The Road Forward **Climate-Conscious** Pavement Design

HOW WARM-MIX ASPHALT (WMA) SUPPORTS DOT GOALS FOR RESILIENCE AND SUSTAINABILITY

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INTRODUCTION

There are many challenges that state agencies face in maintaining roads and highways for the safe and efficient transportation of people and goods. One of them, sustainability, refers to the ability to achieve engineering and environmental goals through economical use of resources[1]. Another, resilience, indicates the ability of the pavement to withstand or recover rapidly from disruptions[2].

Traditional asphalt pavement construction methods often involve high production temperatures that create significant energy consumption and greenhouse gas (GHG) emissions. Increasing demands for sustainable practices necessitate the use of recycled materials without compromising pavement performance.

Agencies must also contend with the need for flexible construction schedules and practices to accommodate a range of weather conditions and emergency responses, while maintaining the safety and wellbeing of construction workers and the traveling public.

Asphalt mixtures produced using warm-mix asphalt (WMA) technology offer a resilient and sustainable solution to these challenges. WMA technologies typically involve one, or a combination of, chemical additives, organic additives, or foaming. WMA technologies reduce energy consumption and emissions through lower production and laydown temperatures, improving workability and compaction. These attributes can support the use of recycled materials, extend the paving season, provide greater scheduling flexibility, and enhance the overall pavement durability and performance.

[1]https://www.fhwa.dot.gov/pavement/sustainability/start-here/
[2]Statutory Definition of "Resilience" at 23 U.S.C. § 101(a)(24). Section 11103 of the Bipartisan Infrastructure Law, enacted as the Infrastructure Investment and Jobs Act, Pub. L. 117-58 (Nov. 15, 2021)

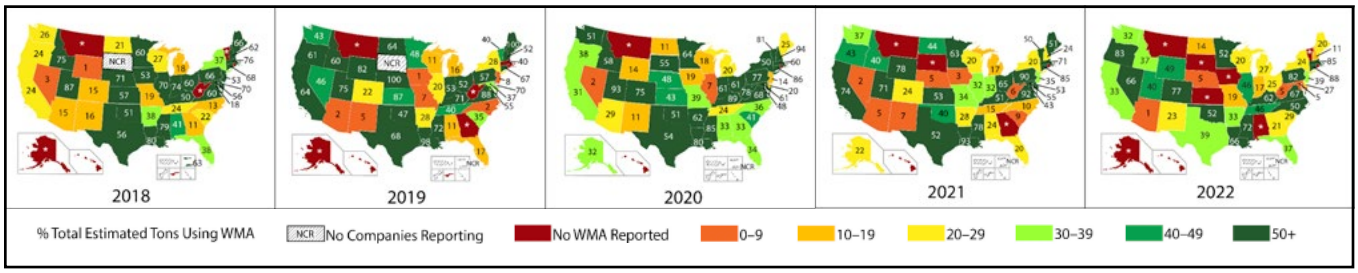

Figure 1: **Estimated percent of total production using WMA technologies in each state, 2018-2022**

This paper explores how WMA technologies provide benefits with respect to resilience and sustainability throughout the life of a pavement, from material selection through production, construction, and operation.

MATERIAL SELECTION

WMA technologies are compatible with the use of reclaimed asphalt pavement (RAP) and recycled asphalt shingles (RAS), supporting sustainable practices by reducing the need for virgin aggregates and asphalt binder. WMA technologies support an increase in recycled material content through increased workability and ability to achieve density targets in the field, resulting in energy savings and lower GHG emissions from the processing of virgin materials, as well as conservation of natural resources and reduced waste.

EACH 10°F DROP IN PRODUCTION TEMPERATURE IS ESTIMATED TO PROVIDE ENERGY SAVINGS OF 10 MILLION BTU PER 1000 TONS OF ASPHALT MIXTURE PRODUCED

Care must be taken to ensure that the recycled asphalt mixture is designed appropriately to meet durability and performance requirements, considering the type and amount of recycled material type along with the production temperature. Some WMA technologies also provide the benefits of an anti-strip agent, allowing for greater flexibility in aggregate materials that can be used.

PRODUCTION

WMA technologies allow for asphalt production and placement at lower temperatures than traditional asphalt mixtures. Data show that in 2022, WMA technologies were used to drop production temperatures by a weighted average of 25.9°F, with some reports of temperature drops as much as 50°F[3]. Using NAPA's GHG Calculator with a projected energy savings of 1,000 Btu/°F/ton, each 10°F drop in production temperature is estimated to provide energy savings of 10 million Btu per 1000 tons of asphalt mixture produced. This energy savings translates into a reduction in GHG emissions as less fuel consumption means fewer emissions from combustion, contributing to a healthier environment.

The lower production temperatures also reduce the emissions of particulate matter (PM10) and volatile organic compounds (VOCs). The actual energy savings and emissions reduction will depend on various factors including the specific plant operations, moisture content of the aggregates, the use of recycled materials, and the type of fuel used. Additionally, these lower production temperatures and associated reduction of emissions improve the workplace for crews.

[3]Williams, B.A., J.R. Willis, & Shacat, J. (2024). Annual Asphalt Pavement Industry Survey on Recycled Materials and Warm-Mix Asphalt Usage: 2022, 13th Annual Survey (IS 138). National Asphalt Pavement Association, Greenbelt, Maryland.
[4]Howard, I. L., B. A. Payne, M. Bogue, S. Glusenkamp, G. L. Baumgardner, and J. M. Hemsley. Full Scale Testing of Hot-Mixed Warm-Compacted Asphalt for Emergency Paving. SERRI Report 70015-011, for the US Department of Homeland Security under US Department of Energy Interagency Agreement, 2012.

CONSTRUCTION

WMA technologies improve the workability of asphalt mixtures, allowing for easier and more effective compaction, especially at lower temperatures. This results in more durable pavements with greater resistance to distresses such as cracking and rutting. WMA technologies can be used with normal production temperatures to facilitate construction in cooler weather, extending the paving season and offering more flexibility in scheduling, empowering DOTs and laydown contractors to optimize construction scheduling and timing. Resilience benefits are realized though the capacity to respond rapidly after an event and the ability to haul asphalt mixtures from longer distances if local plants are compromised during an event[4]. Reduced temperatures result in lower PM10 and VOC emissions, reducing potential workplace exposure.

OPERATION

The increased in-place density that can be achieved using WMA technologies improves the durability and performance of the asphalt pavement. Lower production temperatures can reduce the aging of the asphalt binder that occurs during production, which can result in improved resistance to cracking and moisture damage, thus enhancing the durability of the pavements and extending their service life.

Lower production temperatures are also advantageous with polymer modified binders that would otherwise necessitate higher temperatures, which can degrade the polymers and impact the binder and mixture performance. Improved performance over a pavement's design life provides smoother pavements that reduce vehicle fuel usage and emissions, requiring less maintenance and its associated costs and emissions. Pavements that are in better condition are also more resilient to weather-related events, providing capacity for emergency and recovery vehicle access under flooded conditions and quicker return to full traffic capacity.

Conclusion

WMA technologies provide resilient and sustainable solutions for asphalt pavements. They offer the potential for significant energy savings, reduced GHG emissions, improved durability and performance, enhanced workability, and support the use of recycled materials. By adopting WMA technologies, state agencies and the asphalt industry can contribute to more sustainable and resilient infrastructure.

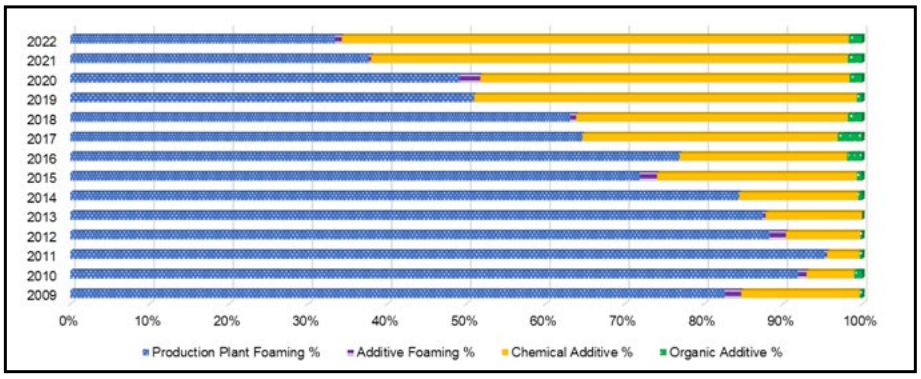

Figure 2: WMA technologies used as percent of WMA production, 2009-2022

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