To investigate volumetric properties (asphalt content, in-place density, and aggregate gradation) and resulting in reduced viscosity of asphalt, thus making it appear more workable and coatability of mixes. In recent years, foam WMA has been widely used:

- Water-based technology: 100% water, e.g. Astec DBG, Water Injection, and Aquablack
- Water-containing additive: zeolite particles containing 20% water, e.g. Aspha-min and Advera

Most research focused on laboratory produced mixes or short-term aged samples. Few studies have extensively evaluated the long-term field performance of foaming WMA pavement. Whether the foaming WMA can work similarly as hot mix asphalt (HMA) needs a field performance validation for confident use of such technology.

**Objectives**

- To evaluate the field performance of foaming WMA pavements as compared to HMA control pavement in terms of cracking and rutting distresses, and
- To investigate volumetric properties (asphalt content, in-place density, and aggregate gradation) for both field mixtures, in a relation with field distresses.

**Introduction**

Foamed asphalt or foaming technology were originally used in asphalt stabilization in Iowa by Professor Csany in the 1950s. When hot asphalt meets water, the volume of asphalt is extensively increased by the water steam, creating a bubbled "foam" and resulting in reduced viscosity of asphalt but an improved workability and coatability of mixes. In recent years, foaming warm mix asphalt (WMA) have been widely used:

- Water-based technology: 100% water, e.g. Astec DBG, Water Injection, and Aquablack
- Water-containing additive: zeolite particles containing 20% water, e.g. Aspha-min and Advera

**Projects Information**

<table>
<thead>
<tr>
<th>State</th>
<th>Pavement</th>
<th>Start</th>
<th>End</th>
<th>ADT</th>
<th>HMA</th>
<th>Water</th>
<th>Construction</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>WA SR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MO</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PA SR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TX SH</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VA I-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Field Survey**

- FIGURE 1 Field performance: (a) HMA vs. Water-containing and (b) HMA vs. Water-based.

**Volumetric Results**

- FIGURE 2 Wheel-path longitudinal crack, (b) core taken at the tip of longitudinal crack, (c) transverse crack: reflective, (d) transverse crack: surface initiated

**Field Performance**

- FIGURE 3 Boxplot for reduced production temperature (HMA minus WMA).

**Conclusions**

- The water-containing foaming can reduce production temperature slightly more than the water-based foaming by 6 to 8°C.
- HMA has slightly higher asphalt content than Foaming. The water-containing foaming has slightly higher asphalt content than the water-based foaming, but the difference is quite limited.
- The use of studded tire and chain in some western states during winter, longer pavement service time, and high traffic volume, may result in polishing of aggregates and make them finer than their original design.
- Foaming pavement showed slightly more wheel-path longitudinal cracking than the HMA pavement. A slightly higher asphalt content would be beneficial for the long-term fatigue performance.
- The water-based foaming showed comparable transverse cracking performance with HMA pavement. The optimal pavement maintenance time would be at the year 4-5.
- Similar rutting performance between Foaming and HMA. Slightly higher in-place air void of foaming than HMA pavement seemed to have no significant effect on the long-term rutting distresses.

**Acknowledgements**

- National Cooperative Highway Research Program 09-49A.
- Dr. Ed Harrigan and panel members, Braun Intertec, Inc. and Bloom Companies, LLC, partner universities and state DOTs.