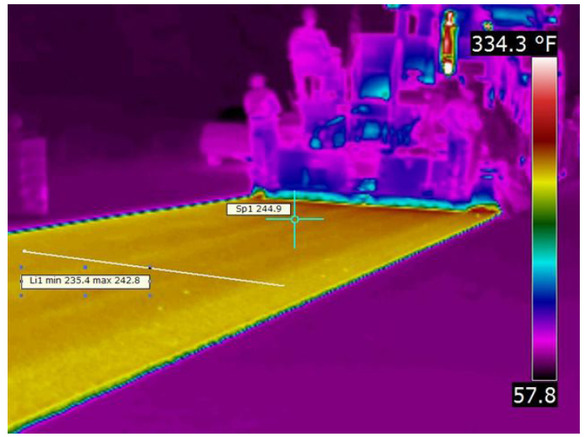
Recommendations

Based on the findings of the study; the technologies used to produce WMA did not appreciably influence the volumetric properties. It is recommended that WMA produced for WSDOT projects be tested and accepted the same as conventional HMA.

For all WMA produced on WSDOT projects, standard HMA test procedures should be used for the determination of Va in conjunction with typical aggregate gradation, asphalt binder content and in-place density testing. In addition, because the optimum compaction temperature of HMA as determined by the asphalt supplier is typically within ten degrees of WMA production temperature, the optimum compaction temperature should be used for SGC specimen preparation.



Thermal camera image depicting WMA temperatures behind the screed.

For more information

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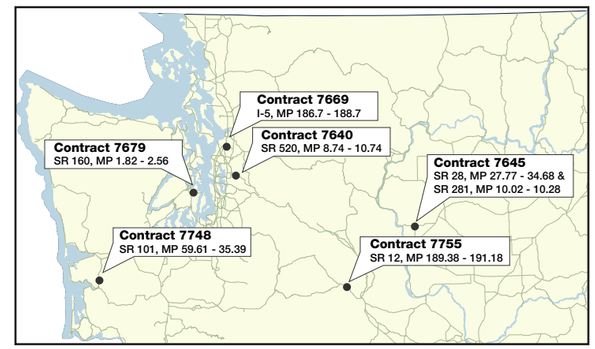
Tech Notes

Engineering and Regional Operations
Construction Division
State Materials Laboratory

Warm Mix Asphalt (WMA) Technologies



Introduction

Warm mix asphalt (WMA) technologies are being promoted throughout the United States for their ability to lower the production and placement temperatures of conventional hot mix asphalt (HMA). From an environmental standpoint WMA has the potential to lower asphalt production temperatures which can equate to reduced energy consumption, and emissions, as well as a smaller carbon footprint.

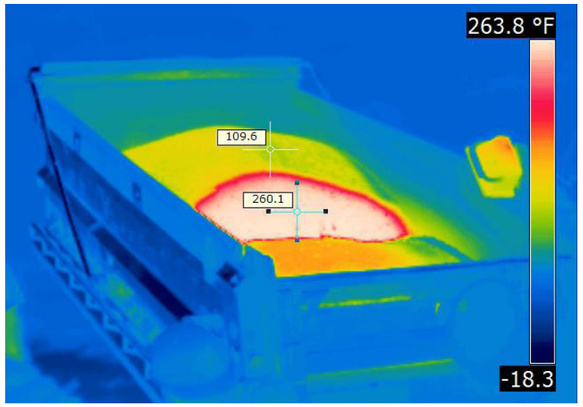
Although Europe is credited with many of the recent developments in WMA technologies one of the first processes used to foam asphalt and reduce mixing temperature was patented in the United States in 1956. This process was later purchased and refined by Mobil Oil of Australia in 1968[1].

WMA in the hopper of a paving machine measured at 238° F.

The first WMA project paved in Washington State was constructed on Interstate 90, West of George in 2008, since that time interest has grown substantially. The interest in producing mixtures with WMA technologies has outpaced the implementation of specifications and modification of test procedures. While most modifications of specifications and test procedures are minor, there are several issues pertaining to simulated testing time and temperature that regulatory agencies are faced with when attempting to make WMA a viable alternative to HMA.

Windrow of WMA on Interstate 90, West of George. The first WMA project paved in the state of Washington.

1. Muthen, K. M. Foamed Asphalt Mixes – Mix Design Procedure. CR-98/077. Sabita ltd. & CSIR Transportek, South Africa, December 1998. http://asphalt.csir.co.za/foamasph/foamasph.pdf



Thermal camera image depicting the range of temperatures of WMA inside the truck at the jobsite.

Description of Technologies

Current technologies for producing WMA include asphalt binder modifiers or additives, chemical foaming technologies and mechanical water foaming systems.

Asphalt binder modifiers or additives are typically added at the HMA plant but may also be added by the asphalt binder supplier during the binder production. Sasobit®, Evotherm™, and Rediset™ WMX are just a few examples of asphalt binder modifiers that reduce the asphalt viscosity which allow a reduction in the temperatures typically observed in production and placement of asphalt mixtures.

Sasobit pellets before introduction to the asphalt binder.

Chemical foaming technologies release water in the HMA, which cause the asphalt to foam. Foaming expands the binder thereby reducing asphalt viscosity which allows a reduction in the production and placement temperatures of asphalt mixtures. Advera®, Aspha-min® and WAM Foam® are all examples of water carrying chemicals. To date, WSDOT has not constructed a project using any of the chemical foaming technologies.

Mechanical water foaming technologies foam the hot asphalt binder at the HMA plant. The foaming process typically injects water into the hot binder, which in turn reduces the asphalt binder viscosity and allows a reduction in the temperatures typically observed for production and placement of asphalt mixtures. Astec Double Barrel Green®, Gencor Green Machine Ultrafoam GX® and Maxam Equipment Inc. AQUABlack™ are examples of foaming systems currently in use. Low Energy (emission) Asphalt (LEA), marketed by Suit-Kote Corporation, is another foaming system that adds moisture to the fine aggregate instead of directly into the asphalt binder. With the exception of two projects constructed prior to 2010, all WMA produced for WSDOT contracts have utilized the mechanical water foaming technology.

Double Barrel Green WMA system in Olympia, WA asphalt plant.

Curing Study

Researchers have documented that WMA technologies lower the viscosity of the asphalt binder and allow the mixtures to be more easily compacted than conventional HMA; however, there is little research that identifies how these technologies affect the mixture volumetric properties that are determined during production.

An area of concern for WSDOT is the potential change in air voids (Va) in WMA samples caused by different conditioning times, when compared to HMA samples.

The WSDOT State Materials Laboratory, Bituminous Materials Section, studied WMA trial projects paved in 2009 and compared how different conditioning times at a constant temperature effect the Va in the WMA sample that were compacted in a laboratory using a Superpave Gyratory Compactor (SGC).

On five of the WMA trial projects paved in 2009, several SGC specimens were fabricated from a single sample of mix taken during production. The production WMA mix was split into multiple representative samples and placed in an oven to condition at the Contractor's WMA production temperature prior to compaction. When the WMA samples reached the Contractor's production temperature, one sample was compacted each hour until all samples were compacted. Each sample was compacted in accordance with WSDOT FOP for AASHTO T 312, "Preparing Hot-Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor".

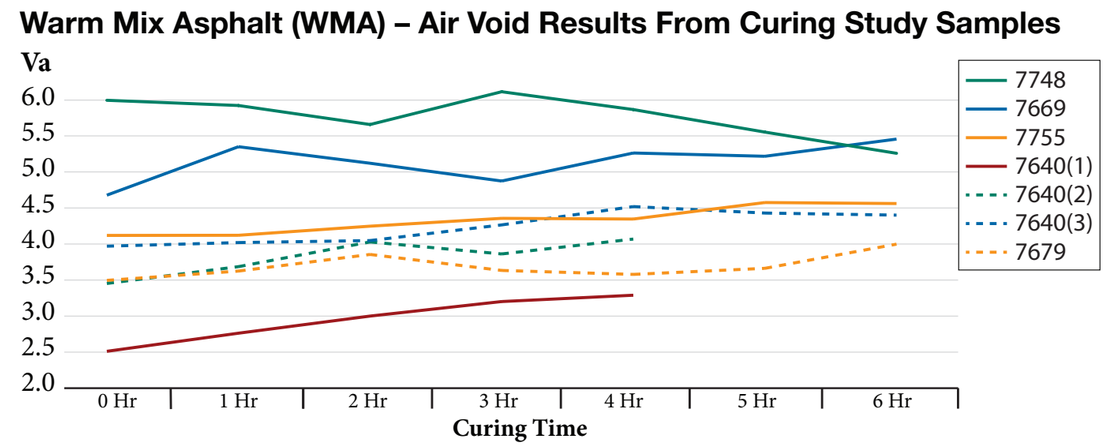
Test Results

After compaction each SGC specimen was cooled to room temperature for 15 hours prior to determination of bulk specific gravity in accordance with WSDOT FOP for AASHTO T 166, "Bulk Specific Gravity of Compacted Hot Mix Asphalt Using Saturated Surface Dry Specimens". The Va for each specimen was calculated using the theoretical maximum specific gravity (Gmm) for the mixture being evaluated in accordance with WSDOT FOP for AASHTO T 209, "Theoretical Maximum Specific Gravity and Density of Hot-Mix Asphalt Paving Mixtures". Chart 1 shows the air voids determined on the samples compacted for this study and Chart 2 shows the variation in Va observed.

Comparing the data in Chart 1 and Chart 2 shows there is no consistent trend of increasing Va from the extended curing times and the results are comparable to that found in the production of HMA.

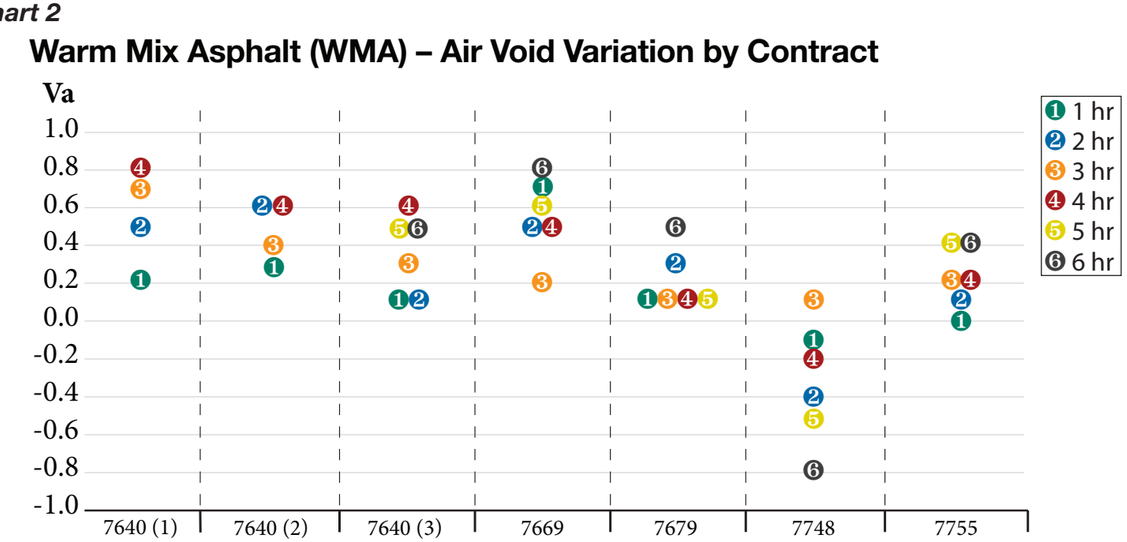
The data collected from this study did not show a consistent trend of increasing Va as may have been expected from driving off residue moisture or altering the viscosity of the asphalt binder from extended conditioning intervals.

Chart 1



Note: This chart shows no consistent trend of increasing air voids from extended curing times.

Chart 2



Note: The variation in sample air voids for each contract falls within normal reproducibility.