2017

Warm Mix Asphalt Peer Exchange

Proceedings
February 14-15, 2017

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Introduction and Purpose

The FHWA Colorado Division, Resource Center Pavement and Materials Technical Service Team and Consensus Building Institute delivered a Warm Mix Asphalt (WMA) peer exchange at the request of the FHWA Colorado Division Office and Colorado Department of Transportation (CDOT) Materials and Geotechnical Branch as part of Every Day Counts follow-up. The peer exchange was held February 14-15, 2017 in Denver, Colorado at the CDOT Materials and Geotechnical Branch facility.

The purpose of this day and a half peer exchange was to facilitate information sharing of best practices of WMA use and implantation between the invited. This event we were able to bring together six states to help them better deliver these new technologies that can bring significant improvements in project delivery for our customers in safety, cost, schedule and quality when used well on the right projects.

Peer Exchange Summary

Participants

Six states participated as noted below and in the final Registration List (Appendix A). To increase the collaboration and capability for implementation, both DOT and FHWA Division Office representatives contributed. Each person had an active role as a presenter and facilitator. The FHWA Headquarters sent a representative to share national experiences and expertise. The participants also included representatives from industry, trade associations, and members of the consulting community.

States/Agencies represented at the Warm Mix Asphalt peer exchange included:
- Florida DOT
- Pennsylvania DOT
- Maryland DOT
- Ohio DOT
- Colorado DOT
- Nevada DOT
- FHWA
- Industry Representatives

Agenda

The Agenda (Appendix B) was designed with presentations from all participating states on their state of practice, issues of greatest concern and other hot topics. Opening remarks were made by John Cater, Division Administrator, Colorado Division Office, and Josh Laipply, CDOT Chief Engineer. Both indicated their commitment and support of WMA. The Chief mentioned the environmental benefits of reducing production temperatures, extending the paving season and providing a quality pavement. The FHWA mentioned the focus of the exchange was to share experiences and learn from one another. The event closed with a facilitated discussion on other issues not included in the formal agenda and as voted by the participants. The final open discussion items are included in the Meeting Notes (Appendix E), along with the important information captured for all presentations.

The agenda items were put together with a substantive input from the host State of Colorado. The Colorado Department of Transportation (CDOT) specifically requested that following items of interest to them be included in the agenda:

- State's Definition Warm Mix Asphalt (WMA)
- Status of WMA use - % of mix in WMA and % in each WMA type (estimated numbers if available)
- DOT's WMA approval process
- DOT's Implementation process
- Summary of WMA specifications and contract practices
- Mixture design practices for WMA
- Mixture production and control requirements
- Placement and compaction equipment practices
- Testing and acceptance process
- WMA performance data
- Other Aspects of WMA – Technology/Concerns/Success Stories/Challenges that you like to share

Takeaways

The following consolidates some takeaways from the peer exchange notes to highlight items that various DOTs found valuable and important for their future implementation efforts.

- **National Overview of WMA:** FHWA continues to focus on "equal or better performance" when WMA is compared to traditional asphalt pavement and proactively encourages its use. Nationally, we are not seeing large saving in energy savings, decreased binder aging, and increased recycled asphalt pavement (RAP) usage (depending on how and what WMA technology). No change in premature rutting when compared to control or asphalt pavement. Chemical additives and foaming processes are the two most common WMA technologies. Different technologies help address customized needs. No major construction differences between WMA and traditional asphalt pavement. Has not been documented that with WMA can reduce aging of the binder (improve performance).

- **State Program Highlights:**

  - **Pennsylvania:** Has a definition of WMA which does not include temperature. They have taken their time to implement WMA. Currently they are a one hundred percent WMA state and led by pressure from management and driven by districts due to the improved density in the field and ten degrees temperature reduction. In 2017, requirement that all asphalt pavement be WMA. Require 0.25% minimum dosage of anti-strip. Chemical additive is being used more because many of the chemical packages have an anti-strip agent added version at a cheaper price (or just as cheap) as anti-strip. They are seeing temperature reductions of ten to fifteen degrees less than traditional asphalt pavement. Research on cost analysis was done on WMA vs asphalt pavement and was proven to be cost effective.
  - **Ohio:** No formal definition of WMA and no temperature requirement currently. In 2006, they did their first trial of WMA using three additives. They were told by their Director that they had to go with one hundred percent WMA in 2008. They don't have an approval list of WMA technologies. The current use of WMA is mainly used for as a compaction aid and mostly uses water-injection process with little experience with chemical additives. After contractors invested money in water injection equipment, very little interest in using chemical additives since they cost money versus

water. Also with the low energy costs, use in general of WMA has slowed down. Overall no performance issues to report. They didn't have any issues with moisture susceptibility before WMA use and thus not worried about stripping issues. Research done in Ohio has substantiated this assumption. Industry has been involved throughout the use of WMA and there was no major pushback. Knowing what they know now, they may not have gone solely with water injection and instead included other WMA technologies but they felt it was the least risk at the time.

- **Maryland:** No clear definition of WMA and is mostly used as a compaction aid rather than lowering temperature. They are primarily using the foaming technology for WMA and requiring the manufactures representative to be present at the plant on the first day of production. Rutting is not a problem. Encourages WMA use and do not have any restrictions. Overall no performance issues to report. A challenge they have is on how they go about certifying the binder in case of in-line blending of WMA additives, producers are hesitant to store water foaming WMA in silos, and how do they know if a plant is running warm mix? Require mix verification on first day of production. Producers are not seeing any clear benefit of WMA and no incentive to use it. Producers also have a pressure from private market to rise temperatures to get densities, some of them reported mix condensation in silos if water foaming is used. Their data shows improvement in cracking performance if chemical additives were used and negative cracking performance if water foaming was used. No clear increase in densities were found in water foaming WMA mixes in Maryland. Maryland would like to see an increase in WMA mixes by re-define WMA and show some clear benefits of WMA mixes in Maryland. MDOT is planning to raise the minimum density limit from 92 to 93%, which will encourage the usage of WMA.
- **Florida:** There is no formal definition of WMA other than it is produced at temperatures lower than WMA with an approved additive or process. Contractors have primarily used the foaming technology for WMA. Their approved processes and additives are shown on website: http://www.fdot.gov/materials/mac/production/warmmixasphalt/ WMA can be used at any time at the contractor's option. WMA isn't required. They have started to see less WMA usage over the past few years. Have not seen much cost savings and don't see an advantage of WMA from the performance standpoint. Currently have ten approved processes that are mostly chemical with a few water injection foaming methods. There is a simple three step process for new processes or additives, which is documented on the above website. They have seen better results when they changed the specification to allow the first five loads of WMA to be produced at asphalt mix temperatures to warm up the equipment.
- **Nevada:** Has a definition and they primarily have looked at the foaming technology. Started using WMA in 2009 and had ten foaming projects. Have done some field trials in which LTPP SPS-10 test sections were created between Reno and Carson City. A lot of lab studies with the assistance with the University of Nevada Reno. Prior to 2010, they didn't use RAP with WMA. They have not really seen a push to go to WMA. It's left up to the contractor if they want to use WMA. Have only placed 33,000 tons of WMA total and the reason for the lack of use they are getting from the contractors is that there is no incentive or benefit from a contractor's perspective. They require "prior demonstration of technology" before it can be used on a project.
- ***Colorado*:** Has a definition and started using WMA in 2007, using three different additives on and I-70 project, which they monitored it over a three year period. Equal or better performance has been documented between asphalt pavement and WMA. They primarily use the foaming process or additive technology while the overall choice to use WMA technology is up to the contractor's discretion. Typically let contractors decide if interested in using WMA and only required WMA in a couple of projects due to crack sealant issues. Regions approve using WMA themselves. They

currently have eleven WMA technologies on their approved projects list that include fourteen contractors that are able to do them. They are using WMA statewide for a range of mixture types and in diverse conditions. Approvals are good for three years and then they need to apply for renewal. WMA is allowed on a project by project basis. Mix design acceptance with submittal of additional information required (including a four point verification).

- **Final Plans and Specification Process:** Every state is defining WMA differently so it's hard to track how much people are using WMA. Industry feels there are challenges for them to get their products approved. Approver lists needs to be updated every three years and supplier needs to provide the documentation. Placement temperature for WMA is not much different than traditional asphalt pavement. The biggest benefit is with compaction. The foaming WMA technology is more challenging and it is often suggested to do field verification. Need for DOTs to work with statewide contractors in developing specifications together. FDOT has a three year material warrantee.

- **Construction Process:** If DOTs have concern of stripping issues, then chemical additives would be better than water injections. Water injection binder foaming lab equipment can be pricey so mix designs are done using traditional asphalt mix methods. Ohio has reported water injection dosage is typically around two percent water by weight of virgin binder and compaction is typically 30^{0}F lower temperature that asphalt pavement. For Ohio water-injection equipment must be approved prior to use at a mix plant and usually this is done by district folks.

  In Pennsylvania the bag house and dust ball issues were encountered when producers were trying to produce at lower temperatures. Producer must record the addition of water or additive on five minute printout. It was discovered that stripping potential is higher with WMA but can be mitigated and that placement temperatures were the only real difference compared to traditional asphalt pavement.

- **Acceptance Program Process:** Maryland's permissive WMA specification has allowed producers to get acclimated and have success in placing WMA. Volumetric properties are no different than traditional asphalt pavement. Contractors will not find WMA specified in contract documents and at the same time producers can use WMA in lieu of asphalt mix on any project.

  Maryland has a four step verification process for WMA. WMA products have to be approved by MPEL, prior plant approval is required, off-site demo has to be given and mix verification will be conducted. If producer prefers to use chemical or organic additive, manufacturer's representative must present at plant on first day of production and QC plan has to be submitted with temperature controls in addition to above steps. An annual plant inspection has to be conducted and plants have to be approved to produce WMA mixes.

  Nevada acceptance program framework for WMA is no different than traditional asphalt pavement. WMA usage is based on contractors' request and facilities must have successful production/construction with technology. Only modification in mix design compared to traditional asphalt pavement requirements is job mix formula temperatures.

- **Other Aspects of WMA:** Nevada is currently evaluating the structural design of WMA through the use of ME design inputs for the mix.

For Florida WMA mixture design process the contractors are responsible for designating their mixes according to FDOT specification. If the WMA processes or additive is changed a new mix design is required. The asphalt producer chooses the mixing and compaction temperatures while all mix designs are verified in the laboratory at the state materials office (central office) and field verified. For WMA mixture production and control requirements FDOT acceptance process is similar to traditional asphalt pavement in which they must meet air voids, density, AC content and gradation. Some contractors reconfigure their plant for WMA production. Since 2009, there has been no significant difference in density of asphalt mix and WMA mixtures. They have limited all mixtures to 20% RAP with modified binders (polymer or ground tire rubber). Some contractors have indicated using RAP with WMA helps with bag house condensation issues. In Florida, three approved WMA processes (Zycotherm, Cecabase, Evotherm) are also approved for use as liquid anti-stripping agents.

- **Overview of NCHRP Project 20-44(01)**
  There has been a vast investment by State, Industry and NCHRP studies on tools related to WMA but still no common definition of it. Should it be "Producing at lower temperatures for energy benefit", "Producing at hot-mix asphalt temperatures for late season paving compaction or FHWA Long Term Pavement Performance definition "asphalt mixtures produced at either 275^{0}F or less, or at 30^{0}F below asphalt pavement production temperature." A workshop was held in Irvine, California on May 8th and 9th 2017 to further research WMA usage and implementation.

- **Industry Perspective – Contractors, Suppliers, Manufactures**
  The reasons why WMA technology in Colorado not being used on all mixes comes down to cost of the products, not being approved for use and many of the customers do not understand the benefits of WMA. Has been identified that compaction is happening quicker. Using what is known today, a better definition of WMA should be "Workability Mixture Additive". There are different ideas of WMA when it comes to reduced temperature mixture, is it an asphalt pavement mixture (APM) produced for workability and as a compaction aid, and is it a process to lower temperature to keep the binder softer and help avoid early cracking of the APM? Recommend that we stop the restrictions of approved WMA products, allow the contactor to make the decision of the minimum production temperature and let the contractor decide the appropriate WMA technology process and utilize the other testing and inspection to determine the end result of APM. In addition, encourage the use of additives based on the current CDOT approved products list for all projects and add information in mix designs submittals which state the approved additive is present in the mix. There is a concern that contractors don't know how to bid with current CDOT requirements and then some just then just don't want to do it. The reduced fuel consumption at the plant and emissions is not really a driving force for WMA. If CDOT encourages use of WMA as equal or better then local agencies would likely use more.

- **Roundtable Open Discussions – State, Industry & FHWA Topics**

  - **Messaging:** There is concern on what message we should be sharing about WMA today and whether we should be incentivizing WMA and if so, how? There is a need to track/quantify long term performance, clarify real benefits of WMA and to rebrand and educate what WMA really does. What are considerations on if/how to define WMA (i.e., how do we highlight that it's more about safety and performance then temperature)? Maybe look at other metrics instead of focusing on tonnage. What

about looking at job duration (minutes of travel, time saved), safety (accidents and flexibility to extend of construction season), performance (density, compaction, ride) Should they be any different for contractors and agencies? How can we brand WMA for future use? How to proceed to next level? How do we coordinate more across states? What additional research is needed?

- ***Technical Construction-Related Issues:*** An area of concern is where binder samples should be taken for testing. Specifications need to identify location (before or after injection for foaming) and time when taken (frequency). If samples are taken after injection has been added it addresses a concern. However, for water injections samples may need to be made prior to injections because the water will remain in the binder sample and negatively impact verification results. Verification testing for PG grade would need to come from the agency.

  How does one control additives in the binder? It was mentioned that calibrated flow meters (instantaneous reading?), pulled samples and possible printouts could be used. There may be use to use infrared or spectrometer to check the percentage of additive.

  Does compaction temperature have any impact on binders? Concern is how do we develop an objective test for determining damaging of binders at lower temperature. The current NCHRP 9-61 project on short and long-term aging methods to accurately reflect binder aging…adjusting RTFO aging times based on laboratory elevation….is a good reference. Every mix will be different. Need to look at specific mix.

  Polyphosphoric acid (PPA) compatibility was another concern mentioned. CDOT doesn't allow it but Ohio does. From the water injection method it is not an issue. For chemical additives the additive supplier needs to be made aware if PG binder has PPA or not to ensure correct additive version is used. The required verification is unknown and we would need to verify if antistrips could affect it and is there a sensitivity issue.

- How to compare testing in field versus what is produced in the laboratory and how does one verify? Timing is critical on when/how to add additives once blended. WMA is more sensitive then asphalt pavement mixture. There are more changes between laboratory vs. field. It is not as cost effective when you have to compare to tradition mixture design. Temperature compaction issues are largely undefined for WMA additives and unsure of what temperature to compact at. Foaming testing is very difficult. Some best practice ideas is to set ovens at expected temperatures in the field and don't set ovens at same temp statewide. Recommend to do warm mix designs with additives in design (not after). One needs to separate foaming from chemical additives.

  Group Discussion:

  1. Gaps or weaknesses: WMA has not been utilized frequently. We have a technology that has proven to have equal or better performance, no rutting, examples of reducing early oxidation, improving workability, enhancing compaction (increasing density) plus environment benefits. Only using it on an intermittent basis (late season, cold weather, long haul, just a small percentage of total mix). The one exception is Pennsylvania in which management issued a

directive to do it 100% and being justified from a field performance basis (improved density).

2. "Proactively Encourage" versus permissively allow, contractors discretion and ensure compliance.

   Address artificial barrier:

   a. Environmental benefit – reduced emissions at the plant.
   b. Rethink/rebrand the foaming process. Compaction aid, hot foaming…

   Address Economics:

   a. Streamline the Approval Process (time and confusion).
   b. WMA Approved Products List – WMA Approved (Green) Products List
   c. Chemical additive is allowed as an anti-strip (reduce or eliminate the use of hydrated lime.
   d. Learning Curve: Construction differences – Higher density bonuses, higher production rates, picking up cones sooner, fuel savings.
   e. 10 degrees –saving.

   Issues/Challenges:

   a. Producers having to switch back and forth due to local agencies not allowing WMA.
   b. Need performance data of the "or better" of the "equal or better"
   c. Approval/Acceptance: Program level approvals plus project level acceptance – time, cost.
   d. Terminology: not WMA, not asphalt mix, moving towards asphalt paving materials
   e. Workability additive, coating/compaction aid, hot foaming.
   f. WMA technology versus complying to a WMA definition based on temperature.

- **Key lessons learned**

  The lessons learned from the Peer Exchange are summarized below:

  - States play a key role in promoting a wider spread use of WMA.
  - Given the option, contractors tend not use WMA unless they see a benefit.
  - There is continued research in WMA nationally.
  - Testing and acceptance process of WMA is the same as asphalt mix.
  - WMA definition varies from State to State. For example some states define it as asphalt produced and paved at lower temperatures than conventional asphalt mix with warm mix additive or process. Others base it on the type of mechanical foaming or chemical additives used.
  - Disparity in the definition of WMA may explain why some states have higher tonnages than others.

  Some of what participants said was a take way for them:

  - States don't need "open the flood gates" but should not overly be restrictive.
  - If long term performance of the WMA is not well documented there will be marketing industry buy-in challenges.
  - States need to conduct life cycle cost analysis.
  - If the State DOTs don't champion the use of WMA, locals will not embrace it either.
  - Improve messaging by emphasize what the benefits of WMA are.

- Contractor's may participate in WMA if they see benefit.
- Continue the research efforts and the technical know-how, especially in construction.
- The definition of WMA needs to be well understood by all the WMA stakeholders in the state.
- Take Advantage of WMA technology and extend the paving season.
- Engage the industry and local agencies and promote benefits of WMA.

Conclusion

The peer exchange met the objectives for information sharing and the evaluations showed that participants gained much towards helping them with next steps of enhanced implementation. The audience's WMA experience was diverse - some were novices and others more advanced. Thus, it appears that some might have gained more than others. In addition to the formal agenda, strong networking contacts were made that will provide ready references as each State moves ahead. Some key gaps were discovered or affirmed that will help FHWA Divisions with follow-up activities and future technical assistance.

Appendices

Appendix A: Registration List

Warm Mix Asphalt (WMA) In Person Peer Exchange

Denver, CO – February 14-15, 202017

Registration List

First Name	Last Name	Title	Agency	Email
Chandra	**Akisetty**	Asphalt Technology Division Chief	MDOT	cakisetty@sha.state.md.us
Jennifer	**Albert**	Pavement Materials Engineer	FHWA PA	jennifer.albert@dot.gov
Eric	**Biehl**	Asphalt Materials Engineer	ODOT	eric.biehl@dot.ohio.gov
James	**Chang**	Region 1 Materials Engineer	CDOT	james.chang@state.co.us
John	**Cheever**	Quality Manager	Aggregate Industries WCR	John.cheever@aggregate-us.com
Matthew	**Corrigan**	Senior Asphalt Pavement Engineer	FHWA HQ	matthew.corrigan@dot.gov
Tom	**Clayton**	Director of Training and Member Services	CAPA/RMAEC	tomclayton@co-asphalt.com
Gary	**Dewitt**	Region 4 Materials Engineer	CDOT	gary.dewitt@state.co.us
Jason	**Dietz**	Pavement Materials Engineer	FHWA RC	jason.dietz@dot.gov
Dahir	**Egal**	Pavement Materials Engineer	FHWA CO	
Neal	**Fannin**	Pavement Materials Engineer	PennDOT	nfannin@pa.gov
David	**Fife**	Quality Manager	United Companies	dfife@united-gj.com
Todd	**Genovese**	QC Engineer	Martin Marietta	todd.genovese@martinmarietta.com
Azmat	**Hussain**	Pavement Materials Engineer	FHWA MD	azmat.Hussain@dot.gov
Randy	**Jensen**	Program Delivery Team Leader	FHWA CO	randy.jensen@dot.gov
Monica	**Jurado**	Pavement Materials Engineer	FHWA RC	monica.jurado@dot.gov
Kenny	**Tong**	Pavement Materials Engineer	FHWA OH	kenny.tong@dot.gov
Jeremy	**Lucero**	Region 3 Materials Engineer	CDOT	jeremy.lucero@state.co.us
Leslie	**McCarthy**	Principal	MMCE	leslie@myersmccarthy.com
Bob	**Mero**	Region 1 Materials Engineer	CDOT	bob.mero@state.co.us
Nathan	**Morian**	Bituminous Operation Engineer	NDOT	nmorian@dot.state.nv.us
Howie	**Moseley**	State Bituminous Materials Engineer	FDOT	howard.moseley@dot.state.fl.us

Thomas	**Peterson**	Executive Director	CAPA	tompeterson@co-asphalt.com
Bill	**Schiebel**	Materials/Geotechnical Branch Manager	CDOT	bill.schiebel@state.co.us
Marshall	**Shackleford**	Technical Manager	Suncor Energy	mshackelford@Suncor.com
Laura	**Sneeringer**	Senior Associate	Consensus Building Inst.	lsneeringer@cbuilding.org
Michael	**Stanford**	Asphalt Program Manager	CDOT	michael.stanford@state.co.us
Tim	**Webb**	Region 5 Materials Engineer	CDOT	tim.webb@state.co.us
Eric	**West**	President	Westest	ewest@westest.net
Craig	**Wieden**	Region 2 Materials Engineer	CDOT	craig.wieden@state.co.us
Doug	**Wingo**	Quality Manager	Brannan Sand and Gravel	dwingo@brannan1.com

Appendix B: Agenda

Warm Mix Asphalt (WMA) In Person Peer Exchange

Denver, CO – February 14-15, 202017

Agenda

Day 1	Session Topic	Facilitator/ Presenter(s)
8:00 am	**Peer Exchange Purpose/Introductions**	Bill Schiebel – CDOT Randy Jensen – FHWA CO
8:15 am	**Opening Remarks**	John Cater – FHWA CO Josh Laipply – CDOT Chief Engineer
8:30 am	**Overview of Warm Mix Asphalt**	Presenter: Matthew Corrigan – FHWA HQ
8:55 am	**State Program Highlights Presentations** (PA, OH, MD, FL, NV, CO) **Brief Overview** of WMA Program, including: 1) Experience/Usage 2) Lessons Learned 3) Current & Future Implementation Process 4) Brief Q&A NOTE: **15 min./presentation**, including brief Q&A (**Detailed discussions to occur during Topic Sessions**)	Facilitator: Jason Dietz – FHWA RC Laura Sneeringer – Consensus Building Institute Presenters: Neal Fannin– PennDOT Eric Biehl– ODOT Chandra Akisetty– MDOT Howard Moseley – FDOT Nathan Morian – NDOT Mike Stanford– CDOT
10:00 am	**Break**	
10:15 am	**Contd.**	
11:00 am	**Topic Session #1:** **Final Plans & Specification Process** • Definition of WMA • New Product Approval • Permissive Specification • Design and Construction Criteria • Summary of WMA Specifications and Contract Practices • % of mix in WMA and % in Each WMA Type NOTE: **15 min./presentation**, + 30 minute facilitated Open Discussion	Presenters: Mike Stanford - CDOT
11:30 am	**Lunch/Network Time**	
1:00 pm	**Topic Session #2:** **Construction Process** • Mix design practices for WMA • Maintaining Adequate Baghouse Temperatures • Placement and compaction equipment practices	Presenters: Eric Biehl – ODOT Neal Fannin- PennDOT

	• Mixture production and control requirements NOTE: **15 min./presentation**, + 30 minute facilitated Open Discussion	
2:00 pm	**Topic Session #3:** **Acceptance Program Process** • Testing and acceptance process • Inspection of the contract work • Materials Quality Assurance (approval process) NOTE: **15 min./presentation**, + 30 minute facilitated Open Discussion	Presenters: Chandra Akisetty - MDOT Nathan Morian – NDOT
3:00 pm	**Break**	
3:15 pm	**Topic Session #4** **Other Aspects of WMA** • Long-term performance data • Quantification of Benefits • RAP and WMA NOTE: **15 min./presentation**, + 30 minute facilitated Open Discussion	Presenters: Nathan Morian - NDOT Howard Moseley - FDOT
4:15 pm	**Q & A for Day 1 / Questions for Day 2 – General**	
5:00 pm	**Adjourn**	

Group Dinner - Meet outside of hotel at 6 pm for pickup.

Day 2	Session Topic	Facilitator/ Presenter(s)
8:00 am	**Day 1 Review / Share Resources**	Facilitator: Jason Dietz – FHWA RC Laura Sneeringer - Consensus Building Institute
8:15 am	**Topic Session #5** **Industry Perspective – Contractors, Suppliers, Manufactures** NOTE: 30 **min./presentation**, + 15 minute facilitated Open Discussion	<u>Presenters:</u> Tom Peterson / Tom Clayton - CAPA
9:00 am	**NCHRP 20-44 Increasing WMA Implementation by Leveraging the State of Knowledge**	<u>Presenter:</u> Dr. Leslie Myers McCarthy – MMCE
9:30 am	**Panel Discussion/Q & A- What Is Working, What Is Not** • Other topics of interest *(Not addressed in Topic Sessions above)*	
10:15 am	**Break**	
10:30 am	**Report Out On Takeaways** • States & FHWA Report on Takeaways Note: 3 **min./Report**	
11:30 am	**Adjourn**	

Appendix C: Fact Sheets

U.S. Department of Transportation
Federal Highway Administration

Warm Mix Asphalt (WMA) In Person Peer Exchange

WMA Program Fact Sheet – PennDOT

Denver, CO 80216

Below is a quick summary of information related to usage of WMA.

Questions	Agencies Responses
State's Definition of WMA	A volumetric asphalt mixture design developed with the Superpave Gyratory Compactor (SGC), using prescribed manufactured additives or modifiers, and/or plant process modifications.
Status of WMA use - % of mix in WMA and % in each WMA type (estimated numbers if available)	100% WMA in 2017
DOT's WMA approval process	Foaming process – WMA is approved based on asphalt mix design. Prior to 2017 Foamed processes required minimum 0.25% anti-strip. In 2017 all mixes need minimum anti-strip addition. All other processes – WMA process the same as asphalt mix processes.
DOT's Implementation Process	Permissive specification prior to 2017. 100% WMA starting in 2017. Leadership decision.
Summary of WMA specifications and contract practices	See Section 411 and 311 of the link below for specification. http://www.dot.state.pa.us/public/PubsForms/Publications/Pub_408/408_2016/408_2016.pdf The WMA policy was to allow a no cost change from asphalt mix (permissive) prior to 2017. Starting in 2017 WMA will be exclusively specified.
Mixture design practices for WMA	Foaming process – WMA is approved based on asphalt mix design. Prior to 2017 Foamed processes required minimum 0.25% anti-strip. In 2017 all mixes need minimum anti-strip addition. All other processes – WMA process the same as asphalt mix processes.
Mixture production and control requirements	Calibrate foaming and additive systems to +/-1%. Audit asphalt invoices to ensure additives and anti-strips are added as required.
Placement and compaction equipment practices	No change from asphalt mix except lower temperature limits.
Testing and acceptance process	Same as asphalt mix.
WMA performance data	No failures noted to date. (2008 to present) Relayed on research done at the time to require anti-strip for foaming

	methods.
Other Aspects of WMA – Technology/Concerns/Success Stories/Challenges that you would like to share	Stripping issues have always been a concern with WMA, especially foaming methods.
Contact Person(s):	
Name:	Name: Neal Fannin
Phone:	Phone: (814)496-6166
Email:	Email: nfannin@pa.gov

U.S. Department of Transportation
Federal Highway Administration

Warm Mix Asphalt (WMA) In Person Peer Exchange

WMA Program Fact Sheet – ODOT

Denver, CO 80216

Below is a quick summary of information related to usage of WMA.

Questions	Agencies Responses
State's Definition of WMA	No formal definition Old requirements required mix to be below 275 deg F if a grade bump is to not be used for mixes containing 26-40% RAP.
Status of WMA use - % of mix in WMA and % in each WMA type (estimated numbers if available)	See attachment. %WMA by water injection (foaming) estimated to be 50-55% in 2016. Tracking in previous years had a high of 67% (see tracking file). Evotherm products used on only a couple of projects in 2015/2016.
DOT's WMA approval process	We do not have an approved list for products. Foaming is at the will of the contractor. Water injection systems must be approved by DOT and meet 402.05. Trials of new methods are used. For other than foaming obtain contractor interest, submit product information and usage, report on production experience and data, and submit samples for our testing. We have allowed future use of product with successful trial on a contractor to contractor basis. Evotherm was successful, Cook Chemical was not (it changed the binder grade). Few contractors have requested products other than foaming.
DOT's Implementation Process	2006 first trial (Sasobit, ASpha Min, Evotherm) along with paver air quality data collection, 2008 6 trials of foaming along with added mix and plant stack testing. 2009 into spec for foaming.
Summary of WMA specifications and contract practices	See Below
Mixture design practices for WMA	For foaming use hot mix design. Other products at recommendation of supplier but our final say.
Mixture production and control requirements	402.04 for foaming equipment and operation. 401.16 for mix temperature. 441.09 C for lab compaction temperature for foaming.
Placement and compaction equipment practices	Only 401.16 for compaction. (for 301, 302 compaction is 250F minimum always.)
Testing and acceptance process	441.09C. Foaming not allowed for SMA.

WMA performance data	2006, 2008 trials data for mix, air quality etc. See attachments for more information.
Other Aspects of WMA – Technology/Concerns/Success Stories/Challenges that you would like to share	Low energy costs have slowed interest in use of WMA. Crews do not like some aspects of WMA also (hand work etc). ODOT doesn't have stripping issues so chemical additives wouldn't be able to be used to help. Potentially see some chemical additives being used to help with fatigue and Hamburg mix testing to allow WMA be used with higher RAP/RAS mixes.
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U.S. Department of Transportation
Federal Highway Administration

Warm Mix Asphalt (WMA) In Person Peer Exchange

WMA Program Fact Sheet – MDOT

Denver, CO 80216

Below is a quick summary of information related to usage of WMA.

Questions	Agencies Responses
State's Definition of WMA	• Any asphalt mixture that utilizes a warm mix technology (below) is considered as warm mix asphalt regardless of temperature decrease. • Mechanical foaming • Foaming using chemical additive ex: Advera • Chemical additives • Organic additives • Other technologies • So far, the majority of WMA mixes in Maryland are with the intent of using as a compaction aid rather than lowering temperature
Status of WMA use - % of mix in WMA and % in each WMA type (estimated numbers if available)	• In 2016, WMA comprised 36% of total asphalt tonnage. • This was mainly via the water-injection method. • Smaller % of chemical additives were used. These are included in the 36%.

DOT's WMA approval process	• Spec is very permissive
	• QC plan required for both plant and field
	• Mix should meet asphalt mix requirements
	• Binder should meet specified grade
	• Mix number shows mix method
	• Warm mix additives have to be submitted and approved through MPEL (Maryland Products Evaluation List)
	  • Producers are allowed to use only approved products
	  • If chemical additives have to be used, manufacturer representative has to present at plant for first day of production

DOT's Implementation Process	• Plant inspections • Pre-approval required for plants equipped with water foaming process • Submit certification from an approved supplier per M332 showing final product meets spec. • JMF shall be submitted according to R 35 for approval • All WMA technology methods require a mix design/field placement demonstration on non-administration project once JMF is approved and before mix verification • Technical representative shall present if chemical or organic products are used during initial shipment • If all specs are met this is a one-time demo per product per plant • Demo can be waived if the producer has successfully placed WMA in past using same aggregate source
Summary of WMA	• Sections 904 and 915, Maryland Standard Specifications for

specifications and contract practices	Construction and Materials • Standards M323 for mixes and M332 for binder • Mix designs shall be developed according to M323 and following Ndesign • <300,000 - 50 • 0.3M to 3M - 65 • 3M to 30M - 80 • >30M - 100
Mixture design practices for WMA	• JMF shall be according to M323 other than dust to binder ratio • Dust to binder ratio is allowed from 0.6 to 1.6 • If WMA is effective to reduce 100 F or more compare to asphalt mix, we need a high temp grade increase to resist rutting • RAP usage is typical • We allow 30% of the binder replacement from RAP • >30% replacement requires submission of binder analysis and blending test results

Mixture production and control requirements	• All requirements shall be met similar to asphalt mix design approval(904.04.03) and R35 in addition to the following (904.04.04):
	  • Warm mix technology and/or additive information
	  • Manufacturers established target rate for water and additives and acceptable variation for production
	  • Producers compaction temperature of gyratory specimens
	  • Producer shall follow manufacturer's recommendation for adding additives
	  • See Section 904.04.08 for Plant Control and Tolerances
	  • http://www.roads.maryland.gov/ohd/frontpage.pdf

Placement and compaction equipment practices	• See Section 504, Maryland Standard Specifications for Construction and Materials. Same as regular asphalt mix placement and compaction practices. • http://www.roads.maryland.gov/ohd/frontpage.pdf
WMA performance data	• None available.
Other Aspects of WMA – Technology/Concerns/Success Stories/Challenges that you would like to share	• Potential for in-line blending of the new additives/modifiers coming on the market: Is it a true WMA or an anti-strip. Bio-binders.
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U.S. Department of Transportation
Federal Highway Administration

Warm Mix Asphalt (WMA) In Person Peer Exchange

WMA Program Fact Sheet – FDOT

Denver, CO 80216

Below is a quick summary of information related to usage of WMA.

Questions	Agencies Responses
State's Definition of WMA	In Florida, WMA is asphalt produced and paved at lower temperatures than conventional hot mix asphalt with an approved warm mix additive or process.
Status of WMA use - % of mix in WMA and % in each WMA type (estimated numbers if available)	FDOT % total asphalt that is WMA: 2006 – 0.02%, 2007 - 0.22%, 2008 – 0.18%, 2009 – 3.73%, 2010 – 4.35%, 2011 – 5.71%, 2012 – 2.36%, 2013 – 5.07%, 2014 – 5.42%, 2015 – 1.35% Percent of WMA by each approved additive or process: AD-here LOF 65-00/Cecabase RT 945 – 7%, Aqua Foam System – 21%, Aspha-min Zeolite – <1%, Double Barrel Green System – 39%, Eco Foam II – <1%, Evotherm DAT H-5 – 1%, Evotherm M-1 – 12%, Ultrafoam GX Process – 14%, Warm Mix Asphalt System – 6%, ZycoTherm - <1%.
DOT's WMA approval process	- 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. - Partner with a contractor and FDOT District Office and construct a demonstration section on a FDOT project. - Meet all FDOT construction specifications during construction of the demonstration section.
DOT's Implementation Process	Same as approval process
Summary of WMA specifications and contract practices	For the most part, they are the same as asphalt mix. Here are a couple of differences: - Any approved WMA process may be used. The process must be indicated on the mix design. - For WMA, the first five loads of asphalt may be produced up to 330˚F to heat the equipment. - When using a warm mix technology, mix may be placed at lower ambient temperatures (5˚F lower by spec) than hot mix asphalt designs.
Mixture design practices for WMA	- Similar to the hot mix asphalt mix design process. Contractors are responsible for designing their mixes according to FDOT specifications. - Each mix design may only have one warm mix

	process. Switching processes requires a different mix design. - The asphalt producer chooses the mixing and compaction temperatures. - All mix designs are verified in the laboratory at the State Materials Office (central office) and field verified. - Verified in the lab at the WMA temperature with any additive.
Mixture production and control requirements	- Same as asphalt mix, no additional FDOT requirements. - Some contractors reconfigured their plant for WMA production. Retuned the burner Changed drum flighting, slope, and/or air flow to increase bag house temperature Sealed leaks in the bag house
Placement and compaction equipment practices	Same as asphalt mix, must meet the same requirements for density, ride, and texture as hot mix asphalt.
Testing and acceptance process	Testing is performed at the warm mix design temperature. Must meet the same requirements as hot mix asphalt. - Air Voids, Density, AC content, Gradation
WMA performance data	To date, WMA performance has been good and comparable to asphalt mix performance. There is more specific information in my presentation.
Other Aspects of WMA – Technology/Concerns/Success Stories/Challenges that you would like to share	There is too much to say for this small area. See my presentations for details.
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U.S. Department of Transportation
Federal Highway Administration

Warm Mix Asphalt (WMA) In Person Peer Exchange

WMA Program Fact Sheet – NDOT

Denver, CO 80216

Below is a quick summary of information related to usage of WMA.

Questions	Agencies Responses
State's Definition of WMA	Additive or process intended to reduce the mixing and/or compaction of bituminous mixtures. Currently, not specifying minimum temp change, but generally see 20-30°F.
Status of WMA use - % of mix in WMA and % in each WMA type (estimated numbers if available)	<10% Usage at state level. When utilized, nearly always (90%) foaming process of one version or another. Exception: 4 technologies used in LTPP SPS-10 project; chemical, foam, water bearing, and wax based.
DOT's WMA approval process	Facility must have previously demonstrated acceptable (within specification) production and construction with same WMA technology, material source, equipment, and contractor. At times permissible to demonstrate within same project, if logistically possible.
DOT's Implementation Process	At Contractor's request by individual project. Exception : LTPP SPS-10.
Summary of WMA specifications and contract practices	All standard material quality, production, and construction specifications are maintained, only production and construction temperatures are adjusted.
Mixture design practices for WMA	Maintain asphalt mix design practices with drop WMA technology during Test Section and Production. Asphalt mix practice is conducted by Hveem method at 230°F (110°C), i.e. near warm mix temps. to begin with.
Mixture production and control requirements	Mixtures must meet asphalt mix specifications and tolerances on Hveem Stability, Hveem compacted Air Void level, bit. ratio, aggregate gradation, and indirect tensile strength (Dry strength and TSR after one freeze-thaw cycle).
Placement and compaction equipment practices	Asphalt mix requirements are maintained. Mat Density: 92-96% Gmm (nuclear density correlated to cores) Joint density: min. 90% Gmm

Testing and acceptance process	Asphalt mix design in Central DOT lab followed by Test Section with drop-in WMA to develop job mix formula. Test Section develops density correlation (nuc. to core), as well as verification of Hveem stability, air void level, TSR results, aggregate gradation, and ignition oven calibration factor. Production requirements follow adjusted JMF as necessary. Acceptance based upon, laboratory test values, adequate particle coating, field density, and smoothness requirements.
WMA performance data	A few trial projects (back to 2011), LTPP SPS-10 (2016), and laboratory research work. Additional background information from local agency trials, prior to NDOT trial sections.
Other Aspects of WMA – Technology/Concerns/Success Stories/Challenges that you would like to share	Lack of contractor incentive limits requested projects and usage. Practically, may see more industry support for hot temp foaming. LTPP SPS-10 intended to address several design aspects, compare materials measures and in-service performance over long-term observations.
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U.S. Department of Transportation
Federal Highway Administration

Warm Mix Asphalt (WMA) In Person Peer Exchange

WMA Program Fact Sheet – CDOT

Denver, CO 80216

Below is a quick summary of information related to usage of WMA.

Questions	Agencies Responses
State's Definition of WMA	An alteration to traditional Hot Mix Asphalt, through either foaming or additives that allow the mix to be produced at lower temperatures with the benefit of reducing energy consumption, emissions and worker exposure, while improving field compaction, extending the paving season and increasing haul distances.
Status of WMA use - % of mix in WMA and % in each WMA type (estimated numbers if available)	The use of WMA is typically at the discretion of the contractor. When it is used, it is often used as a compaction aid or to assist with long haul distances and not necessarily to reduce fuel consumption and emissions.
DOT's WMA approval process	Technologies and Contractors are approved separately. Tiered approval process (for technologies) based on successful field performance. The approval process is listed in Colorado Procedure 59 – Warm Mix Asphalt Approval.  13- CP 59-17.pdf
DOT's Implementation Process	2007 WMA Pilot Project on I-70, 70 miles west of Denver. 3 additives were tested (Advera, Sasobit & Evotherm). Project was monitored for 3 years. Task Force formed in December 2009, with CDOT and Asphalt Industry. Specifications and WMA Approval Procedure was developed and approved in July 2010.
Summary of WMA specifications and contract practices	CDOT 403 Specification: CDOT approved Warm Mix Asphalt (WMA) may be allowed on this project in accordance with CP 59. Unique requirements for WMA design, production and acceptance testing as documented during CDOT WMA approval shall be submitted and approved prior to creation of the Form 43 and before any WMA production on the project.
Mixture design practices for WMA	Contractor shall provide a summary of anticipated differences in volumetric mix properties between the asphalt mix design values and the WMA production values.

	Contractor shall provide necessary data to support field volumetrics targets that are different from the asphalt mix design values. At a minimum, three full volumetric samples will be produced with WMA additive at asphalt mix design optimum AC and compared to the asphalt mix design properties to document anticipated impact on field volumetric properties.
Mixture production and control requirements	Colorado Procedure 59: If the WMA produced on a project fails mixture verification, goes in to condition red, or if the asphalt plant fails to satisfy the WMA production controls outlined in the submittal for WMA approval, WMA production shall cease, written explanation shall be provided for the failures, and production may be required to revert to conventional asphalt mix.
Placement and compaction equipment practices	WMA Technology Supplier submittals shall include Equipment and Plant requirements.
Testing and acceptance process	All WMA will be tested for acceptance by existing asphalt mix procedures.
WMA performance data	Performance Data for WMA is not tracked separately from traditional asphalt mix.
Other Aspects of WMA – Technology/Concerns/Success Stories/Challenges that you would like to share	Success Story: Slickrock, Co - hauling about 125 miles from the plant in Durango to the job and batching at 285F – Utilizing Zychotherm (WMA Technology).
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