product Submittal-*
   This includes instructions to the vendor for the submittal process.
4. *Production Trial Mix-*
   Instructions on how the production trial mix is to be produced.
5. *Testing-*
   Instructions are given for the laboratory testing phase.
6. *Evaluation Mix-*
   This describes how the mix is to be evaluated in the field.
7. *Alternate Evaluation Process-*
   (To be discussed in the next paragraph)
8. *Report-*
   This details the requirements of a report.

The second alternate procedure for approval that can be used in Alabama is described by the following quote from ALDOT-36-09:

> "An alternate evaluation process, "The National Warm Mix Asphalt Certification," is available at the National Center for Asphalt Technology (NCAT) and may be used in lieu of the procedure as given above. Once evaluated by NCAT, a formal report must be submitted to ALDOT's Bituminous Engineer for review and recommendation to the Product Evaluation Board. Information concerning NCAT's certification may be obtained by contacting NCAT at:…." (An address is given).

Arkansas – In Arkansas, the approval process for WMA appears to be more informal. After discussions with personnel from the Arkansas State Highway and Transportation Department

(AHTD) by research personnel, it was determined that WMA projects were approved on an individual basis. Each project was approved after cooperation and consultation between venders, contractors, AHTD materials personnel, AHTD administrative personnel and other interested parties.

Florida - A document published by the Florida Department of Transportation (FDOT) from the State Materials Office, titled *"Warm Mix Asphalt,"* describes the procedure for approval of WMA technology.

Requirements to be included on the approved products/process list:

1. Be acknowledged by another state agency as an acceptable warm mix technology or be listed on the following website: http://warmmixasphalt.com with a successful project(s) constructed nationally or internationally.
2. Partner with a contractor and the FDOT District Office and construct a demonstration section on an FDOT project.
3. Meet all FDOT construction specifications during construction of the demonstration section.

Kentucky – Like Arkansas, Kentucky's process for approving WMA technology was a more informal procedure. It was a collaboration of interested contractors, materials personnel from the Kentucky Transportation Cabinet (KyTC), and officials of KyTC.

North Carolina – On April 1, 2013, North Carolina DOT published a document titled "Approved Warm Mix Asphalt (WMA) Processes." This document outlines the procedure necessary for approval of a new WMA technology. The following information is from that document.

Prior to any approval, the WMA process manufacturer must submit documentation from a minimum of three (3) successfully constructed projects using the WMA process that includes the following:

- Product Name and Supplier;
- Contact Name and Telephone Number;
- WMA Process 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, the WMA process can be given the following approval status based on the construction and performance of NCDOT-approved job mix formulas (JMFs) using the WMA process.

There are different levels of approval as listed in the above referenced document.

1. Trial Approval – one or more NCDOT-led projects have been successfully constructed using the WMS process and monitored through a minimum of one winter season.
    - WMA processes 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 process have been successfully constructed on NCDOT-led projects.
    - WMA processes with Limited status may be used on US, NC and Secondary routes.

3. Unlimited Approval – a minimum of 250,000 tons of mix using the WMA process have been successfully constructed on NCDOT-led projects.
    - WMA processes with Unlimited status may be used on any route, including Interstate routes.

South Carolina – On February 4, 2011, the South Carolina Department of Transportation (SCDOT) published a document titled "Qualified Products Policy for Warm Mix Asphalt Additives and Foaming Processes (Qualified Products Listing No. 77)." That document listed the following steps necessary to obtain approval of a warm mix asphalt technology:

> The request shall be submitted to the Asphalt Materials manager at the SCDOT Office of Materials and Research. The request must include the following items:
>
> 1. Technical literature for the product or process;
> 2. Instructions for use to include, at a minimum, typical dosage rates, and expected range of mining temperatures;
> 3. A current materials safety data sheet (MSDS) for additives;
> 4. At least one of the following:
>
>   a. Documentation that the WMA additive or foaming process has been used successfully at the National Center for Asphalt Technology (NCAT) in Auburn, AL. The foaming process or additive must be placed on the test track for a long enough period of time to ensure that the mixture performed satisfactorily. A report from NCAT must be submitted to the Asphalt Materials Manager (AMM) in order for the additive or process to be evaluated. The AMM may use this report to determine whether the product is acceptable or if further research will be required.
>
>   b. Documentation that the WMA additive or foaming process is accepted by at least five state transportation agencies. The states should have at least one test or routine WMA section placed with successful operations. WMA additives suppliers must submit a copy of each state's qualified product list along with all necessary contact information in regard to the sections placed within each state. Any production

research performed for county government municipalities or done overseas will not be accepted.

5. Certification that the additive or foaming process meets all applicable SCDOT Specifications.

Tennessee – On April 1, 2013, the Tennessee Department of Transportation published a document tilted *“QPL 39 Warm Mix Asphalt.”* The third section of that document titled *“Procedures”* details the process for approval of warm mix asphalt technology.

A completed Product Evaluation form, MSDS sheets, product data information, and a one-gallon sample of the product being tested must be submitted to the Divisions of Materials and Tests. To be placed on the departments Qualified Products List, a warm mix asphalt additive must be certified by the National Center of Asphalt Technology (NACT) Warm Mix Asphalt (WMA) Certification program or meet the following requirements:

1. Shall be capable of reducing typical hot mix asphalt mixing temperatures to a mixing temperature of 275^{o} F (135^{o} C) or less.

2. The additive supplier must be able to show that the additive has been used successfully in the United States on a project receiving an approved level of traffic in excess of one mile in length. The project must have been subjected to traffic loading for greater than one year, and exhibit the following:

   a) No visible cracking, rutting, or delamination.
   b) No measurable rutting in excess of 0.25 in (6.35 mm).
   c) Documentation of the additive’s successful ability to reduce mixing temperatures without being detrimental to the mixtures’ ability to achieve roadway density according to Departmental specifications.

3. The additive supplier must then demonstrate the additive on a TDOT project. The additive supplier will be responsible for identifying an existing or proposed project for demonstration of the additive, and will be responsible for coordinating the demonstration with the prime contractor. The project must be subjected to traffic loading for greater than one year and must exhibit the following:

   a) Details a through c listed above in Item 2.
   b) Documentation of the additive-modified mixture’s ability to resist moisture damage by evaluation per TDOT’s specification of Tensile Strength Ratio (TSR).
      i) Test specimens will be prepared from freshly produced warm mix at the plant at temperatures comparable to that in which the mixture is intended to be placed in the field.
      ii) Prepared specimens shall be tested per TDOT Standard Specification 407.03, by a TDOT certified testing technician.

***Virginia* –** Like all new products or processes, new warm mix asphalt technologies seeking approval in Virginia must submit an application to the District Materials Engineer and the central new products committee. According to an undated memorandum from the New Products Committee to all new-product applicants, their application must include the following:

> *Please provide trade literature, test data, Materials Safety Data Sheets, product specifications, instructions, benefit cost analysis, projected life, and product guarantee electronically. Clearly state the benefit of the use of this innovative product to the Department and identify an application and/or location in the transportation system for the use of this product. Please send a minimum of five copies of color photographs, pamphlets, booklets, binders or other professionally produced materials*.

Warm mix asphalt products currently (October 2012) approved for use in Virginia is List No. 66 (**Approved Warm mix Asphalt Products and Processes**).

***West Virginia* –** From conversations research personnel had with personnel in the West Virginia Department of Transportation, it appears that the warm mix asphalt approval process was similar to those in Arkansas and Kentucky. It was a more informal process where interested industry personnel worked with materials personnel in the WVDOT and with WVDOT supervisory personnel to build test sections for evaluation and ultimate approval of the technology.

SUMMARY AND CONCLUSIONS

Currently all states in the southeast region of the United States utilize WMA technology to some extent. To facilitate the use of WMA, each state has modified their standard specifications or has written special provisions to accommodate this technology. The majority of these specification changes have primarily focused on lowering permissible temperatures for mixing and laying WMA. In general, all other laboratory tests necessary for approval and acceptance of HMA are the same for WMA.

The approval process for the acceptance of WMA technologies has varied across the region; some have written policies specifically for WMA, while others use established new product committees to approve WMA. Others have used more informal (and possibly unwritten) procedures for WMA approval. All three major types of WMA technologies chemical additive, organic additive [waxes], and water additive [foamed]) are being used in the region, with water foaming being the predominate technology currently being used.

Based on the information reviewed during this study, there appears to have been minimal problems with WMA during construction and thus far the performance of WMA pavements has been comparable to those constructed with HMA. Continued long-term performance monitoring is necessary.

Most states indicated they had not experienced any significant cost difference between WMA and HMA. In addition, it also appears that the presence of WMA has not increased competition among bidders.

The use of WMA technology as a replacement for conventional HMA paving appears to be a viable alternative and it seems that its use will continue to increase.

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APPENDIX

Print out version Monday, July 15, 2013

UK UNIVERSITY OF KENTUCKY Kentucky Transportation Center

Southeast Transportation Consortium
Regional Implementation of Warm Mix Asphalt Survey

The Kentucky Transportation Center is working with the Southeastern Transportation Consortium at Louisiana State University to conduct a survey of state highway agencies relating to their use of Warm Mix Asphalt. This survey is part of a research synthesis of Warm Mix Asphalt usage in the southeastern states which will outline a variety of topics including, performance, mix design, constructability, and cost. If you have any specific questions relating to the survey, please contact Dr. Clark Graves, 859-257-7388, clark.graves@uky.edu.

Materials Related Questions

No. 1: Identify the Types of mixes where Warm-Mix Asphalt is used by your agency.

- ☐ a. Surface
- ☐ b. Open-graded friction course
- ☐ c. Base/Sub-base
- ☐ d. SMA Base/Surface
- ☐ e. None

No. 2: Do you use RAP in your WMA?

- ☐ Yes
- ☐ No

If so, what is the highest percentage of RAP allowed in your specifications for WMA

☐

No. 3: Do you use RAS in your WMA?

☐ Yes

☐ No

If so, what is the highest percentage of RAS allowed in your specifications for WMA

[ ]

No. 4: What Type of WMA have You Utilized? Check all that apply.

☐ *a. Foamed*

☐ *b. Chemical*

☐ *c. Wax Based*

☐ d. Other [ ]

No. 5: Have you modified your standard specifications to allow WMA?

☐ Yes

☐ No

No. 6: Is WMA permitted on an experimental basis?

☐ Yes

☐ No

No. 7: Does your state have an approved list for allowing the different WMA technologies?

☐ Yes

☐ No

<u>No. 8</u>: Does your state have an approved procedure for allowing the different WMA technologies?

☐ Yes

☐ No

<u>No. 9</u>: Have you modified your mix design procedures to facilitate the use of WMA?

☐ Yes

☐ No

<u>Cost Related Questions</u>

<u>No. 10</u>: Compared to the conventional HMA, is WMA more or less expensive in your state?

☐ More Expensive

☐ Less Expensive

<u>No. 11</u>: Has the use of WMA created more competition among bidders on projects due to the ability to haul mix further prior to placement?

☐ *Yes*

☐ No

<u>Construction Related Questions</u>

<u>No. 12</u>: List any positive constructability issues associated with WMA.

<u>No. 13</u>: List any negative constructability issues associated with WMA.

<u>No. 14</u>: Has WMA allowed you to extend the construction season in your state?

☐ Yes

☐ No

If so, by how much?

<u>No. 15</u>: Have you increased in-place density on projects where WMA has been utilized?

☐ Yes

☐ No

<u>No. 16</u>: Are any contractors using less compactive effort to achieve the same in-place density as HMA?

☐ Yes

☐ No

No. 17: *Estimate the quantities of the following that have been used in your state. (Tons)*

a. HMA: [ ]

b. WMA – Foam: [ ]

c. WMA – Chemical: [ ]

d. WMA – Wax Based: [ ]

e. Other: [ ]

No. 18: *Have you observed any constructability differences among the different types of WMA technologies?*

☐ Yes (Describe) [ ]

☐ No

No. 19: *Has your agency modified their construction specifications to specifically address WMA?*

☐ Yes

☐ No

Performanced Related Questions

No. 20: *How long has your oldest WMA project been in service?*

[ ]

No. 21: *Have you observed any performance differences between conventional HMA and WMA?*

☐ Yes (Describe) [ ]

☐ No

No. 22: Are there particular distresses that seem more prevalent in WMA versus HMA pavements?

☐ Yes

☐ No

No. 23: Are you currently monitoring any specific WMA sections for long-term performance?

☐ Yes

☐ No

No. 24: Has your agency completed any research projects in any of the following areas, if so are there research reports or summaries available?

Research	*Research Reports or Summaries Avaiable?*	
☐ WMA Constructability	☐ Yes	☐ No
☐ WMA Mix Design	☐ Yes	☐ No
☐ WMA Performance	☐ Yes	☐ No

No. 25: Do you currently have research underway Related to WMA?

☐ WMA Constructability

☐ WMA Mix Design

☐ WMA Performance

My Comments

Contact Information

Name: * Required

Agency: * Required

Area of Responsibility:

Mailing Address:

Email Address: *Required

Phone Number: