Proceedings of
Global Warm Mix Asphalt Workshop

GWMAW 2013

Editor: Hosin "David" Lee

About LACT

Laboratory for Advanced Construction Technology (LACT) was established with support from Asphalt Paving Association of Iowa (APAI), Construction Materials Testing (CMT), Korea Institute of Construction Technology (KICT), and LL Pelling Co. The main purpose of LACT is to help member institutes and companies develop and implement their innovative new construction technologies in practice by performing objective laboratory testing and field evaluation.

Objectives are to:

- Perform research and testing (both laboratory and field) on emerging construction technologies for member organizations
- Evaluate advanced construction technologies developed by member organizations for implementation
- Help member organizations commercialize innovative construction technologies

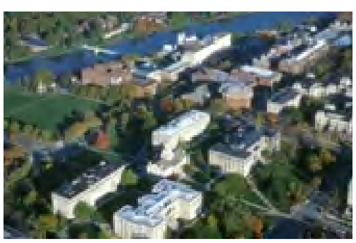
Benefits include:

- Serving on the Board of Directors to oversee the operation of LACT
- Having the problems solved through research and testing at LACT
- Enhancing the organization's operational efficiency and sustainability through consulting with LACT staff
- Participating in organizing the workshops and seminars in addressing the problems encountered in construction industry
- Obtaining the third-party objective evaluation of the organization's innovative construction technologies
- Advertising new products and technologies through the LACT website
- Disseminating successful testing and implementation results through the LACT website
- Reaching out to potential employees and clients through LACT's professional network
- Receiving a professional assistance from the full-time staff members at LACT

Global Warm Mix Asphalt Workshop

GWMAW 2013

Marriott Hotel, Coralville, Iowa, October 30-31, 2013



Laboratory for Advanced Construction Technology (LACT)

http://lactiowa.org/events/global-warm-mix-asphalt-workshop

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Warm Mix Asphalt (WMA)
– Time for Paradigm Shift after A Decade of Experiences

To celebrate the establishment of Laboratory for Advanced Construction Technology (LACT) at the University of Iowa with support from KICT, APAI, CMT and L.L. Pelling Co., join us at the 2013 Global Warm Mix Asphalt Workshop. As we have reached a great milestone of 10 years since the first Warm Mix Asphalt application in the US, the theme of GWMAW 2013 is the paradigm shift on Warm, not Hot, Mix Asphalt that would re-define, certify and revitalize WMA.

Over a decade, the Warm Mix Asphalt has enjoyed a tremendous growth in the US and the world. However, a significant reduction in temperature of asphalt mixtures has not been realized. Through this workshop, the WMA should be re-defined, measuring the production temperature of WMA for certification should be discussed, and ways to revitalize the WMA application should be explored. We all agree that the society demands cooler asphalt mix but the question is "Who should pay for it?" For next two days, I would like to challenge you to openly debate about the benefits and costs of various WMA technologies.

I would like to record my indebtedness to Matthew Corrigan of FHWA and Bill Rosener of APAI who constantly encouraged and guided me to the success of this workshop. Finally, I would like to thank participants who convened in Coralville, Iowa, from countries such as Korea, Norway and Iceland, far, far away, to share their knowledge and learn more about WMA technologies.

Let's think out of the HMA box and, with less heat and fumes, enjoy the better working environment of WMA.

When we depart, you may ask "Is this heaven?" And I say, "No, it's Iowa!"

Hosin "David" Lee, Chairman, GWMAW 2013
Professor, University of Iowa

Welcoming Remarks by Board of Regents, State of Iowa

Congratulations to the Laboratory for Advanced Construction Technology and welcome to all the attendees of the Global Warm Mix Asphalt Workshop. Whether you've been involved in a lot of warm mix projects or none at all; you're here to learn, to think outside the box, to look at our product through a little different lens and see if we can do it better.

Whether you're an engineer, contractor, or project owner; this process takes our existing environmentally responsible recycled asphalt pavements to the next level. Warm mix cuts fuel consumption and decreases the production of greenhouse gases making it the most environmentally friendly pavement choice by far.

I would also like to mention the equipment manufacturers and additive suppliers. You recognized this opportunity to improve our product and rose to the occasion by supplying the processes and materials to make warm mix a success.

Thanks to the Korea Institute of Construction Technology, the Asphalt Paving Association of Iowa and the L.L. Pelling Co. for supporting LACT. Congratulations to Dr. Lee for what looks to be a very worthwhile workshop.

Milt Dakovich, Board of Regents, State of Iowa
President, Aspro, Inc.

Welcoming Remarks by Dean of Engineering, University of Iowa

I am delighted to welcome you to Iowa City and the University of Iowa! Hosting the Global Warm Mix Asphalt Workshop here is not only an honor; it also is a very appropriate location. The University of Iowa's College of Engineering is proud of the leadership and knowledge that Professor Hosin "David" Lee has shown in this important area for more than a decade. We are also proud of the recent establishment of the Laboratory for Advanced Construction Technology through the visionary sponsorship of the Korea Institute of Construction Technology; LL Pelling Co.; and the Asphalt Paving Association of Iowa. I had the distinct pleasure of visiting the Korea Institute of Construction Technology just last October and participated in the signing of a Memorandum of Understanding, along with Dr. Byung Suk Kim, who is here today. Also, we are thankful for the wonderful continued support and collaborations with the Asphalt Paving Association of Iowa, including a generous scholarship program for our students who are focused on the asphalt construction field.

Speaking of our students, please let me take a moment to "brag" a bit about the college and the level of high quality that rests among our students, faculty and staff. This fall we achieved an eight straight year of record undergraduate enrollment with approximately 2,000 exceptionally talented undergraduate students and 350 graduate students on campus. Our research enterprise also achieved record productivity with $56 million in research expenditures in a college with 86 engineering faculty. That corresponds to ~$636,000 per faculty member. With continued high quality undergraduate and graduate student enrollment, coupled with continued growth in our research exterprise, the College of Engineering now is moving ahead on a plan to expand our facilities on campus. The building project will give us more state-of-the art classrooms, more study space, and more facilities to grow our research enterprise even further.

As you can see, engineering at the University of Iowa has a very bright future, as does the entire warm mix asphalt industry. And we look forward to a great partnership between us that will create new technologies in road surface management. Again, welcome to the University of Iowa. We are delighted you are here.

Alec Scranton, Dean of Engineering College,
University of Iowa

Welcoming Remarks by Vice President of Korea Institute of Construction Technology

Good morning. I am Byung-Suk Kim, Vice President of Korea Institute of Construction Technology (KICT), the main national research institute in the civil and environmental engineering in Korea with over 800 employees.

It is my great pleasure to be here at this significant gathering of Warm Mix Asphalt Experts from the all over the US and as far as from Iceland, Norway, Taiwan and Korea, at the 2013 Global Warm Mix Asphalt Workshop. On behalf of KICT, I wish to thank all of you for being here today. In particular, much appreciation goes to Professor Hosin "David" Lee of University of Iowa, also Chairman of Global Warm Mix Asphalt Workshop and as well as Director of Laboratory for Advanced Construction Technology (LACT).

On October 12, 2012, University of Iowa and KICT has signed the Memorandum of Understanding (MOU) to capitalize on their core capabilities and advance the areas of science and engineering that may be of mutual interest and benefit. KICT has identified the University of Iowa as a top-notch institute among many universities in US because of Professor David Hosin Lee. Under the MOU between University of Iowa and KICT, KICT is pleased to support the establishment of LACT and willing to continue the sponsorship for LACT to promote various technologies developed in KICT to the US market as well as worldwide market.

KICT is engaging itself in conducting the R&D in the areas such as Structure, Highway, Transportation, Geotechnical Engineering and Water Resource. In addition, KICT is facilitating the total development of domestic construction- technology by helping the Korean government establish and implement national construction policies.

I hope today's workshop will serve as an opportunity for not only LACT but also all the attendants to better vitalize Warm Mix Asphalt Technology, and to further strengthen close cooperation among government officials, researchers, contractors and manufacturers. I believe the presentations and discussions on the current status of Warm Mix Asphalt as well as the direction for the future are ever meaningful.

Once again, I would like to acknowledge LACT of University of Iowa for hosting this workshop as well as the participating experts for your presentations and discussions.

Byung-Suk Kim, Vice President
Korea Institute of Construction Technology

Congratulatory Remarks from Executive Vice President of APAI

On behalf of the 132 members of the Asphalt Paving Association of Iowa (APAI), we would like to sincerely congratulate you for your successful organization of the Global WMA Workshop in Iowa City, IA. This timely event highlights the strong bond between the Laboratory for Advanced Construction Technology (LACT) at the University of Iowa, the members of the APAI, the Iowa Department of Transportation, and the Federal Highway Administration. The strong interest in this event from around the world highlights the desire to move these remarkable technologies forward to improve the quality and longevity of our roadways; enhance the workplace for our employees and inspectors; and reduce the asphalt industries' carbon footprint for a more sustainable future.

The State of Iowa has a long history of innovation and quality pavements. The use of high RAP pavements, cold-in-place recycling and more recently, Warm-mix asphalt all demonstrate the willingness of the IDOT and the Iowa asphalt contractors to improve the quality and sustainability of our pavements. Iowa contractors have been recognized for their successes nationally over the past 13 years. The National Asphalt Pavement Association (NAPA) has recognized four different Iowa contractors as finalists for the prestigious Sheldon G Hayes Award given to the best asphalt paving project in the nation. Iowa contractors have won the award three times and been finalists four other times during this brief time span. None of this can be achieved without the cooperation and partnership between industry, agency and academia.

We wish you all the success you deserve for your hard work in organizing this great event and continued success for the Laboratory for Advanced Construction Technology (LACT).

Bill Rosener, Executive Vice President
Asphalt Paving Association of Iowa

Congratulatory Remarks from President of LL Pelling Co.

I'd like to say thank you as well as congratulate Dr. Lee and the Laboratory for Advanced Construction Technology for organizing this global workshop on the technologies of Warm Mix Asphalt. This gives us all a chance to come together, share our experiences, ideas and knowledge on the use of WMA not only in the United States but globally.

Our local company, LL Pelling Co. Inc., has had the opportunity to use a variety of additives to make warm mix asphalt as well as utilizing the foaming method. As recently as this past April we installed a new Astec Double Drum asphalt plant in Cedar Rapids that has foaming capabilities as well as the capabilities to recycle both RAP and RAS in our mixes. We have also had the opportunity to partner with the University of Iowa, the Iowa DOT and the City of Iowa City on projects utilizing both warm mix and recycled asphalt mixes. The most recent project utilized high RAP and warm mix asphalt on US 6 here in Iowa City.

The LL Pelling Co. is proud to be a supporter of the Laboratory for Advanced Construction Technology (LACT) and we encourage you also to join us in supporting the LACT to help in the research of problems we may encounter in the asphalt industry (such as what is the optimum asphalt and aggregate temperatures for foaming?) The owners of our streets and highways, the tax payers, highly encourage the use of green technologies but they also expect quality results in doing so. It is our duty as the builders of the nation's highways to use the latest most technological methods but to produce a long lasting pavement. The use of Warm Mix Asphalt will continue to increase nationally as we proceed through the coming years and LACT will be the industry's partner in making sure we achieve the quality pavements that are expected of us.

Again thank you for attending and for sharing your ideas with your colleagues from around the globe.

Chuck Finnegan, President,
LL Pelling Co.

Wednesday, October 30, 2013

7:30 – 8:30 am		**Continental Breakfast**
8:30 – 9:00 am		**Welcoming Remarks** **Chair: Hosin "David" Lee, Professor and Director of LACT, University of Iowa** **Milt Dakovich, Board of Regents, State of Iowa** **Alec Scranton, Dean, Engineering College, University of Iowa** **Byung-Suk Kim, Vice President, Korea Institute of Construction Technology**
9:00 am – 10:15 a.m.	Exhibition Booths Open	**Workshop on Present Status of warm Mix Asphalt by Government Employees** **Chair: Scott Schram, Iowa DOT** **Joe Peterson, Caltrans,** "California WMA Study: Specifications, Product Approvals, and Implementation" **Tim Clyne, Minnesota DOT,** "Minnesota's Experience with Warm Mix Asphalt" **Dave Panos, City of Iowa City,** "First Warm Mix Asphalt Construction in Iowa City" **Jim Musselman, Florida DOT,** "FDOT's Experience with Warm Mix Asphalt" **Panel:** Mike Kindschi, Jeremy Purvis, Gene Hellige, Eric Thompson, Janet Doerstling,
10:15am – 10:45 am		**Coffee Break (at exhibition booth area)**
10:45 am - 12:00 pm		**Workshop on Future of warm Mix Asphalt by Government Employees** **Chair: Matthew Corrigan, Federal Highway Administration** **Matthew Mueller, Illinois DOT,** "Warm mix Asphalt Implementation on Illinois DOT Projects" **Scott Schram, Iowa DOT,** "Future of Warm Mix Asphalt in Iowa" **Panel:** Mike Kindschi, Jeremy Purvis, Gene Hellige, Eric Thompson, Janet Doerstling, Dave Panos, Tim Clyne, David Jones
12:00 pm – 1:30 pm		**Lunch and Visit Exhibition Booths**
1:30 pm – 3:00 pm		**Workshop on Development of Warm Mix Asphalt by Manufacturers** **Chair: Haifang Wen, Washington State University** **Mike Palmer, InVia Pavement Technologies, "**Evotherm Warm Mix Asphalt Technology: Comprehensive Additive Package" **Sundaram Logaraj, Akzo Nobel Surface Chemistry LLC,** "Use of Rediset warm-mix additives to improve workability, compaction, moisture resistance and enhance sustainability of asphalt paving" **Jun-sang Park, Kumho Petrochemical Ltd,** "The Introduction to Warm-Mix Asphalt Additive:LEADCAP and RAPCAP" **Chris Strack, Sonneborn Inc.,** "Overview of Organice wax as a Warm Mix Additive" **Roger Sandberg, Maxam Equipment, Inc.,** "WMA - A Foamer's Perspective" **Panel:** Petur Petursson, Donna Kwapis, Santanoo Sen, Ashish Shah, Annette Smith
3:00 pm – 3:30 pm		**Coffee Break (at exhibition booth area)**
3:30 pm – 5:00 pm		**Workshop on Application of Warm Mix Asphalt by Contractors** **Chair: Bill Rosener, Asphalt Paving Association in Iowa (APAI)** **Brad Henningsen, Henningsen Construction,** "Warm Mix Asphalt Every Day" **Jeremy Anderson, Tri-State Paving Company,** "Dickinson County Iowa 2012 WMA/HMA Side by Side Comparison" **Steve Jackson, West Contracting Company, Inc.,** "Warm Mix Asphalt: Every Mixtures, All of the Time" **Brett Finnegan/Gary Netser, LL Pelling Co.,** "Quality Control of Warm Mix Asphalt Mixtures" **Panel:** Soon-Jae Lee, Chuck Finnegan, David Jones, Ryan Lynch, Dan Staebell, Anand Sampath, Bjorn Lerfald
5:00 pm – 6:00 pm		**Cocktail at Exhibition Booth Area**
6:00 pm – 9:00 pm		**Welcoming Dinner** **Speaker: Byung-Suk Kim, Vice President of Korea Institute of Construction Technology**, "State-of-the-art in Ultra High Performance Concrete"

Thursday, October 31, 2013

7:30 – 8:30 am		**Continental Breakfast**
8:30 – 9:00 am		**Congratulatory Remarks** **Chair: Tim Clyne, Minnesota DOT** **Bill Rosener, Executive Vice President, APAI** **Chuck Finnegan, President, LL Pelling Co.**
9:00 am – 10:15 am	Exhibition Booths Open	**Keynote Presentations** **Chair: Pétur Pétursson, Icelandic delegate in CEN/TC227/WG1** **Matthew Corrigan, Asphalt Pavement Engineer, Federal Highway Administration,** "Warm Mix Asphalt in the United States: From Evolution to Revolution" **Randy West, Director, National Center for Asphalt Technology,** "Warm Mix Asphalt Experiments on the NCAT Test Track"
10:15am – 10:45 am		**Coffee Break (at exhibition booth area)**
10:45 am - 12:00 pm		**National WMA Research Updates** **Chair: Janet Doerstling, Arizona DOT** **Carolina Rodezno, National Center for Asphalt Technology,** "Finding of the NCHRP 09-47A project: Properties and Performance of Warm Mix Asphalt Technologies" **Haifang Wen, Washington State University,** "Performance of WMA Technologies: Long-Term Field Performance" **David Newcomb, Texas A&M Transportation Institute,** "Measuring Asphalt Foam Properties and Their Effects on Mixtures"
12:00 pm – 1:30 pm		**Lunch and Visit Exhibition Booth**
1:30 pm – 3:15 pm		**Recent Advances in WMA Technology** **Chair: Bjørn Ove Lerfald, Veidekke Industri, Norway** **David J. Jones, University of California at Davis,** "California WMA Study: Accelerated Load Testing, Use in Rubberized Asphalt, Emission Reduction, and Long-term Field Performance" **Pétur Pétursson, Icelandic delegate in CEN/TC227/WG1,** "Use of Temperature Reducing Materials in Bituminous Mixtures in Iceland" **Chris Williams, Iowa State University,** "An Examination of Warm Mix Asphalt Using Iowa Aggregates" **Cheolmin Baek, Korea Institute of Construction Technology**, "Performance and Field Applications of LEADCAP WMA Technology" **Hosin "David" Lee, University of Iowa,** "Temperatures and Field Densities of LEADCAP Warm Mix Asphalt"
3:15 pm – 3:45 pm		**Coffee Break (at exhibition booth area)**
3:45 pm – 5:00 pm		**Findings from Workshops by Government Employees, Manufacturers and Contractors** **Chair: Hosin "David" Lee, University of Iowa** **Scott Schram/Matthew Corrigan, Government Employees Workshop Summary** **Haifang Wen, Manufacturers Workshop Summary** **Bill Rosener, Contractors Workshop Summary**
5:00pm – 6:00 pm		**Cocktail at Exhibition Booth Area**
6:00 pm – 9:00 pm		**Closing Dinner (Halloween Costumes Optional)** **Speaker: Chia-Pei Chou, Taipei Economic and Cultural Representative Office,** "Role of National Science Council in Technology Development in Taiwan"

Keynote Presentation:

Warm Mix Asphalt in the United States: From Evolution to Revolution

Matthew Corrigan, P.E.
Asphalt Pavement Engineer | Mobile Asphalt Testing Trailer Technical Manager
U.S. Department of Transportation | Federal Highway Administration
matthew.corrigan@dot.gov

Production and placement of hot-mix asphalt (HMA) pavements in the United States has evolved over the last 130 years, from hand mixing and application with rakes and shovels to computerized facilities feeding highly automated remixing, placement, and compaction equipment. During this time, engineers have learned that temperature control is crucial to aggregate coating, mixture stability during production and transport, ease of placement, compaction, density, and ultimately a pavement's long-term performance.

The Federal Highway Administration (FHWA), in cooperation with the HMA industry, researchers, and academia, is constantly exploring technological improvements that will enhance the performance, construction efficiency, resource conservation, and environmental stewardship of asphalt mixtures. One approach to achieving all these goals is to reduce HMA production temperatures and to this end engineers explored the concept of warm-mix asphalt (WMA) in the United States.

WMA was first publically demonstrated in the U.S. at the 2004 World of Asphalt Trade Show and Conference. By 2005 it was obvious that WMA needed to be fully understood and adopted in the United States through a coordinated effort of asphalt pavement industry partners. FHWA responded to the challenge of reducing temperatures and maintaining performance by forming the Warm Mix Asphalt Technical Working Group (WMA TWG) and tasked it with proactively providing national guidance in investigating and implementing WMA technologies. The group included multiple sectors of the asphalt pavement industry, such as State highway agencies, academia, and contractors. The group's longstanding goal was to provide technical guidance that lead to a product with quality, cost-effectiveness, and performance at least equal to conventional HMA. The WMA TWG was successful in moving forward research needs statements that resulted in eleven National Cooperative Highway Research Program funded projects. These projects represent over 7.5 million dollars of investment in the continued success of WMA.

Although WMA technologies originated outside the U.S., it has been the collective U.S. asphalt paving industry that has advanced the technology beyond a niche market into mainstream common practice. The growth of WMA usage has continued to increase even as the overall asphalt pavement market demand has decreased. More than 68 million tons of WMA was placed in 2011 representing 19 percent of total asphalt mixture production in the U.S.

At FHWA we see the use of WMA technologies as a tremendous opportunity to improve construction quality, extend the construction season, and minimize impacts to the environment. The collective efforts from highway agencies and industry partners to advance warm mix asphalt technologies as a standard practice has been tremendous.

FHWA's Mobile Asphalt Testing Trailer

Keynote Presentation:

Warm Mix Asphalt Experiments on the NCAT Test Track

Presenter: Randy Clark West, Director of NCAT at Auburn University
westran@auburn.edu
Authors: Randy West and Carolina Rodezno

Over the past seven years, several different WMA technologies have been evaluated at the NCAT Test Track. Experimental objectives have also varied with the different evaluations. This paper describes some of key WMA experiments and the findings from those studies.

Test sections at the NCAT Test Track are 200 feet in length and are trafficked 16 hours per day in two-year periods by five heavily loaded truck-trailer rigs. Trailer axles are loaded to 20,000 lbs. Performance of sections is closely monitored for distresses. Some sections are also instrumented to measure the pavement's response to loading and climatic changes.

The first evaluation of a WMA technology on the Test Track occurred in the fall of 2005 when three temporary test sections were constructed to evaluate MeadWestvaco's Evotherm ET technology. The mixing temperature of the WMA mixes was 239°F (115°C) and the target compaction temperature was 225°F (107°C). Paving equipment problems were encountered during paving the surface of one section, so the WMA remained in a silo for 17 hours. When it was placed, the mix had cooled to 205°F (96°C). However, in-place densities of all WMA mixtures were above 96% of G_{mm} which indicated that Evotherm ET enhanced compactability even at temperatures much lower than conventional HMA. Each of the test sections performed well through the rest of the cycle with less than 1.1 mm of rutting after more than ½ million ESALs. One section was left in place for more than 16 million ESALs with only 4 mm of rutting before it was removed for a different experiment.

In 2009, a group of WMA and control test sections were constructed as part of the Test Track's 4th research cycle. The WMA sections were built using the WMA technologies in each lift of a 7-in. asphalt pavement structure. An objective of this experiment was to evaluate the pavements' structural responses under full-scale loading. State DOT sponsors of the experiment selected two WMA technologies to use: Evotherm-DAT and Astec Double Barrel Green, referred to as WMA-A (i.e. Additive) and WMA-F (i.e. Foam), respectively. A control section was built using all virgin materials and Superpave mix designs. One section was built with WMA-A, and another with WMA-F using the same mix designs for each layer as the control section. Another pair of sections included 50% RAP, one of them produced at HMA temperatures and the other produced with water-injection asphalt foaming at WMA temperatures. All of those sections performed very well through the 4th cycle and were left in place for the 5th cycle. Some minor cracking is now evident after about 14 million ESALs and rut depths for the virgin WMA sections are slightly higher than the control section.

Falling-weight deflectometer (FWD) testing performed to compare the seasonal behavior of the pavement layer moduli showed that the virgin WMA sections had 7 to 10% lower moduli than virgin HMA at all temperatures, likely due to the reduced plant aging of the binders for the WMA sections. These test sections were also instrumented with strain gauges and pressure plates to measure the response of the pavements under live traffic. Despite the small differences in moduli for virgin WMA and HMA, the pavements did not respond differently under traffic for critical strains. The 50% RAP HMA and WMA sections, however, have significantly higher moduli and critical strains.

California WMA Study: Specifications, Product Approvals, and Implementation

Presenter: Joseph Peterson, California Department of Transportation
joe_peterson@dot.ca.gov
Authors: Joseph Peterson, David Jones and Cathrina Barros
Acknowledgements: California Department of Transportation (Caltrans)

Introduction

The use of warm-mix asphalt (WMA) has increased substantially in recent years. Given the significant differences to hot-mix asphalt (HMA) practice and fears of a moratorium on the use of WMA if unexplained problems occur, Caltrans followed a conservative approach to implementation, based on the findings from a phased comprehensive research study discussed in a separate presentation. Using the findings from this study and based on satisfactory performance in various pilot studies around the state, Caltrans revised their Standard Specifications to accommodate the use of WMA. Caltrans also initiated a product approval list, which requires technology suppliers to provide a brief report summarizing laboratory testing and field experiment monitoring that shows equal or better performance to HMA controls. Nine technologies are currently approved for use in the State. Statewide implementation was facilitated through a series of workshops held in each of the 12 Caltrans districts. These workshops, which were attended by state and local government as well as industry, provided an overview of WMA, the research carried out, changes to the specifications, and how WMA could be used on future projects. The level of implementation has varied across the state. One project on Interstate-5 will be presented as a case study. This approximately 20-mile jointed plain concrete pavement rehabilitation project consisted of selected slab replacements, crack-and-seat, and asphalt overlay. WMA was used as an alternative to PCC in some of the slab replacements and in the different lifts of asphalt overlay. About 600,000 tons of warm-mix asphalt was used on the project. All paving was done at night towards the end of the paving season. The use of warm-mix resulted in numerous benefits including reduced smoke and odors (Figure 1 and Figure 2), improved workability, improved compaction, and the ability to continue paving during colder ambient temperatures.

Figure 1: Smoke from HMA during night paving

Figure 2: Smoke elimination with WMA during night paving

This presentation provides an overview of specification changes to accommodate the use if WMA in state projects, the Caltrans product approval process and the statewide implementation initiatives. A case study on the use of warm-mix asphalt in a major Interstate rehabilitation project is also summarized.

Minnesota's Experience with Warm Mix Asphalt

Presenter: Tim Clyne, Metro Materials & Program Delivery Engineer, Minnesota Department of Transportation
tim.clyne@state.mn.us
Author: Tim Clyne
Acknowledgements: John Garrity, Jill Thomas

Introduction

The Minnesota Department of Transportation (MnDOT) has followed the usage of warm mix asphalt (WMA) in the United States since 2004. Besides the environmental and operational benefits of WMA, we have been intrigued by the perceived performance benefits in terms of low temperature and reflective cracking because of the reduced binder aging. This presentation describes the brief history of WMA projects and specifications in Minnesota, discusses the pros and cons of WMA, and projects the future prospects of WMA.

From Trial to Full Implementation in 5 Years

The use of warm mix asphalt in Minnesota was principally driven by the asphalt paving industry, with parallel work being conducted in MnDOT research. The first WMA demonstration projects were built in 2007 on several county roads in the southeast corner of Minnesota. Several more WMA projects were constructed in Crow Wing County in the north central part of our state. More recently, several local contractors have installed foaming nozzles on many permanent asphalt plants around the Twin Cities and greater Minnesota.

MnDOT paved the first WMA project on a state highway in 2008 at the MnROAD research facility. The following year WMA was used on a mill and overlay project on TH 95 to complete paving late in the season. In 2010 warm mix was required on two district paving projects per the District Materials Engineers' requests. One of these jobs on TH 169 also incorporated intelligent compaction and thermal bar technology, which gave MnDOT additional insight into the behavior of WMA during construction. In 2011, MnDOT far exceeded our goal of 200,000 tons of WMA produced as part of FHWA's Every Day Counts initiative.

MnDOT WMA Specifications

MnDOT's bituminous specifications have evolved over the last five years, and today WMA is allowed under a permissive spec. RAP and RAS are allowed in WMA mixtures, and the Department has no pre-approved list of WMA technologies.

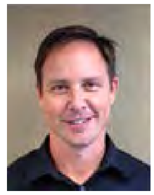
Pros and Cons

Several positives are gained by MnDOT and the Contractors by using WMA including "drop in" mix designs, "business as usual" at the plant and paver, reduced fumes and emissions, fuel savings, and improved public relations. Some difficulties encountered include miscommunication about laboratory compaction temperatures for QC/QA, incomplete blending with RAP/RAS binders, lack of WMA implementation in portable plants in the outstate districts, and the deficiency of long term performance data.

Future Prospects for Warm Mix Asphalt

Some of the buzz about WMA seems to have worn off in Minnesota, but that is because of its widespread use and acceptance. WMA went from about 2% of asphalt mixture production in the first few years to over 40% and rising at last count. MnDOT continues to support the use of WMA, and it will ultimately be up to the contractors to determine when WMA makes sense for a project and which technology to use. We will continue to build on our successes and encourage the widespread acceptance of warm mix asphalt.

First Warm Mix Asphalt Construction in Iowa City



Presenter: David Panos, Senior Civil Engineer, City of Iowa City Public Works Department
Dave-panos@iowa-city.org
Authors: Dave Panos, P.E. and Hosin "David" Lee, Ph.D., P.E

Introduction

On August 15, 2011, the first project of the PE Wax-based WMA Additive called "LEADCAP" was applied for rehabilitating Capitol Street between Prentiss Street and Court Street in Iowa City. The paving contractor for this project was LL Pelling Co. from North Liberty, Iowa. This section of street was included as a part of the City of Iowa City annual pavement rehabilitation program. Capitol Street between Prentiss Street and Court Street is 50 feet wide with 1,400 ADT. Bus service was maintained.

Project Description

The scope of the project consisted of a standard "mill and fill" project as rehabilitation. The existing asphalt pavement was milled 3" and replaced with a new 3.8-cm (1.5-inch) HMA binder course and 3.8-cm (1.5-inch) WMA surface course. A total of 327 tons of a 1 million ESAL 12.5-mm WMA surface mix with 10% RAP was used. A PG 64-22 asphalt binder was used on this project. The binder was heated to 135°C (275°F) before mixing with the aggregate at 135°C (275°F), then the asphalt mixture was stored in a holding container until it was ready to be loaded onto dump trucks at 130°C (266°F). The mix was then driven to the jobsite and placed on top of the binder course at 115°C (239°F). Field measurement of the WMA mixture indicated compacted at a temperature of 110°C (230°F). On September 27, 2012, due to underground utility rehabilitation work required by the University of Iowa, a part of the Capitol Street constructed on August 16, 2011, was removed and reconstructed using 100 tons of the same LEADCAP WMA mixture.

Densities of Pavement Cores

The average field densities of WMA mixtures placed in 2011 and 2012 resulted in air voids of 9.0% and 6.0% for binder content of 4.6% and 5.4%, respectively. The relatively higher average air void in 2011 was partly due to the asphalt temperature that was lowered to match the lower aggregate temperature.

Observations

During the installation of this product in Iowa City very low fumes and odor were created by the product as it was placed. Also, less heat generated at the paving level was very noticeable by inspection personnel along with contractor's personnel installing the product. The lack of fumes and odor emissions created a better working environment for the installation crew and also gives a better sense of a more environmentally friendly pavement installation. The reduction in pavement residual heat helped to provide a usable surface quicker than a standard HMA pavement installation would have provided. For the Capitol Street project, traffic on the WMA pavement was allowed immediately after the construction. The prompt use of WMA pavements to the traveling public, City emergency, and City transit services after installation was very helpful on this project, and was noted as a strong benefit to incorporating this technology into this asphalt pavement rehabilitation project.

FDOT's Experience with Warm Mix Asphalt

Presenter: James A. Musselman, P.E., Florida DOT

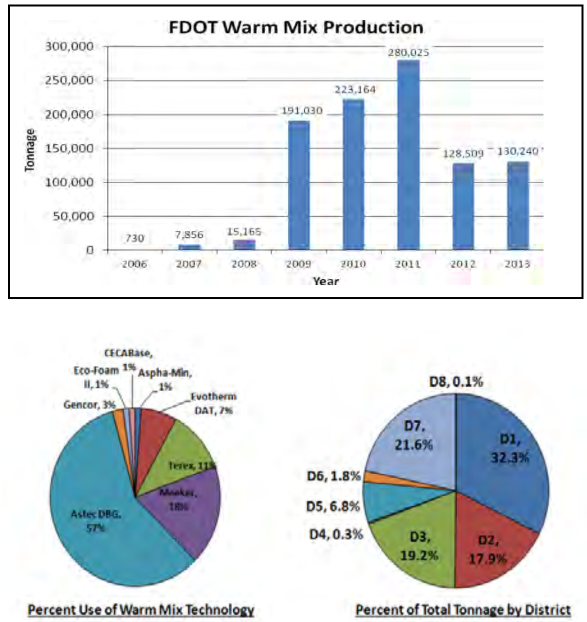
Introduction

Florida's State Highway System consists of 43,212 lane miles, and carries more than 54% of all the traffic in the state. Whereas the U.S. averages 94% of their lane miles as asphalt pavements, Florida's state system is comprised of 97.6% asphalt, with only 8.4% of those pavements considered deficient. Approximately 5 million tons of asphalt was produced for the FDOT in the fiscal year of 2012-2013; however, only 2.8% of that tonnage was warm mix, which is a relatively low number considering FDOT's permissive specification on warm mix.

Warm Mix in Florida

In 2006, the first warm mix project in the U.S. was produced on Florida's SR-417 (Florida's Turnpike) using an open-graded friction course (OGFC), a polymer modified asphalt binder, and Aspha-min as a foaming additive. The texture of the mix was excellent and the production and continued performance has been equivalent to the hot mix control. Three additional pilot projects were constructed using Astec Double Barrel Green (2 projects) and Evotherm DAT with similar results.

The use of warm mix became the contractor's option in the January 2010 FDOT specifications. To date, Florida has constructed 89 warm mix projects, totaling nearly one million total tons of asphalt mix. The asphalt mixing temperatures differences between HMA and WMA have ranged between 25-85ºF, with the average difference at 40ºF. There are currently nine approved warm mix products/technologies with more being evaluated each day.



Warm mix production and distribution of use by product and location in the Florida.

Comparison Pavement Performance

The FDOT continues to monitor the performance of each of these projects and compare them to their hot mix controls or equivalents. A 2012 evaluation compared six of the early warm mix projects, ranging from 2-6 years old, to 35 years of historical pavement performance. For each performance indicator (crack, rut and ride), WMA continues to show comparable performance to HMA.

Conclusions

Despite the successful implementation of warm mix into the FDOT specifications and the potential benefits, the down economy and market seem to be the primary driver for the slow adoption by the asphalt industry in Florida.

Warm Mix Asphalt Implementation on Illinois DOT Projects

Presenter: Matthew Mueller, PE, Engineer of Tests, Bureau of Materials and Physical Research, Illinois DOT
Matthew.Mueller@illinois.gov

Introduction

This paper provides an overview of the implementation of Warm Mix Asphalt (WMA) into Illinois Department of Transportation (IDOT) and local agency projects. Additionally, some review of obstacles to WMA implementation are explored.

Background

WMA technologies were introduced to IDOT more than a decade ago. Additionally, Eric Harm, Bureau Chief of Materials & Physical Research, participated on a WMA international scanning tour of several European countries. Early marketing of WMA in Illinois was focused on burner fuel savings from lower mixing temperatures at the plant and the corresponding lower emissions (smoke) as the material was loaded into trucks. Almost immediately, two camps formed in marketing warm mix technologies; the chemical additives group, and the foamers. The chemical additives group has steadily grown over the years to encompass several distinctly separate methods for lowering mixing temperatures. The foaming group can arguably be lumped into a single segment simply described as a plant modification which sprays water into the mix chamber where it interacts with the asphalt to disperse it at lower temperatures than traditional hot mix asphalt (HMA).

Purported benefits of WMA have increased over the years too. In addition to lowering mixing temperatures and reducing air pollution, beneficial claims of longer haul times, later season paving, aid to achieving compaction, reduced asphalt binder aging, greater mix fatigue resistance, elimination of overlay bumps due to expansion of underlying hot pour joint sealant, better mixing of high recycle mixes, and greater asphalt binder replacement (ABR) without grade bumping.

State of Practice

Illinois HMA contractors have been slow to embrace WMA. There are many indirect reasons for this including; changes in HMA/WMA acceptance for pay by the IDOT, legislative mandates to increase the amount of recycle (RAP) and reclaimed (RAS) materials, a shift to smaller top size aggregate mixes and the introduction of fine graded mix designs, implementation of the Hamburg Wheel mix test program, and the sudden availability of cheap (natural gas) burner fuel. All of these initiatives have kept industries' quality control (QC) managers very busy.

IDOT continues to study the effects of WMA and the many other changes to the mix as it relates to pavement performance. Stripping has been a major concern of HMA pavements and many of the changes previously mentioned are the result of the initiative to minimize moisture damage. Adoption of the Hamburg Wheel following many of the guidelines established by the Texas Department of Transportation has enabled IDOT to virtually eliminate rutting of new mixes. Some WMA mixes have not performed well in the Hamburg Wheel and evaluation of field performance is still pending. The need for a mix test to predict cracking potential both for fatigue and environmental concerns remains elusive. Several test methods show some promise but validation with field work calibrated to Illinois' environmental conditions is lacking. Several ongoing efforts are underway to establish criteria for mixes which should help to spur the use of WMA in Illinois.

Future of Warm Mix Asphalt in Iowa

Presenter: Scott Schram, Ph.D., P.E., Bituminous Engineer, Iowa DOT
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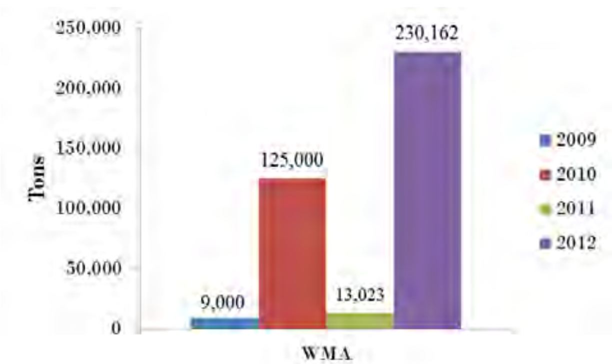
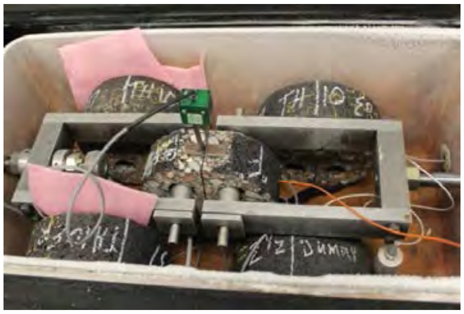
Introduction

The Iowa DOT first experimented with WMA in 2009. In 2011, the specifications became fully permissive. Another recent change in specifications also waives the maximum plant temperature for WMA past October 1st. This change has been utilized to extend paving in the fall months. To date, the use of WMA by contractors statewide is moderate to low. This is partly due to experience and equipment.



To expand and encourage the use of WMA, the Iowa DOT is looking into implementing a low temperature cracking performance test for high rap mixtures. Limited results are available, though there are early indications that WMA benefits the fracture energy at low temperatures. In addition, there is reluctance in the industry regarding the impact on the incentives/disincentives under a young PWL specification implemented in 2009. Data analysis will be presented showing no reason for concern.



Questions

After 10 years of WMA implementation in the US, I would like to pose the following questions for discussion during this future of WMA workshop:

1. Shall the agency pay for the WMA additive as a separate item like anti-stripping additive?
2. Shall the contractor be required to do the mix design of WMA mixtures like HMA mixtures?
3. Shall the contractor be allowed to use less amount of binder if the mix design of WMA confirms it?
4. Shall the contractor be required to report the temperatures of the WMA mixtures when the truck leaves the plant?
5. How much is the saving to the contractors in terms of energy?
6. How to quantify the benefit of the WMA such as less fume, better working environment, easier to compact, etc.?

Evotherm Warm Mix Asphalt Technology: Comprehensive Additive Package

Presenter: Mike Palmer, General Manager – Upper Midwest, InVia Pavement Technologies
mike@invia-tech.com

What is Evotherm?
Evotherm is a water free warm mix asphalt technology. By employing a combination of specialty surfactants and unique chemistry, Evotherm is optimized to deliver improvements in mixing, coating, workability, compaction, and adhesion, as well as significantly lower production temperatures.

How does Evotherm work?
Surface tension can be described as a property of a liquid that allows it to resist an external force. Surfactants are compounds that lower the surface tension between two liquids, or between a liquid and a solid. In traditional hot mix asphalt production, massive amounts of heat are used to lower the surface tension of liquid asphalt, allowing it to mix with and bind to aggregate particles. The surfactants used in Evotherm decrease the surface tension of liquid asphalt, allowing for the mixing and coating of aggregate particles with significantly less heat.

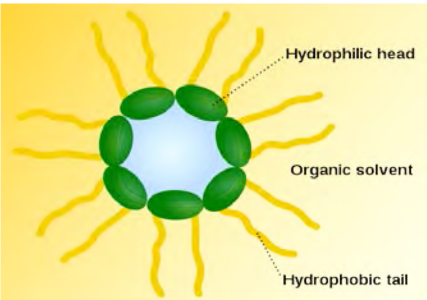


*Figure 1. Surfactant

Due to their structure, the surfactant molecules in Evotherm also promote adhesion of asphalt to aggregate. Evotherm surfactants have a polar head, and a carbon chain for a tail. The polar head will readily bond to aggregates, while the tail will bond to asphalt. The picture (figure 1) shows an example of how surfactants can bond to different types of surfaces, and promote adhesion between substances that would otherwise not mix or bond.

Why use Evotherm?
Evotherm is easy to use. Available in ready-to-use form, Evotherm is a liquid additive than can be shipped directly to your mix plant, or blended with liquid asphalt at your asphalt supplier's terminal. Evotherm can be used in any type of mix plant, and is compatible with any grade of liquid asphalt.

Evotherm has best in class low temperature performance. Through dramatically lower mix production temperatures, Evotherm delivers fuel savings, decreases asphalt oxidation, and reduces mix plant emissions. On the grade, this translates to easier compaction, improved worker safety, longer hauls, and an extended paving season.

Evotherm has proven performance. With nearly a decade of use, Evotherm warm mix technology has been used to produce over 70 million tons of warm mix asphalt, enough mix to pave nearly 100,000 lane miles, or circle the world almost four times.
The unique properties of Evotherm warm mix asphalt provide a host of benefits for asphalt producers, asphalt paving contractors, and road owners. There exist numerous examples and case studies of how using Evotherm improves mix quality, provides ease of production and paving, and aids mix producers and asphalt paving contractors to meet performance criteria established by road owners.

Most importantly, the benefits provided by Evotherm ultimately lead to pavements with increased life cycles, lower life cycle cost, and financial savings for all parties involved in asphalt road construction when using warm mix asphalt.

Use of Rediset Warm-mix Additives to Improve Workability, Compaction, Moisture Resistance and Enhance Sustainability of Asphalt Paving

Presenter: Sundaram Logaraj, Ph. D., Market Development Manager, AkzoNobel
Sundaram.Logaraj@akzonobel.com

Introduction

AkzoNobel's Rediset® surfactant-based warm-mix additives have been used for many years and their performance in improving workability, compaction and moisture resistance have been confirmed based on laboratory tests and field data, which are presented in this paper.

Enhancing Sustainability in Asphalt Paving

The environmental and practical benefits of warm-mix have been well established. Warm Mix already provides energy savings, reduced emissions, and health and safety benefits over comparable hot mix. Life Cycle Analysis of Rediset treated asphalt mixtures has confirmed that the products deliver improved sustainability. But additional benefits could accrue if warm mix technology could enable or facilitate the use of recycled materials in asphalt mixtures. In this paper examples of the use of warm mix technology together with various levels of reclaimed asphalt pavement (RAP) in a project at Chicago's O'Hare International Airport are described.

Figure 1. Standard HMA (left) and Rediset WMX (right) paving of US 190 between Jasper and Woodville, TX.

Use of warm-mix technology not only helped to cut down emissions and energy use, but also provided various practical benefits for the hot-mix producer and contractor. Compaction of mixes took less amount of time and so increased the productivity of the paving project. Also paving was possible at continued to near freezing temperatures in December 2011, maximizing the utilization of men and machinery.

Figure 2. Rediset LQ warm mix paving of Taxiways at O'Hare Airport in Chicago

Improving the Properties of Foamed Asphalt

Foamed asphalt (where water is injected into hot asphalt ahead of the mixer) is a cost-effective and widely-used warm mix technology that can be combined with Rediset chemistry. Rediset warm-mix additives have been evaluated in foam mixes in the laboratory and in the field and they significantly improve properties of foam mixes in terms of coating, the length of time that the mix exhibits enhanced workability, and the moisture resistance of the paving material.

Conclusions

The work described demonstrates the continued development of Warm-mix towards a technology that delivers environmental benefits in its own right, but also enables the higher use of recycled materials, and provides operational advantages to the paving contractor. Different warm mix technologies are not mutually exclusive and the combination of surfactant additives with widely-used foam asphalt mixes is a viable option for improved performance.

The Introduction to Warm-Mix Asphalt Additive: LEADCAP and RAPCAP

Presenter: Jun Sang Park, Chief Researcher, Kumho Petrochemical Co.
polymer@kkpc.com

Introduction

In 2009, the Korea Institute of Construction Technology and Kumho Petrochemical in South Korea started a research project to develop the WMA technology and apply it to the South Korean pavement system. Recently, an innovative WMA additive has been developed to reduce mixing and paving temperature.

LEACAP

This additive, called low energy and low-carbon-dioxide asphalt pavement LEADCAP, is an organic additive of a wax-based composition that includes crystal controller and artificial materials. LEADCAP allows the producing and paving of WMA at temperatures 30 °C lower than HMA. The LEADCAP additive has been applied to dense-graded HMA to evaluate the performance of WMA with LEADCAP.

The characteristics of LEADCAP can be divided into three parts: function, low-temperature property, and adhesion. First, the major component of LEADCAP is polyethylene-based wax.

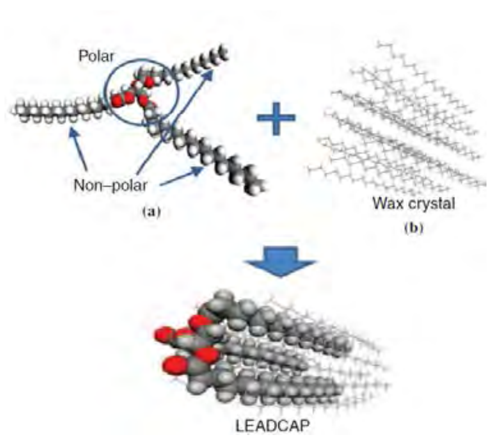


Figure 1. Molecular structure of LEADCAP

In general, wax material can be fully melted at over melting temperature because it is crystalline. The second characteristic of LEADCAP is superior low temperature properties. Normally, wax-based WMA additives give poor low-temperature properties to asphalt mixtures because crystalline wax material is very stiff and brittle at temperatures below the crystallization point. To decrease the potential for cracking, a crystal controller is used in LEADCAP, as shown in Figure 1. Finally, LEADCAP contains an adhesion promoter to improve the adhesion between asphalt and aggregates. The adhesion promoter is a metallic salt that is aggregatephilic on one side and asphaltphilic on the other.

RAPCAP

RAPCAP is a liquid type WMA additive for high RAP. A high RAP asphalt pavement should be developed to increase RAP usage ratio. Moreover, if it is warm mix asphalt to reduce the temperature, the benefit of that technology can be very effective to environment and cost. High RAP means here around 50% or more RAP. RAPCAP is composed of rejuvenator, adhesion promoter and WMA additive.

Table 1. Properties of RAPCAP

Virgin binder (wt%)		100		58	56
Aged binder (wt%)			100	43	43
RAPCAP (wt%)					2
Penetration (dmm), 25℃		56	15	42	59
Softening point (℃)		50	63	54	53
Viscosity (cps)	120℃	1,200	2,900	1,330	1,056
	140℃	420	830	450	366
Ductility (cm)	15℃	>140	4	98	>140

Overview of Organic wax as a Warm Mix Additive

Presenter: Chris Strack, Market Manager Asphalt – Sonneborn Inc.
Chris.strack@sonneborn.com
Authors: Chris Strack and Tim Yasika
Acknowledgements: Dr. Walaa Mogower University of Massachusetts

WMA Technology Description

SonneWarmix™ is a high melt point, organic wax hydrocarbon blend. The melting point, using of SonneWarmix™ is 175 °F (79 °C) and it is a liquid between 185-195°F (88-92 °C).It is an organic wax which is non-toxic and non-hazardous.

Mix Design Modifications

If the binder is not available in a pre-blended form for laboratory use, SonneWarmix™ could be heated to 200-225 °F (93-132 °C) and the appropriate amount added to the hot binder using a low shear mixing device. Typical addition rates 0.50 to 1.00 percent by weight of the total binder weight (including RAP/RAS), depending on the percentage of RAP, RAS, crumb rubber or other polymer modifiers in the mix. The maximum recommended dosage for unmodified, virgin mixers is 0.50 percent. Samples should be mixed and compacted at anticipated field temperatures. As shown in the pictures below, 50 °F (28 °C) reduction in compaction temperature is typical. Our Additive works well with PMA, GTR and in colder weather regions, to allow an extension of the paving season and can increase the haul times for contractors.

Plant Modification

SonneWarmix™ is added to the liquid asphalt at the plant, terminal or refinery. No modifications at the hot mix plant are required. The product must be heated to 200-230 °F (93-115 °C) in order to liquefy for the addition process. SonneWarmix™ is supplied in 55-gallon drums, steel tight-head (FOH) drums, tank trucks and rail cars. We also have a liquid version WMA available in drums, totes or bulk. If heating of the wax is an issue at the terminal or plant.

Other WMA products

We also make additives for high RAP and RAS usage our Rejuvenators called SonneWarmix RJ. We have a high melt point additive called SonneWarmix HM and additives for cold patch and cut back fluids. The cut back fluids are no VOC high flash point alternatives to jet fuel and diesel options for cut back fluids. We also have a chip seal additive which lowers the temperature on rubber chip seal products and reduces the CO2 level on rubber chip seal jobs. In 2014, we will be launching a WMA with an anti-strip additive. The compounded product is due for release in March of 2014.

WMA - A Foamer's Perspective

Presenter: Roger Sandberg, Ambassador-at-Large
Maxam Equipment, Inc. Kansas City, MO
rsandberghma@gmail.com

This presentation will deal with three areas of Warm Mix Asphalt. The presenter has been involved with WMA from its earliest beginning in the U.S. As Vice President, Technology & Market Development with the National Asphalt Pavement Association for nine years, he was involved in the movement to bring WMA to this country to eliminate environmental and worker health concerns with HMA.

Maxam Equipment is the largest retrofitter of WMA foaming systems in the world and has worked with every type of plant and every type of mix.

Area 1: The presenter will deal with several aspects with the current market for WMA, including clarifying several areas not well understood by many users and agencies.

Area 2: The growth in the use of WMA has been hindered by some states due to a lack of information about the product, its use and the benefits. Many of the benefits of WMA have been overlooked or discounted and we will attempt to present a comprehensive list of these benefits.

Area 3: The presenter will discuss the experience of Maxam Equipment with WMA and will explain the different components, the technological differences with other foaming systems and how the technology of high pressure water injection enhances the workability of WMA.

Warm Mix Asphalt Every Day

Presenter and Author: Brad Henningsen, Vice President, Henningsen Construction
brad@henningsenconst.com

Introduction

In this presentation I will be discussing how Henningsen Construction has implemented warm mix asphalt into our company. And also discuss the benefits and disadvantages of using WMA every day in the state of Iowa.

Background and History

Henningsen Construction has been in the asphalt business since it started in 1949. There have been many changes since then and one of the largest is happening now with the shift toward warm mix asphalt. We got into WMA because we could see the benefits and wanted to stay competitive in our industry. We heard stories of better production, lower burner fuel use, and better densities, so we decided to equip all three of our asphalt plants with CMI Terex WMA foaming systems.

Henningsen Construction has currently produced and laid over 600,000 tons of WMA to date and still going every day. We have recently started using RAS along with RAP in mixes and have done almost 100,000 tons of WMA using RAP and RAS.

Henningsen Construction paving WMA

Asphalt Plant running Warm Mix Asphalt

Benefits

During our use of WMA we have noticed that we have used less burner fuel per ton of mix and can produce more tons per hour. Not only does it have economic and environmental benefits, but our asphalt employees are much happier working around asphalt that isn't as hot.

Disadvantages/Unknowns

We have not done any anti-stripping test or have not been on any projects were we needed to use any anti-strip to know the benefits or disadvantages of working with them. We have not noticed any stripping in our mixes, but we also use a majority of limestone mixes. We have not noticed a significant amount of density increase in paving. We have basically kept the same roller patterns and distances as with HMA. The only disadvantage that we have run into is a simple one of making sure the water is metered into the foamer correctly. Not enough or too much makes a BIG difference.

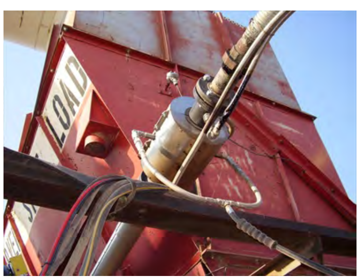
Conclusion

Henningsen Construction is extremely happy that we jumped on the bandwagon of WMA and have only positive benefits from our usage.

Dickinson County Iowa 2012 WMA/HMA Side by Side Comparison

Presenter: Jeremy Anderson, General Manager, Tri-State Paving Company
janderson@omgmidwest.com

Introduction
During the summer of 2012 Tri-State Paving Company performed a side by side comparison of warm mix asphalt (WMA) and hot mix asphalt (HMA). In conjunction with Dickinson County and the APAI, we also held an open house during the paving of the WMA surface lift for cities, counties, Iowa DOT, consulting engineering firms, as well as contractors. The project was approximately 3 miles in length and consisted of a 2" thick intermediate lift and a 1.5" thick surface lift. The mix design remained identical for the comparison. The warm mix process used was foaming, through a Tarmac water injection system. The mix design also utilized 2.5% recycled asphalt shingles (RAS) and 5.0% recycled asphalt (RAP).



Process
For the production of the warm mix asphalt portion of the project, the asphalt plant heated up to its normal starting temperature, initially producing hot mix. Temperatures began to drop as the Tarmac foaming system began injecting water through high pressure nozzles, at the same location as the oil is injected, to begin the foaming process. Within two hours the mix temperature leaving the plant dropped from 310 degrees to 260 degrees. As we monitored densities on the road, temperatures were dropped even lower, 230 degrees to 240 degrees. Out on the road nothing in the paving process was changed, with the exception of closer monitoring by our QMA personnel. Paving speed and rolling patterns stayed identical to that of hot mix. It was very common to see temperatures of 215 degrees to 220 degrees directly behind the paver!

Results
By using the WMA we were able to slow our rolling patterns with the lower temperatures because there was not a steep temperature break point. Densities were more consistent throughout the intermediate course as well as the surface course. Using the Iowa DOT's PWL system, the pay factor for intermediate HMA was 1.038, for intermediate WMA that pay factor increased to 1.04. For the surface mix the pay factor differentiation was even greater. Surface HMA pay factor was 1.000, and for surface WMA this pay factor was 1.04. It is also worth noting that in every instance the film thickness was increased by half of a percent or greater.

Conclusions
This side by side comparison proved that through the use of the WMA foaming process we were able to achieve more consistent test results. By using the Iowa DOT's PWL testing system we had also improved incentives by using the WMA. More specifically, the WMA had a more effective binder and a higher film thickness with a tenth less liquid asphalt. This made the WMA lighter by about 1.2 lbs per CF, about 1% of the total weight. Mix temperatures at the plant were reduced on average 45 degrees, with maximum reductions reaching up to 80 degrees while still maintained great results. We were also able to save on plant energy usage including electricity and burner fuel. Additionally, when using RAP and RAS in the mix design, the reduced mixing temperatures lowered the amount of green house gases produced considerably.

Warm Mix Asphalt: Every Mixture, All of the Time

Presenter: Steve Jackson, P.E., Technical Manager, West Contracting, St. Louis, MO
sjackson@nbwest.com

Introduction

This discussion is about using Warm Mix Asphalt (WMA) in all asphalt pavement mixtures in every season. West Contracting has been using Warm Mix Asphalt for the last five years in many different commercial, municipal and state paving projects. These projects have been successful in a variety of weather conditions including wet early season paving, hot summertime paving and cold wintertime paving.

Mixture Selection for All Customers

In 2010 the Missouri Department of Transportation had a budget of $1.3 Billion for construction. In 2014 the Missouri Department of Transportation has a budget of $800 million for construction. At the same time a prolonged economic recession has diminished the budgets of municipalities and private developers.

At the very least there is more competition for every contract. Fewer bidding opportunities means that contractors need to increase their market area or increase the amount of recycled material in their mixtures to remain competitive. In order to thrive during this time asphalt contractors must be able to deliver high quality pavements on time and on budget.

The use of Warm Mix Asphalt (WMA) has allowed contractors to haul asphalt further distances thereby opening new markets. Warm Mix Asphalt has also allowed the use of higher amounts of recycled asphalt pavement (RAP) which has allowed for more economical mixture designs. The lower mixing temperatures at the plant have helped mitigate the stresses on the mixing drum and other components as well. This allows the contractor to have fewer breakdowns and higher production rates. These benefits have been realized by the Missouri Department of Transportation for years. Now we are bringing these benefits to the commercial and municipal markets. In areas that are not used to Warm Mix Asphalt, a mix delivered to the job site at 250° F (121° C) may be rejected based on previous expectations. Now it is up to the contractor to educate and demonstrate how Warm Mix Asphalt can benefit municipalities and commercial customers. This may require new mix designs that optimize warm mix technology.

All Season Paving

Warm mix technologies that are surfactants, such as Evotherm 3G M1, may allow you to pave earlier in the spring since any residual moisture will be “tied up” by the surfactant. During the hectic summer paving season Warm Mix Asphalt may be used to increase your production rates or allow you to use more recycled materials. Late fall paving in cooler temperatures could be problematic for achieving density, however warm mix technology can help a contractor deliver a well-constructed, high-quality pavement.

Conclusions

Warm Mix Asphalt (WMA) has been successfully used in Missouri for commercial, municipal and state projects in many different environmental conditions. The use of Evotherm 3G M1 has allowed West Contracting to obtain bonuses, increase our market area and extend our paving season. Warm Mix Asphalt will help you deliver quality pavements all year and with every mixture.

Quality Control of Warm Mix Asphalt Mixtures


Presenters: Gary Netser, Quality Control Manager & Brett Finnegan, Vice President
LL Pelling Co., North Liberty, IA
garyn@llpelling.com brettf@llpelling.com

Introduction

In the past 20 years the asphalt industry has seen many innovative changes, from the days of 50 and 75 blow Marshall asphalt mixtures to 'Superpave' gyratory designs. The recent development of warm mix asphalt (WMA) has made a significant impact in the asphalt industry. Many state DOT's have written specifications to allow the substitution of WMA for HMA.

CV Urban Fishery

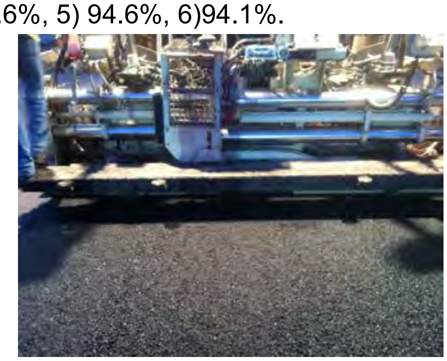
One of LL Pelling's first projects to include WMA was constructed in 2010 at the Cedar Valley Urban Fishery in Cedar Rapids, Iowa. WMA technology was used to construct a large parking area and entrance road. The WMA was produced at temperatures 50-60 degrees (F) lower than conventional HMA with compaction temperatures at 45-55 degrees (F) lower as well. QC testing showed near-target air voids at 3.5%. Field cores sampled on the parking area and roadway entrance confirmed that the WMA was compacted to an acceptable level. With assistance from the WMA additive manufacturer, Mead WestVaco, the project was deemed a success.

Capitol Street

In 2011, the City of Iowa City, Iowa requested warm mix asphalt to be used on a section of Capitol Street. Roughly 350 tons of WMA were used to overlay the street at full-width. Temperatures for production and compaction were 40-50 degrees (F) lower than HMA. LEADCAP additive was used for this mixture at a rate of 1.5% of the total binder content. The mix design included 10% RAP. Air voids testing on two hotboxes were on target at 4.0% each. Traffic was allowed on the new mat as soon as each side was compacted. Density measurements taken later showed good compaction (94.8% avg. of Gmb).

Highway 6 Research

LL Pelling's most recent WMA project was on a heavily used section of Highway 6 in Iowa City, Iowa. The project involved a high percentage of RAP; Thirty eight percent was incorporated into the surface mixture in order to replace thirty percent of the virgin binder. A LEADCAP additive designed for RAP materials was directly added to the asphalt tank. Production temperature of this mix design (270 degrees F) was monitored carefully at the plant and onsite as it was compacted (at around 240 degrees F). Due to the high RAP content an extra effort was made to stabilize the temperatures during mix production. QC testing on this test section resulted in lower than targeted air voids at 2.8%, mostly due in part to the high amount of RAP. The rolling pattern was unchanged and showed good numbers later. Results of the six field core samples were 1) 92.9%, 2)94.0%, 3)93.3%, 4)94.6%, 5) 94.6%, 6)94.1%.



Conclusions

- WMA additives can be used to produce asphalt mixtures at lower temperatures with good compaction results.
- Warm mix additives can be used for mixtures designed for any traffic level.
- Warm mix additives also work as rejuvenators when recyclables are used.

Dinner Presentation:

State-of-the-art in Ultra High Performance Concrete

Presenter: Byung-Suk Kim, Vice President, Korea Institute of Construction Technology
bskim@kict.re.kr
Authors: Byung-Suk Kim and Jong Sup Park
Acknowledgements: Gyungtaek Koh and Changbin Joh

Introduction

Ultra High Performance Concrete (UHPC) is a new construction material which has ultra-high strength, high fluidity and durability. Various countries such as France, Germany, Japan and Korea have spurred themselves to develop UHPC, design guidelines and its application to the structures.

Korea has done organized research led by Korea Institute of Construction Technology (KICT) on the development of UHPC and its application to bridges. Recently, KICT successfully developed the technology to apply UHPC to cable stayed bridges that reduces 20% of construction cost of a cable stayed bridge. This paper introduces recent development of UHPC technology and its prospects.

Application of UHPC to Cable Stayed Bridge: "SUPER Bridge 200"

KICT launched a 6-year research project called "SUPER Bridge 200" in 2007. This project deals with the application of UHPC to a cable stayed bridge. The total budget was approximately $17 million. The main goal of "SUPER Bridge 200" is to reduce construction and maintenance cost of cable stayed bridges by 20% and extend the service life of main structural elements up to 200 years by combining UHPC and cable stayed bridge technology together.

The "Super Bridge 200" research project has developed technologies for (1) hybrid UHPC with tensile strength of 19 MPa, (2) design of slender and durable UHPC structures such as girders and plates based on extensive structural tests and analyses, (3) light and durable UHPC decks based on the optimization and tests, and (4) UHPC cable stayed bridge systems with the main span of 200 m ~ 1000 m based on the structural optimization and detailed cost analysis.

UHPC pedestrian cable stayed bridge built at KICT

Conclusions

The UHPC fabrication specification and the UHPC structural design guideline were developed. And the "Super Bridge 200" technologies were successfully applied to the design and construction of an UHPC pedestrian cable stayed bridge in 2009 and an UHPC road bridge in 2012, and the design of Jobal Bridge in 2011, the first UHPC cable stayed bridge.

Bird's eye view of Jobal Bridge in Korea

Finding of the NCHRP 9-47A Project: Performance and Engineering Properties of Warm Mix Asphalt Technologies

Presenter: Carolina Rodezno, Assistant Research Professor, NCAT, Auburn University
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Authors: Randy West, Carolina Rodezno, Grant Julian and Brian Prowell

Introduction

This presentation summarizes the findings of the NCHRP 9-47A project "Performance and Engineering Properties of WMA Technologies". WMA sections and corresponding HMA sections around the United States were monitored to compare their relative measures of performance. The field performance evaluation was limited to short-term performance since the oldest documented WMA pavement was less than 10-years old at the completion of this study. The engineering properties were evaluated in terms of the following tests: Recovered binder testing, Dynamic Modulus, Flow Number, Indirect Tensile Strengths, TSR and Hamburg wheel tracking test.

Projects Evaluated

Six WMA projects built prior to the start of this study and eight new WMA projects (constructed during the course of this study) were monitored. A total of 12 WMA technologies were evaluated and the age of the pavement sections range from 5.5 years to 1 year. Table 1 summarizes this information.

Table 1. Projects Evaluated

Location	Route	WMA Technologies	Date Const.
St. Louis, MO	Hall Street	Evotherm ET, Sasobit, Aspha-min	May-2006
Iron Mtn., MI	M95	Sasobit	Sep-2006
Silverthorne, CO	I-70	Advera, Sasobit, Evotherm DAT	Aug-2007
Franklin, TN	SR45	Astec DBG, Advera, Evotherm DAT, Sasobit	Oct-2007
Graham, TX	US 380	Astec DBG	Jun-2008
George, WA	I-90	Sasobit	Jun-2008
Walla Walla, WA	US-12	Maxam Aquablack	Apr-2010
Centreville, VA	I-66	Astec DBG	Jun-2010
Rapid River, MI	CR-513	Evotherm 3G, and Advera	Jun-2010
Baker, MT	Route 322	Evotherm DAT	Aug-2010
Munster, IN	Calumet Ave.	Evotherm, Gencor foam, Heritage wax	Sep-2010
Jeff. Co., FL	SR 30	Terex foaming system	Oct-2010
Queens, NY	Little Neck Pkwy	Cecabase, SonneWarmix, BituTech PER	Oct-2010
Case Grande, AZ	SR 84	Sasobit	Dec-2011

Findings

1. Testing of recovered binders from mixes obtained during construction showed that the WMA binders had aged slightly less than the corresponding HMA binders.
2. Testing of recovered binders from cores taken after approximately one to two years of service generally indicate that the true grades of HMA and WMA were not substantially different.
3. Statistical analyses indicate that the dynamic moduli of WMA mixtures are lower than those of corresponding HMA mixtures in most cases.
4. FN results for plant-produced WMA mixes were statistically lower than corresponding HMA mixes in more than 2/3 of the comparisons.
5. The TSR test showed that 82% of the mixes passed the standard 0.8 minimum TSR criterion. The six mixes that failed the criterion included four WMA and two HMA mixes.
6. Hamburg tests showed that 59% of the WMA mixes had statistically equivalent rut depths to their corresponding HMA mixes, the other 41% of the WMA mixes had greater rut depths.
7. WMA sections have performed the same as HMA sections with regard to rutting.
8. None of the field projects had any evidence of moisture damage. Cores taken from the projects after 1-2 years of traffic were inspected for visual evidence of stripping.
9. Little cracking of any type was observed. Transverse cracking was the most common type of cracks. Of the projects with transverse cracking, the WMA and HMA sections generally had similar amounts.
10. WMA did not appear to effect density changes under traffic. This observation was confounded by the fact that many of the WMA test sections were constructed in different lanes than the HMA section.

Performance of WMA Technologies: Long-Term Field Performance

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Authors: Haifang Wen, Shihui Shen, Louay Mohammad, Shenghua Wu, Weiguang Zhang

Introduction

WMA was proved to offer significant benefits, but the long-term field performance was not well investigated. The use of WMA technologies should not compromise the pavement performance. Therefore, facilitating the implementation of WMA technologies in the United States requires continuously collecting and monitoring the field performance and material's engineering properties of WMA pavements for a longer service span, and using the findings to guide the future engineering practices of WMA pavements.

Research Objectives

There are two overall objectives of this project: (1) To identify the material and engineering properties of WMA pavements that are significant determinants of their long-term field performance, and (2) To recommend best practices for the use of WMA technologies.

Research Scope

Five newly paved WMA pavement projects (2011/2012) and 23 in-service pavements projects were monitored and evaluated in this study, covering different climatic zones, traffic volume, WMA technologies, pavement structure, etc., as shown in Figure 1. The material properties will be measured in the laboratory using the field cores (Figure 2), and then will be compared in an HMA-WMA pair, to characterize the field performances of HMA-WMA pair. The significant determinants of field performances will be determined as shown in Figure 3.

Figure 1. Project Locations in the United States

Figure 2. Pavement Condition of WMA Pavement (left); Field Core at Tip of Transverse Crack (right)

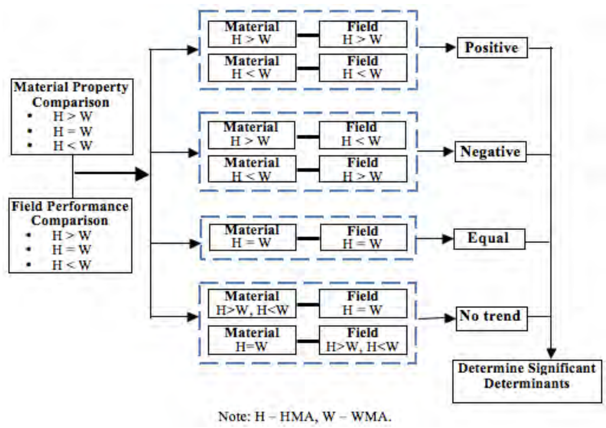

Figure 3. Material Property Indicators Determination

Preliminary Findings

In general, the WMA pavements appear to have better transverse cracking resistance than the WMA pavement but worse in fatigue resistance. The rutting resistance is comparable.

Most transverse cracks are initiated from the surface. Mixture fracture work density (14°F) is found to be a significant determinant of transverse cracking in asphalt overlays. Most of the cracks in the wheel path of an overlay are surface-initiated, indicating that these cracks are top-down fatigue cracking. The mixture creep compliance, horizontal failure strain and vertical failure deformation obtained from IDT (Indirect tensile) tests (68°F) are found to be the significant determinants of top-down fatigue cracking.

Measuring Asphalt Foam Properties and Their Effects on Mixtures

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Authors: David E. Newcomb, Edith Armabula, Fan Yin, Jun Zhang at Texas A&M Transportation Institute

Introduction

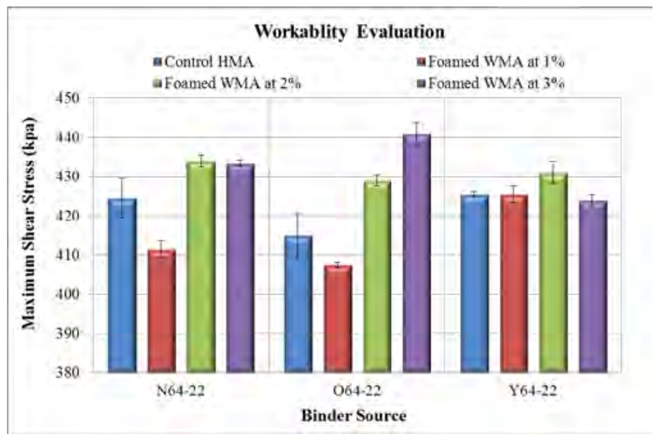
Through National Cooperative Highway Research Program (NCHRP) Project 9-53, the Texas A&M Transportation Institute has been engaged in an investigation of foamed asphalt properties and the effects of foamed asphalt on mixture properties. The project first focused on methods to measure foamed asphalt properties. Parameters such as expansion ratio, half-life, bubble size and foam density were identified for further investigation.

As the investigation has proceeded, the expansion ratio and decay rate were found to be best characterized by laser measurements while bubble size was best captured by processed photography. Mixture characterization was focused on coatability and workability parameters in terms of the coating on coarse aggregate detected through water absorption methods and the shear stress development during compaction, respectively. The foamed asphalt testing has been successful in identifying foaming from non-foaming asphalt, the effect of water content on foaming, and the distinction between different foaming devices.

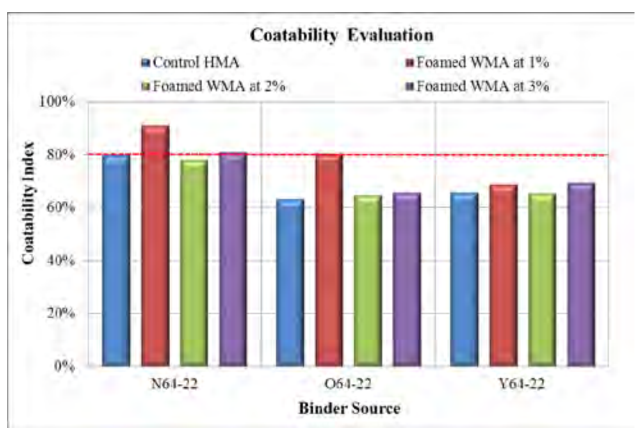
The next phase of research will be to test the laboratory developed foamed asphalt characterization procedures and mixture evaluation on plant produced materials. Ultimately, the project will result in methods to optimize the amount of moisture used in foam processes to maximize the coating of aggregate particles and workability of the foamed asphalt mixtures.

Conclusions

The mixture tests have shown that there is an optimum moisture content for coatability and workability, and, to this point, those values coincide. The mixture tests have shown that for one asphalt that did not foam, there were no advantages to foaming the asphalt binder. These are preliminary results that will be expanded in the future, and thus, are subject to change.



Workability testing shows that for asphalts that foam, there is an optimum moisture content as indicated by the lowest maximum shear stress in compaction.



The optimum moisture content for coating is shown by the maximum Coatability Index for asphalts that foam.

California WMA Study: Accelerated Load Testing, Use in Rubberized Asphalt, Emission Reduction, and Long-Term Field Performance

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Authors: David Jones, Rongzong Wu, Cathrina Barros and Joseph Peterson
Acknowledgements: California Department of Transportation (Caltrans)

The use of warm-mix asphalt (WMA) has increased substantially in recent years. Given the significant differences to hot-mix asphalt (HMA) practice and fears of a moratorium on the use of WMA if unexplained problems occur, Caltrans followed a conservative approach to implementation, based on the findings from a phased comprehensive research study. Phases 1 and 2 investigated rutting behavior and moisture sensitivity of three different WMA technologies against an HMA control in an accelerated loading test with associated laboratory testing. A number of controlled pilot studies were also constructed during these phases, which were monitored throughout the study. Phase 3 investigated the use of seven different WMA technologies in rubberized asphalt following the same testing program used in Phase 1. An investigation into emissions reductions during paving was also undertaken in this phase. The findings from the research were used to prepare a WMA technology approval process and a framework for statewide implementation that resulted in over one million tons of warm-mix asphalt being placed on state highways in the 2011 paving season. Key findings from the study include:

- Actual emissions during paving vary between WMA technologies and the temperatures at which they are placed. Consequently, generalizations about reduced emissions from WMA when compared to HMA should not be made.
- WMA cools at a slower rate than HMA and consequently there is a longer time window to complete compaction. However, periods of mix tenderness are also generally longer and breakdown rollers may need to be held back to accommodate this. Reducing the binder content to minimize this problem is not advised as this could lead to a stiffer mix that is more susceptible to early reflection cracking, especially in thin overlays.
- Ambient temperatures and haul time need to be closely monitored in the setting of production temperatures to ensure that adequate compaction can still be achieved.
- Laboratory rutting performance of WMA specimens prepared according to standard procedures with no additional conditioning is generally poorer than HMA specimens prepared in the same way, indicating that some early rutting is possible until the binder oxidizes to the same extent as that of HMA. This implies that early rutting is possible in the first few months after construction on thicker WMA projects that carry heavy truck traffic, a finding supported by accelerated load testing. However, no difference in rutting was observed on any of the field sections (mostly thinner overlays), indicating that the problem is probably limited to applications in thicker pavements.
- No increase in moisture sensitivity was noted on any of the test sections, but was noted for some technologies in laboratory testing. However, measurements at the asphalt plants indicated that the moisture contents of the warm-mixes were generally higher than the hot-mix controls, although all were within specification, indicating that the potential for moisture related problems does exist if aggregate moisture contents are not closely monitored.

Use of Temperature Reducing Materials in Bituminous Mixtures in Iceland

Presenter: Pétur Pétursson, Consultant in Road Research and Icelandic delegate in CEN/TC227/WG1 Bituminous Mixtures
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Acknowledgements: Icelandic Road and Coastal Administration, City of Reykjavik, Hlaðbaer-Colas Asphalt Plant, Hofdi Asphalt Plant and Icelandic Innovation Center.

Introduction

This paper presents the test results and field trials with temperature reducing materials (trm's) in bituminous mixtures in Iceland. The materials that have been tested so far are Sasobit and Evotherm. Results indicate that using these materials in the dosage of 3% by weight of the bitumen can increase the resistance to deformation of Asphalt Concrete (AC) and Stone Mastic Asphalt (SMA) considerably, even though the mixtures are produced at normal temperatures. Also, better compaction at lower temperatures has been observed. The trm´s lead to more rut resistant asphalt layers that can also be laid at lower temperatures than the traditional mixtures, enabling longer hauling distances and longer working season.

Testing of mixtures with trm's

Although Iceland is not known for hot summers, warm and sunny days will occur once in a while. Under such circumstances the temperature of asphaltic surface courses can be as high as 45-50°C and the danger of deformation is considerable, especially as the use of relatively soft asphalt (pen. 160/220) is common in Iceland. Wheel tracking test has been used in recent years to analyze the deformation of asphaltic mixtures (see Figure 1). The test has proven to be a good method to measure the effect of trm's and other additives on the stability of bituminous mixtures compared to traditional mixtures (see Figure 2). Also, the rutting of laboratory compacted samples compared to samples from the road surface is being studied.

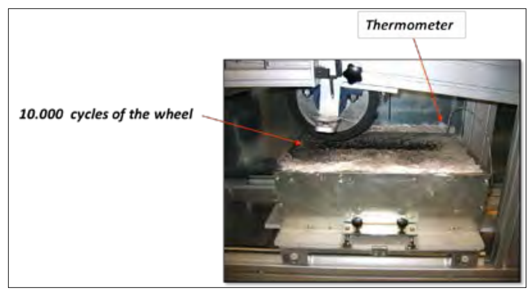

Figure 1. Effects of trm's on asphalt stability

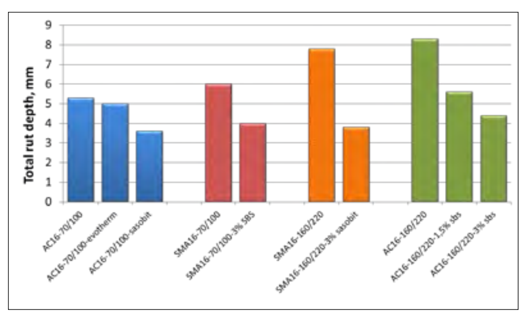

Figure 2. Effects of trm's on rut depth

Conclusions

As Iceland is a very small producer of asphaltic layers on the global scale (~0,02%), energy saving and emission reduction is hardly significant. On the other hand trm's have proven locally to increase the stability of asphaltic layers as well as increasing the workability at lower temperatures, which is important for the industry. However, long term performance has not yet been established.

An Examination of Warm Mix Asphalt Using Iowa Aggregates

Presenter: R. Christopher Williams, Professor, Iowa State University
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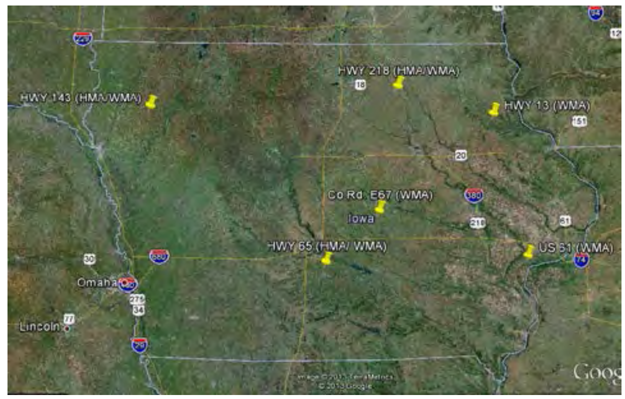
Authors: R. Christopher Williams and Ashley Buss

Introduction

A combination of a laboratory and field study evaluated the performance of plant-produced warm-mix asphalt (WMA) mixes by conducting mixture performance tests, comparing virgin and recovered binder properties, performing pavement condition surveys, and comparing survey data with the Mechanistic Empirical Pavement Design Guide (MEPDG) forecast for pavement damage over 20 years of service life. Further objectives detailing curing behavior, quality assurance testing, and hybrid technologies were as follows:

- Compare the predicted and observed field performance of existing WMA trials produced in the previous Phase I study to that of hot-mix asphalt (HMA) control sections to determine if Phase I conclusions are translating to the field
- Identify any curing effect (and timing of the effect) of WMA mixtures and binders in the field
- Determine how the field-compacted mixture properties and recovered binder properties of WMA compare to those of HMA over time for technologies common to Iowa
- Identify the protocols for WMA sample preparation for volumetric and performance testing that best simulate field conditions



Iowa Warm Mix Asphalt Pavement Test Sections

Findings

The findings of this research indicate that WMA additives do show statistical differences in mixture properties in some of the mixes tested. These differences will not always be statistically different from mixture to mixture. Multiple factors, such as WMA additive type, amount of recycled asphalt material, construction conditions, and mixture variability all play a role in determining the extent of which WMA and HMA mixes differ. Other significant findings of this study include effects of curing, aging in recovered binders from HMA and WMA cores, and the influence of recycled asphalt shingles (RAS) used with WMA. These findings will be of interest to owner agencies and contractors utilizing WMA technologies.

Performance and Field Applications of LEADCAP WMA Technology

Presenter: Cheolmin Baek, Senior Researcher, Korea Institute of Construction Technology
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Acknowledgements: Kyudong Jeong, Dongwoo Cho, Yeongmin Kim, Munsup Lee, Sunglin Yang, and Jinwook Lee

Introduction

LEADCAP (Low Energy and Low Carbon-Dioxide Asphalt Pavement) is the first WMA additive developed in Korea. It is an organic additive of a wax-based composition including a crystal controller and anti-stripping agent. Since 2006, LEADCAP technology has been applied in nine countries.

Performance of LEADCAP WMA Mixes

LEADCAP has been applied to different types of asphalt mixture and some mixes include the high RAP (up to 50%) and the highly modified asphalt binder (i.e., PG 82-22) for porous pavement. LEADCAP WMA mixes are normally mixed and compacted at 30°C lower temperature than HMA mixes.

Many research teams in the world, i.e., Univ. of Iowa and North Carolina State Univ. in USA, Minho Univ. in Portugal, Institute of Road Engineering in Indonesia, and Jiangsu Transportation Research Institute in China, have evaluated the LEADCAP technology using local materials and specification. They concluded that the performance of LEADCAP WMA is excellent and comparable to HMA.

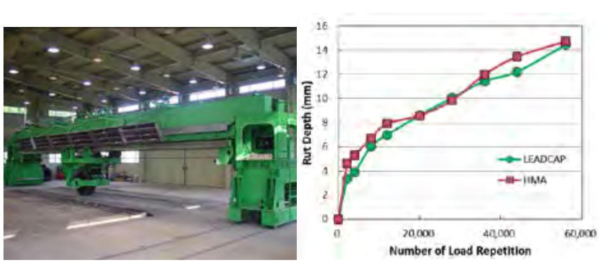

Figure 1. Rutting Evaluation of LEADCAP WMA using APT Test Facility

LEADCAP Field Applications in the World

Since 2009, twelve LEADCAP WMA pavements have been successfully constructed in national highway and expressway in Korea (total length is more than 30km) and thirteen international LEADCAP WMA pavements were constructed. Figure 2 summarizes the design and construction results from nine countries. It should be noted that the production temperatures of WMA ranged between 125°C ~145°C which were generally 30°C lower than HMA but the air voids still met the specification and comparable to HMA. Recently, LEADCAP construction projects were completed in state highways of Iowa (for the mixture including 38% RAP) and Ohio. It was reported that both constructions resulted in good quality pavements.

	Portugal	Italy	Japan	USA	Thailand	China	USA	Indonesia	Mongolia
Weather Condition	2010. 9. (fall)	2010. 11 (winter)	2010. 12. (winter)	2011. 8. (summer)	2011. 9. (summer)	2011. 9. (fall)	2012. 7. (summer)	2012. 8. (summer)	2012. 9. (fall)
Mix Type	Dense-Graded Asphalt	Dense-Graded Asphalt	Porous Asphalt	Dense-Graded Asphalt	Dense-Graded Asphalt	Polymer-Modified SMA	Dense-Graded Asphalt	Dense-Graded Asphalt	Dense-Graded Asphalt
Additive	LEADCAP-70	LEADCAP-70	LEADCAP-64	LEADCAP-64	LEADCAP-64	LEADCAP-64	LEADCAP-64	LEADCAP-64	LEADCAP-64
RAP Use	0%	0%	0%	10%	0%	0%	25%	0%	0%
Plant Type	Batch 500T	Batch 50T	Batch 500T (30,000T)	Drum 350T	Batch 130T	Batch 400T	Drum 700T	Batch 60T	Batch 300T
Dosing Method	Pre-mixed	Plant-mixed	Pre-mixed	Pre-mixed	Plant-mixed	Plant-mixed	Pre-mixed	Pre-mixed	Plant-mixed
Mixing Temp.	125±5°C	135±5°C	145±5°C	130±2°C	130±5°C	145±5°C	130±2°C	125±3°C	140±5°C
Comp. Temp.	120±5°C	120±5°C	140±5°C	120±5°C	120±5°C	140±5°C	120±5°C	120±3°C	130±5°C
Air Void (HMA)		6.07%* (4.45%*) * after 4 months	18.7%** (19.5%**) ** 18.8% target	8.97% (7.01%)	4.0%	4.5%	6.3% (5.2%)		7.8% (9.5%)

Figure 2. LEADCAP Construction in the World

Conclusion

Based on the extensive laboratory tests and field applications, it can be concluded that LEADCAP WMA has the comparable performance to HMA and more benefits like no fume and less energy usage. It is believed that LEADCAP WMA pavement can be used successfully in the world.

Temperatures and Field Densities of LEADCAP Warm Mix Asphalt

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skytrust@gmail.com
Authors: Hosin “David” Lee and Taha Ahmed
Acknowledgements: Russ Carlson, Clint Van Winkle, Hanjun Kim and Jeremy Nash

Introduction

This paper presents the implementation results of LEADCAP Polyethylene Wax-based WMA additive with crystal controller to increase the low temperature cracking resistance and anti-stripping agent to enhance moisture susceptibility. LEADCAP has been applied to rehabilitate state highways in Minnesota in 2012, Iowa and Ohio in 2013.

Temperature Monitoring of Mixes

The asphalt plant temperature often fluctuates and it is critical to monitor the temperature of the mix on the truck at the plant. As can be seen from Figure 1, the fume of the LEADCAP mixture as loaded to the paver in Iowa was significantly less than that of HMA. As shown in Figure 2, there was no fume observed during the paving process in Minnesota and the temperature of the LEADCAP pavement was monitored using the MOBA PAVE-IR device.

Since HMA temperature changes depending on the binder type, the temperature of the WMA mix should be at least 45°F lower than that of HMA. LEADCAP mix was produced at 275°F whereas HMA mix (4.3% total binder from PG 64-28 and 25% RAP) at 320°F in Minnesota, LEADCAP at 271°F and HMA (5.4% total binder from PG 64-28 and 38% RAP) at 333°F in Iowa and LEADCAP at 269°F and HMA (6.2% total binder from PG 70-22 and 20% RAP) at 312°F in Ohio.

Figure 1. HMA (left) and LEADCAP (right) mixes during night construction of State Highway 6 in Iowa

Figure 2. LEADCAP pavement during night construction of State Highway TH 169 in Minnesota

Densities of Pavement Cores

Densities of cores from the LEADCAP pavements were 93.6% (average of 8 cores of 94.0, 94.0, 91.8, 90.7, 94.5, 94.6, 94.4, 94.5) in Minnesota, 93.9% (average of 6 cores of 92.9, 94.0, 93.3, 94.6, 94.6, 94.1) in Iowa and 96.0% (average of 3 cores of 95.9, 96.4 and 95.6) in Ohio. Densities of LEADCAP pavements were similar to those of HMA pavements but the compaction passes applied on WMA pavements were often less than those applied on HMA pavements. Based on MOBA PAVE-IR device, the temperatures of LEADCAP pavements were more consistent than those of HMA pavements.

Conclusions

To claim as Warm Mix Asphalt (WMA), its temperature should be significantly lower than that of HMA, at least 45°F. The average temperature of LEADCAP was lower than that of HMA by 43°F in Ohio, by 45°F in Minnesota and by 62°F in Iowa. Average densities of LEADCAP pavements were 93.6% in Minnesota, 93.9% in Iowa and 96.0% in Ohio and they exceeded the minimum density requirements. LEADCAP produced no fume for a better environment for workers and neighbors.

Dinner Presentation:

Role of National Science Council in Taiwan's Science and Technology Development

Presenter: Chiapei Chou, Director of Science and Technology Division
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Introduction

This paper presents the science and technology development in Taiwan in the past decade and how the National Science Council plays its both leading and supportive roles in this area. The most updated information of National scale research projects and achievements are also presented.

About National Science Council

The National Science Council (NSC) in Taiwan is the most important funding agency for research projects and science and technology education promotion. The budget of NSC spent on R & D in 2013 is around US 1.48 billion which is around 48 % of the total government S & T budget. The ratio of research funding of bottom-up (free topics) and top-down (mission-oriented) is 49% to 25%. The other 26% of budget has been used for enforcing the research environment. Figure 1 displays the comparison of numerous world R&D leading countries based on data obtained in 2010. The colored circular area represents the research expenditure scale calculated on Purchasing Power Parity (PPP). Figures behind the country indicate R&D expenditure as a percentage of GDP(%), researchers per 1,000 employment (FTE), and R&D expenditure (Billion USD PPP), respectively.

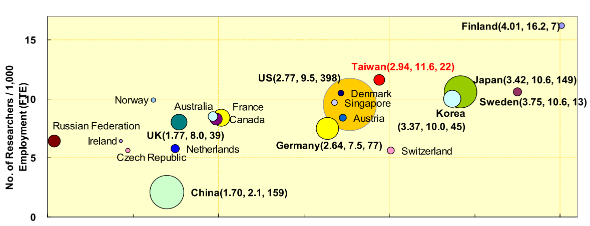

Figure 1. Research data of leading countries.

The major missions of NSC include but not limited to the promotion of national S & T development, support for academic research, and development of science parks. In addition to supporting the basic and applied research work, the most recent efforts are focused on promoting innovation, cultivating talents, and strengthening research translation.

Bi- &Multi- Lateral International Collaborations

There are several on-going international research collaborations sponsored by NSC, either bi-lateral or multi-lateral, which have great impacts on Taiwan's science & technology international participation. A few examples are given.

- Pacific Rim Application and Grid Middleware Assembly (PRAFMA): This program includes four working tasks: Resources and Data, Telesciences, Biosciences, and Geosciences. www.pragma-grid.net
- Global Lake Ecological Observatory Network (GLEON): Through the collaboration of American, Australia, and Asian research institutes, real-time lake ecological data are obtained, stored, and shared for academic uses. www.gleon.org
- Atacama Large Millimeter/ Submillimeter Array (ALMA): This international astronomy facility has 66 antennas that have been completely constructed in March 2013.This program has partnership of East Asia, Europe and North America in cooperation with the Republic of Chile.

Science Parks Development

Besides being a funding agency, NSC has another unique function, i.e. to operate 13 science parks in Taiwan. Up to 2011, more than 450 tenants in Hsinchu Science Park and contributed 4.9 Taiwan's GDP. The total revenue in 2011 was over $65 billion. The most recent focuses are biomedical parks for drug and medical devices development.

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