The Rapid Implementation of WMA in Virginia

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ABSTRACT

1 Every year, transportation agencies are approached by various entities to implement new
2 technologies. For asphalt materials, the most notable implementation in the last 20 years has
3 been the conversion from the Marshall Mix Design method to the SUPERPAVE™ method. The
4 Virginia Department of Transportation (VDOT) made the full conversion to SUPERPAVE™
5 over a decade ago. Since then, numerous other technologies have been tried with varying
6 degrees of success. One of the most successful implementations has been warm mix asphalt
7 (WMA) technology. Since the initial trial sections in 2006, more than sixty-five percent of the
8 asphalt placed on Virginia’s roadways in 2010 was produced using WMA technology. This
9 paper will document the rapid implementation of WMA; VDOT and contractor experiences with
10 WMA in the field; and present lab data comparing WMA and traditional hot mix asphalt.
INTRODUCTION

Every year, transportation agencies are approached by various entities to implement new technologies. For asphalt concrete (AC) materials, the most notable implementation in the last 20 years has been the conversion from the Marshall Mix Design method to the SUPERPAVETM method. The Virginia Department of Transportation (VDOT) made the full conversion to SUPERPAVETM over a decade ago. Since then, numerous other technologies have been tried with varying degrees of success. One of the most successful implementations has been warm mix asphalt (WMA) technology. From the initial trial sections in 2006, more than sixty-five percent of the 4.1 million tons of AC placed on Virginia’s roadways in 2010 was produced using WMA technology.

BACKGROUND

Each year, contractors in Virginia produce over 10 million tons of AC for use on VDOT, Federal, local government, commercial and private projects. This tonnage is divided between base mixes, intermediate/binder mixes and surface mixes. Annually, VDOT will pave between 3 and 5 million tons of AC. With the downturn in the economy since 2008, surface mix tonnage related to maintenance overlay projects comprised a large percentage of the tonnage produced. For calendar year 2010, approximately 1.9 million tons of surface mix was placed on maintenance projects (i.e. overlays and inlays).

As with the downturn in the economy, rising fuel and liquid asphalt costs have put pressure on contractors to perform their operations more efficiently and cost-effectively. During the production of AC, the fuel cost is a major component. The amount of fuel used is proportional to the amount of moisture in the virgin aggregate and recycled asphalt pavement. Almost any improvement in the production process that can reduce the amount of fuel used and save the producer money is implemented.

For the past two decades, companies have tried to develop technologies that will allow AC to be produced at lower temperatures while still meeting the need for a workable, compactible product in the field. Much of this work was conducted in Europe where warm mix technologies have been employed since the 1990’s. Initial interest in the United States for WMA started in 2002 (1). Virginia, like several other states, began investigating WMA and more companies began developing WMA technologies in order to capture this potential new market. According to the warm mix asphalt website, 19 different products and processes were available (2). However, one major concern to transportation agencies and contractors was the added cost. Strapped for funding, most transportation agencies took a cautious approach. Either not allowing the use of the technologies or allowing them only on a project by project basis. Some agencies specified WMA in order to gauge the cost compared to conventional AC. For contractors, the cost of the technology had to be offset by fuel savings during production or provide other financial/environmental benefits to justify use.

RISK ASSESSMENT OF WMA TECHNOLOGIES

Throughout the year, transportation agencies are approached with new products or technologies. Some have been used in other states or countries while others have had little more than laboratory testing. Most agencies have a new products committee tasked with evaluating these products or technologies. The process by which the agencies employ may be different, but the
For WMA technologies, VDOT had to determine what were the positives associated with WMA and what were the negatives. To do this, a series of meetings were held between VDOT and the asphalt industry. In these meetings, the positives were categorized for VDOT and for the contractor. The positive aspects for VDOT were increased paving season, improved density in the field, longer material life, lower material cost, increased competition, and reduced emissions.

The contractors identified several potential positive aspects for their companies and industry. First, the potential for fuel savings during the production of AC could be realized through WMA technologies. Second, the improved workability of the AC – particularly handwork, when the mix is hauled longer distances or has cooled. Third, the ability to extend the paving season and keep crews busy would improve the cash flow and keep people employed. And fourth, the use of a WMA technology may allow a contractor to be competitive in new markets as well as have a cost advantage over contractors not using WMA.

Even with the long list of positive attributes, two large negative concerns were identified. First, no one in the country had long-term performance data. Even though used in Europe, the experience was not extensive. VDOT wanted to make sure the use of WMA did not jeopardize or harm the overall pavement network. Second, stripping had been a problem in Virginia. To overcome the problem in the past, VDOT specifications required the use of lime or chemical anti-strip in all AC mixes. Since plant temperatures are reduced with WMA, VDOT engineers were concerned with not getting all of the moisture out of the virgin aggregate and recycled asphalt pavement (RAP). The excess moisture would lead to stripping even with the use of lime or chemical anti-strip. Given these concerns, intense testing of the initial mixes and long-term performance monitoring must be performed.

HISTORY OF WMA TECHNOLOGIES IN VIRGINIA

2006 Paving Season

WMA was introduced in Virginia in 2006 through the construction of three demonstration sites (3). The aspects of each site were different. The first site was constructed on a rural primary route approximately 45 minutes from the asphalt plant. The asphalt mix incorporated approximately 20% RAP and used a PG 64-22. A wax-based product (Sasobit) was used as the WMA technology. A companion hot mix asphalt site was constructed adjacent to the WMA site. The primary difference in sections was the reduction of the plant temperature by 50F. Density was achieved for the WMA and HMA sections.

The second site was constructed on a rural section of a primary route approximately 105 minutes from the plant. To deliver the AC to the project, trucks had to traverse five mountain ridges. The same WMA technology was used with approximately 10% RAP. Plant temperatures were slightly reduced during the production of the WMA; the primary goal for this site was to observe the workability of the mix after a long haul. Unlike the first site where a material transfer vehicle (MTV) was used to remix the AC, a MTV was not used on the second site. Given the long haul and the unprotected sections in the truck bed, chunks were present in the mix upon delivery. These chunks had to be removed during paving. Like the first site, density was easily achieved.

The third site was constructed on an urban section of a primary route near a local asphalt plant. This site incorporated an emulsion based WMA technology – Evotherm DAT. Unlike the
first two sites, the third project was not successful. Various construction-related issues were encountered.

Overall, the demonstration projects were deemed successful. The AC materials met the laboratory specifications and field density requirements on the first two projects. However, part of the evaluation process was the determination of the tensile strength ratio following AASHTO T-283. Based on results obtained by VDOT, the TSR value for several of the samples failed to meet the 80% requirement. The lowest values were in the upper 60% range (4). Other than TSR, one of the initial VDOT concerns with WMA, no other concerns were raised after the demonstration projects.

**2007 and 2008 Paving Seasons**

Given the late completion of the 2006 demonstration projects and the lack of research test results prior to advertising for the 2007 paving contracts, no WMA was placed on VDOT projects. However, a few contractors utilized the wax-based technology on private projects. Toward the end of 2007, VDOT and the asphalt industry started the development of WMA special provisions. While not intending to use the special provisions in statewide paving contracts, the desire was to have the special provisions ready for limited use on 2008 projects. During 2008, WMA was being increasingly used on private projects; however, WMA was not used on more than one or two VDOT projects.

**2009 Paving Season**

By the 2009 paving season, the interest and use of WMA by contractors was growing. Many of the additive based WMA technologies proved to be cost prohibitive; however, the foaming technology was gaining momentum. Except for the initial capital expenditure, the cost for operating the foaming system was negligible. Therefore, during the 2009 season, four different foaming technologies were evaluated and approved by VDOT. Once approved by VDOT, a contractor could use the technology on VDOT projects. To aid the project inspectors, delivery tickets identified the mixes as “warm mix” for field temperature measurements. WMA technology was being used on interstate, primary and secondary routes with dense graded asphalt. In addition, stone matrix asphalt with polymer-modified PG 76-22 was produced and laid using foamed WMA technology. By the end of 2009, VDOT had three additive and four foaming technologies on the approved products list.

**2010 Paving Season**

Over the 2009 – 2010 Winter, many contractors in Virginia invested in WMA technology. By June 2010, almost 50% of the asphalt plants supplying AC to VDOT projects used WMA technology. These were higher volume plants that supplied well over 65% of the tonnage to VDOT projects. WMA was becoming the norm in many parts of the state.

**SPECIFICATION DEVELOPMENT**

**Initial Specification - Materials**

In order to incorporate new processes or products into standard contracts, new specifications or special provisions are required. Through the evaluation of the initial demonstration projects constructed in 2006, VDOT decided to develop two special provisions regarding WMA. The
first special provision had to address the WMA material design, production and plant acceptance.
The second special provision had to cover the placement aspects of WMA as well as field acceptance criteria. In Section 211 of the VDOT Road and Bridge Specifications – 2007 (5), the composition, design and production of asphalt concrete materials is described. The WMA material special provision had to replace or modify the language contained in this section. Four main topics were discussed for this special provision – minimum TSR value, allowed WMA technologies, mixture properties and mixture temperature. From the 2006 TSR results as discussed earlier, some samples had a value between 65% and 70%. Subsequent testing of materials obtained in the field did not indicate a stripping problem. Therefore, the minimum TSR value was set at 60% for WMA.

Second, VDOT was aware of the development and marketing of new WMA technologies. It was decided to develop an approved product list. This list would contain products and processes that were proven successful on VDOT projects. WMA must utilize a product or process on this list (6).

Third, the composition and properties of the WMA must be the same as traditionally produced AC. VDOT did not want to remove or modify the volumetric requirements nor did they want to reduce the AC content in the mixes. Therefore, it was decided to require mixes with additives to meet the same properties as a non-additive companion mix. In order words, the gradations and AC content must be the same and the volumetric properties must be within the design criteria. For mixes produced with the foaming process, the mix must be approved as a traditional AC mix.

Finally, Section 211 contains mixture temperatures for compaction and testing in the lab. The temperatures in the spec book are based on the virgin binder grade. In most cases, the mixes obtained from the back of trucks are brought into the lab, reheated, and then compacted for volumetric property determination. In the case of WMA, the production temperature could be lower than the lab temperature criteria. A concern was the sampling and testing of WMA at lower that specified temperatures. By not testing at the hot mix temperatures, the volumetric results would be inaccurate. Additionally, for those mixes produced through foaming, VDOT wanted to ensure the added moisture had evaporated prior to testing. Therefore, the VDOT special provision required the mixes to be cooled to 100F and then reheated to the lab specified temperature.

Initial Specification – Placement

Two primary concerns were raised with the placement of WMA – temperatures and density. With the placement temperature reductions possible with WMA, VDOT had to determine what mixture and field temperature criteria to specify. In Section 315.04(b) of the Road and Bridges Specification Book – 2007, a minimum mixture placement and base temperature table was provided. The temperatures were based on the binder grade specified for a project. The minimum base temperature was 40F and the minimum mixture temperature was 250F. With WMA, VDOT had placed AC at approximately 220F on the demonstration projects and subsequent field trials. Also, with the differences in WMA systems, one single minimum mixture placement temperature was impossible to set. Given that complexity, VDOT decided not to specify a minimum mixture temperature for WMA. The second temperature that was considered was base temperature – the temperature of the surface on which the WMA was to be placed. In the specifications book, this temperature changed based on binder grade – the stiffer the binder the higher the minimum temperature. However, some WMA processes altered the
viscosity of the binder during production and placement. Therefore, VDOT set the minimum base temperature for all WMA to be 40°F.

As demonstrated on the trial sections in 2006 and subsequent test sections, WMA could be compacted and meet the minimum density requirements set for traditional AC at lower temperatures. Therefore, no changes to density were placed in the placement special provisions. Even with the initial successes, concerns remained with the placement of the WMA. These concerns revolved around placing AC at lower mixture temperatures and at colder air/base temperatures. VDOT was worried about temperature segregation, poor appearances and poor ride quality that were typically associated with cold weather paving. VDOT and industry agreed that all aspects of quality paving must be followed and no adjustments to the specifications should be allowed to relax these requirements. For that reason, the only language modified in Section 315 was the minimum base temperature and removal of minimum mix temperatures.

Revised Specification
In the 2009 paving season, several contractors incorporated WMA into their paving program. During the season, VDOT evaluated the lab and field testing results. Most contractors were using the foaming process. No issues were raised by VDOT field personnel with problems achieving density. The issues that were identified focused on difficulty handling the material at lower temperatures (i.e. handwork) and visual segregation. These issues were addressed by increasing the mix temperature and employing better paving techniques such as incorporating a material transfer vehicle.

In the lab, contractors were performing their standard quality control tests and VDOT labs were performing their verification sampling and testing. Through the 2009 season, no global test result problems were identified. Mixes were meeting the aggregate gradations, AC contents and volumetrics approved by VDOT. However, there were two portions of the special provision that was reviewed. First, the minimum TSR value required was 60%. Through testing during 2009, it was determined that 80% could be achieved through the adjustment of the anti-strip percentage. Therefore, the special provision for use in 2010 was modified to set the minimum TSR to 80%; the same value used for non-WMA. Second, the cooling and reheating requirement of mixes for volumetric testing was evaluated. Several contractors and the VDOT Central Office Materials Lab compared cooled and reheated mixes to those tested after sampling from the truck or only reheating. By comparing the results from the different approaches, VDOT deemed the cooling portion of the special provision could be removed.

When developed, the WMA special provisions were intended to apply to all asphalt mixtures – but only replaced or modified language in Sections 211 and 315. However, stone matrix asphalt (SMA) was covered in Sections 247 and 317 of the VDOT Road and Bridges Specifications – 2007. Therefore, general use special provision language was adopted to cover all asphalt mixes and remove any confusion.

LAB RESULTS
VDOT District and Central Office personnel continuously monitor the volumetric properties as well as asphalt content and gradations of asphalt mixtures provided to VDOT projects on a system basis. VDOT has paid particular attention to this data to ensure that AC content and dust ratios (Fines to Effective Asphalt Binder) do not develop adverse trends due to the adoption of either the WMA or higher RAP use. Volumetrics are monitored daily and are not permitted to
exceed specification limits. When volumetrics fail, the contactor is placed on limited production or production is halted until the mix is corrected.

To investigate the impact of WMA production on mix properties, several analyses were performed. The following series of charts were created from plants with WMA capability in 2010 but not 2009. Using 2,000 ton lot averages of 4 stratified randomly selected mix production, the AC content and minus #200 materials was evaluated. Large data sets of equal count were then randomly drawn and ranked from each year per VDOT mix type and plotted against each other to show trends against the line of equity (LOE). The SM-9.5 and BM-25.0 were used for this analysis.

FIGURE 1 Evaluation of AC Content and #200 Material for SM-9.5

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LOE Comparison of 2010 to 2009 Dust and %AC for SM-9.5 Mixes

AC loe
-200 loe
Linear (loe)

2010 (%AC or -200)

2009 (%AC or -200)
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4.00% 4.50% 5.00% 5.50% 6.00% 6.50% 7.00% 7.50% 8.00%
This simple analysis of these large data sets supports the ongoing feedback from VDOT’s quality assurance personnel that mixture performance properties are not changing when contractors run WMA. One trend of note is a slightly higher proportion of dust in mixtures produced in 2010 as opposed to 2009. This trend is being seen across all plants. While the increased use of WMA could be a reason for this difference, it is not the probable cause. In addition to WMA, contractors were allowed to use more RAP in 2010. With a maximum fines to effective asphalt ratio of 1.2 for surface and intermediate mixes and 1.3 for base mixes, contractors were pushing the upper limit and that can be seen in these analyses.

LESSONS LEARNED

Over the last three paving seasons (2009 through early 2011), VDOT and asphalt contractors have learned and shared valuable lessons regarding WMA. Most of these lessons learned have been with the foamed WMA. Overwhelmingly in Virginia, this is the most popular and used technology with contractors. To a much lesser extent, MeadWestvaco’s Evotherm 3G has been used on specific projects in order to improve compaction and workability or to extend the paving season.

As with the special provisions, the lessons learned can be separated between plant production and field placement. For plants producing foamed WMA, contractors must start their plants at “normal” production temperatures. In the cooler weather this could be temperatures approaching 350F; in the summer time these temperatures are around 300F. Once production starts and the plant temperatures are stabilized, then the plant operator will begin reducing the
production temperature. A typical reduction is between 25F and 50F depending on the weather conditions, type of paving (mainline vs. short segments), distance of haul, and stockpile moisture content. Most plants in the summer will operate their plant around 250F to 275F. In the cooler weather, 300F is a common temperature. Contractors who have the foaming equipment tend to run the foaming system close to 100% of the time. For that reason, most of the AC supplied by these plants is WMA.

Placement of the WMA at lower temperatures provides benefits and some challenges. One of the primary challenges is handwork. At lower temperatures, the AC is more difficult to manipulate. For that reason, contractors whose projects require more than minimal handwork will increase the temperature of the AC. Several contractors commented that a temperature between 250F and 275F in the field is necessary for handwork. A second challenge is the prevention of temperature segregation. This is more common during cold weather paving. The use of a material transfer device minimizes or eliminates segregation. Overall, good paving practices will overcome many of the placement challenges.

While placement has some challenges, it has many benefits as well. With the lower mixture temperature, traffic can be returned to the travel surface sooner. This allows for increased paving production during a limited timeframe. The lower mixture temperature has helped in compacting tender mixes. These mixes may move at higher temperatures, but the lower temperatures allow the rollers to initiate compaction sooner and improve final density. Finally, the contractors paving crews have observed and felt the reduced temperature and absence of fumes when using WMA. While it has not been proven scientifically in Virginia, the paving crews expressed an improved work condition.

CONCLUSIONS

Since 2009, VDOT has been actively using warm mix asphalt technologies. Not since the implementation of SUPERPAVE™ in 2000 has a new technology changed the way VDOT and contractors produce and place AC. From discussions with the Virginia asphalt contracting industry, almost 100% of the asphalt produced in Virginia will be through a WMA technology by 2015. The economics and benefits of WMA have been realized by contractors and will be evaluated by VDOT continuously over the next many years.

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