

# Delaware T<sup>2</sup> Center Technical Brief

## Warm Mix Asphalt

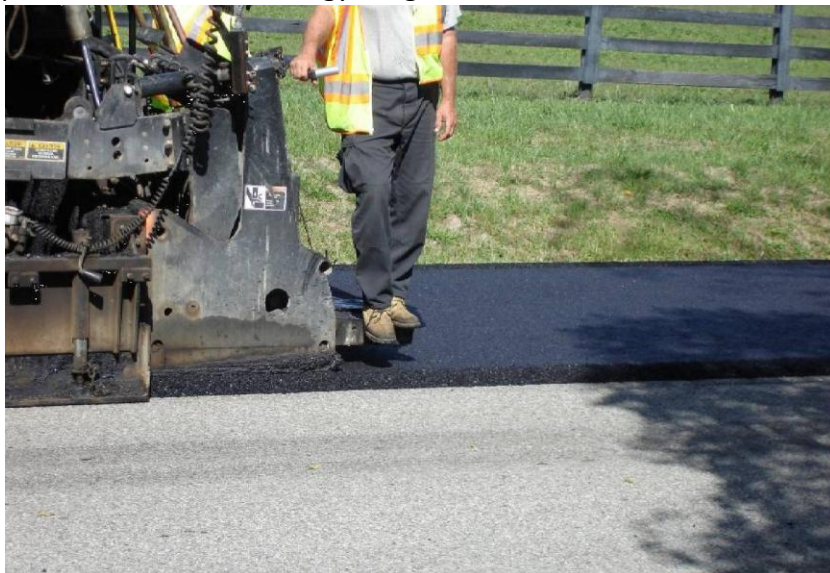
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### Summary

Since its introduction here from Europe in 2002, a number of state DOTs have begun to experiment with warm mix asphalt and it appears to be catching on in several regions of the country. For those who have been trained in the design and construction of hot mix asphalt pavements, where the need to maintain elevated mix temperatures in order to achieve an acceptable product has been correctly indoctrinated, the notion of much the same materials being applied at substantially reduced temperatures is usually met with skepticism. However, the introduction of various additives appears to permit compaction of the mix at lower temperatures by lowering its viscosity, with minimal tradeoff. This technical brief provides an overview of the techniques and current state of the technology, as applied in the United States.

### Discussion

With some 500 million tons of asphalt pavement material produced each year in the United States, the Federal Highway Administration (FHWA), state departments of transportation (DOTs), other highway/street owning agencies, the Environmental Protection Agency, and the asphalt pavement industry have continually sought to lower the fuel usage and pollutant emissions from mixing, transporting, and placing asphalt pavement as well as, of course, lowering its cost. FHWA and the hot mix asphalt (HMA) industry have evolved pavement designs with the goal of greater sustainability as part of a green future (such as, but not limited to, the use of recycled asphalt pavement (RAP) and recycled asphalt shingles). With the promise of lowered energy usage and reduced emissions, warm mix asphalt (WMA) technology



is gaining “street credibility.” WMA techniques are increasingly accepted alternatives to traditional HMA, appealing to those who seek greener solutions, less dependence on foreign hydrocarbon products, lowered cost, and greater flexibility.

Europeans have utilized WMA technologies for some time and in 2002, the

National Asphalt Pavement Association (NAPA) organized a tour of applications in Denmark, Germany, and Norway. Research in the U.S. followed and the first U.S. WMA demonstration project was constructed in 2004. With traditional HMA, aggregates (sand, stone, gravel) make up about 95% of the mix and are heated at the plant (to minimize moisture and facilitate mixing) and asphalt cement is added; the resulting mix is about 280-340°F as it is loaded into trucks. Warm mix techniques employ two basic methods that allow lower production temperatures (about 215-275°F): a small quantity of water can be added to create foaming of the asphalt, or; chemical additives can be introduced.<sup>1</sup> Regardless of the method, WMA techniques allow greater compaction at lower placement temperatures by modifying the chemical and/or physical properties of the mix. The reduction in mix temperature (some 50-100°F) saves fuel and reduces air emissions, along with other benefits.

While European experience is a reported 30% reduction in fuel usage, a more conservative 15% reduction is typically used to calculate savings here in the U.S. The majority of emissions from an asphalt plant result from the combustion of fuel oil to heat the aggregate, so as fuel usage is reduced, a commensurate

reduction in carbon dioxide can be expected.<sup>2</sup> The reduction in plant emissions also translates to cost savings because 30-50% of plant overhead costs can be attributed to emissions control. The cooler temperatures also provide greater flexibility at the project site, where the WMA is more forgiving than HMA and longer cooling periods provide more opportunity to apply compaction equipment.



Compaction of asphalt pavement is essential to its long term stability and service life. Warm mix technologies introduce compaction aids which improve the workability of the mix and extend the cooling period (and hence the time available to apply compaction equipment) because the temperature differential between the mix itself and the ambient air is smaller (put another way, the temperature gradient or slope is flatter). For similar reasons, WMA can be used in cooler weather than HMA and/or it can be hauled greater distances to a project site.

Warm mix test applications have been in place in the U.S. since 2004. The National Center for Asphalt Technology has applied it at its Pavement Test Track (where it has reportedly performed well with little rutting despite the application of excessively heavy truck loads). State DOTs have begun to apply the technology on a large scale experimental basis. Delaware DOT constructed its first WMA overlay in late 2008.<sup>3</sup> Roadways in Yellowstone National Park were paved with WMA (nearly 31,000 tons) in August 2007 and FHWA's Federal Lands Highway

division intends to monitor performance criteria on an on-going basis.<sup>4</sup> Texas applied 400,000 tons of WMA to various projects in 2008 and Caltrans staged a warm mix demonstration in Morro Bay, California in May 2008.<sup>5</sup>

FHWA and the American Association of State Highway Transportation Officials (AASHTO) toured Europe again in 2007 to examine pavements in place for longer periods and were told by European agencies that they expect WMA to perform equally or longer than HMA. In addition, there is speculation that the lower production temperature will reduce aging of the asphalt binder (less oxidation) and therefore the potential for thermal and block cracking.

On the other hand, the lower compaction temperature may increase the potential for moisture damage (due to incomplete drying of the aggregate) and an anti-stripping agent may be necessary based on field tests reflective of the regional application temperatures. Also, some of the WMA technologies require substantial physical plant modifications.

There are numerous (mostly proprietary) approaches to WMA<sup>6</sup> and it is not yet clear which are most effective. Indeed, the industry seems to acknowledge that much research is still needed before the most optimal application of these various techniques is known for regions of the country under various environmental conditions (although the same can perhaps still be said of hot mix asphalt). All WMA technologies are generally considered to be experimental at this time in the United States.

#### Further Reading

The published information on this topic is voluminous and the excerpts selected here should in no way be considered exhaustive or even necessarily representative of nationwide findings, policies, specifications, or conclusions.

- “Warm Mix Asphalt; the Future of Asphalt” is a brief overview of WMA by the National Asphalt Pavement Association (NAPA) and FHWA’s Warm Mix Asphalt Technical Working Group.<sup>7</sup>
- The official site of the Federal Highway Administration’s Warm Mix Asphalt Technical Working Group, <http://www.warmmixasphalt.com/AboutWma.aspx>, contains overviews, articles, presentations, and other publications on the topic.
- The National Center for Asphalt Technology (NCAT), at Auburn University, studied the use of Sasobit® as a chemical additive.<sup>8</sup> NCAT also studied Evotherm® as an asphalt emulsion additive<sup>9</sup> and Aspha-Min® Zeolite.<sup>10</sup>
- “Low Energy Asphalt – A Cooler Mix,” is a presentation that identifies a broad range of needed further research.<sup>11</sup>
- The “Warm Mix Asphalt SCAN” presentation provides an overview of findings from the may-June 2007 tour of Norway, Germany, Belgium, and France WMA projects by FHWA and other industry leaders.<sup>12</sup>
- FHWA’s WMA Technologies and Research web site is an excellent source of information regarding various technologies and products.<sup>13</sup>
- A summary document on the May 2007 tour of European WMA technologies by 13 professionals from FHWA, industry associations, and state DOTs expands on various technologies and discusses performance history and challenges.<sup>14</sup>



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<sup>1</sup> Sasobit® is one example of a chemical additive (in the form of flakes or pellets) to traditional HMA; described as an "asphalt flow improver," its ability to lower the viscosity of the asphalt binder allows working temperatures of the mix to be lowered a reported 32-97°F. As an additional benefit, when used with, for example, a PG 58-28 binder, a PG 64-22 binder resulted, presumably helping to offset its cost. Evotherm®, on the other hand, is an example of an asphalt emulsion that is stored at 176°F in liquid form. Still another additive, Aspha-Min® zeolite, is a manufactured synthetic sodium aluminum silicate better known as zeolite. It contains approximately 21% water by mass and is released at a temperature range of 185-360°F; it is added to the mix at the same time as the binder and water is released, causing a volume expansion of the binder that creates an asphalt foam (which in turn allows greater workability). Other additives include Double Barrel® Green, Rediset™ WMX, and REVIX™.

<sup>2</sup> A 2007 tour of European projects suggested that CO<sub>2</sub> was reduced by 30-40%, SO<sub>2</sub> by 35%, VOCs by 50%, CO by 10-30%, NO<sub>x</sub> by 60-70%, and dust by 20-25%.

<sup>3</sup> Email discussion of Marrows Road with James Pappas, Chief Materials & Research Engineer, DelDOT, December 4, 2008.

<sup>4</sup> <http://www.tfhr.gov/focus/apr08/03.htm>.

<sup>5</sup> "Warm Mix Asphalt in Texas and California," Hot Mix Asphalt Technology (HMAT), November/December 2008, Volume 13, No. 6, National Asphalt Pavement Association.

<sup>6</sup> WMA technologies are generally categorized as: 1) organic, wax-like additives (e.g., Sasobit®, Asphaltan B, Fatty Acid Amides); 2) foaming processes (e.g., Aspha-min® zeolite, Low Energy Asphalt, WAM Foam, LEAB®); 3) emulsion based additives (e.g., Evotherm™); and 4) vegetable based synthetic binders.

<sup>7</sup> "Warm Mix Asphalt; the Future of Asphalt," warmmixasphalt.com and National Asphalt Pavement Association.

<sup>8</sup> Hurley, Graham C. and Prowell, Brian D., "Evaluation of Sasobit® for Use in Warm Mix Asphalt," NCAT Report 05-06, National Center for Asphalt Technology, Auburn, AL, June 2005.

<sup>9</sup> Hurley, Graham C. and Prowell, Brian D., "Evaluation of Evotherm® for Use in Warm Mix Asphalt," NCAT Report 06-02, National Center for Asphalt Technology, Auburn, AL, June 2006.

<sup>10</sup> Hurley, Graham C. and Prowell, Brian D., "Evaluation of Aspha-Min® Zeolite for Use in Warm Mix Asphalt," NCAT Report 05-04, National Center for Asphalt Technology, Auburn, AL, June 2005.

<sup>11</sup> Harder, P.E., Gregory A., "Low Energy Asphalt – A Cooler Mix," 2007 WMA Technical Working Group Meeting, Baltimore, MD, December 13, 2007

<sup>12</sup> "Warm Mix Asphalt SCAN" presentation, warmmixasphalt.com and National Asphalt Pavement Association.

<sup>13</sup> Warm Mix Asphalt Technologies and Research, FHWA, <http://www.fhwa.dot.gov/pavement/asphalt/wma.cfm>.

<sup>14</sup> "Warm Mix Asphalt: European Practice," FHWA-PL-08-007, February 2008, <http://international.fhwa.dot.gov/pubs/pl08007/pl08007.pdf>.