Compaction Benefits of Foamed Asphalt Mixtures

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Foamed Asphalt

- Foamed asphalt was introduced in the 1950’s by Csanyi
- Initially used for stabilization of soils and aggregates
- A small amount of cold water is introduced into hot asphalt
- Hot asphalt turns water to steam, resulting in an expansion of the binder
Benefits of Foamed Asphalt

- Better coating due to increase binder volume
- Improved compaction
- Better utilization of RAP
- Reduction in production temperatures
- *Does it still work at high temperatures?*
Founded in 1907 as Chugai Asphalt Co., Ltd.

Japan’s Largest Asphalt Producer.

Headquartered in Tokyo, Japan.

Over 150 asphalt plants throughout Japan producing more than 12 million tons annually.
Warm Mix Asphalt in Japan

- High RAP mixes in Japan – 80% Base, 60% surface.
- WMA technology used for more than 8 years in Japan.
- Used as compaction aid for cold weather paving and long hauls.
- Additives only (including foaming additives).
- *Currently min 330 degrees F.*
USA Nippo WMA Study Objectives

• Japanese government will not allow temperature reductions.
• Considering this, can plant foamed asphalt system provide better compaction for:
  – Long haul distances
  – Cold weather paving
• Marshall mix design method used in Japan and Marshall sample compaction is sensitive to temperature so Marshall pills used to evaluate compactability.
• Limited comparisons with SGC.
Sawyer Paving Salem, Virginia

Second generation Double Barrel Green foamed asphalt system
State-of-the-art Asphalt Mix Design and Quality Control Laboratory with Marshall & Superpave equipment
Sawyer processes their own RAP and uses 30% in their surface mixes.

Laboratory adjacent to asphalt plant for rapid sampling and testing.
HOT Foamed Asphalt
Storage Silo Simulation
Half-life of foam tends to decrease with increasing temperature.
## Experimental Plan

### Target Production Temperature

<table>
<thead>
<tr>
<th>Mix</th>
<th>Foamed WMA</th>
<th>HMA¹</th>
<th>Foamed WMA</th>
<th>HMA¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virgin</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>30% RAP</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

- **Mix**: Virgin and 30% RAP
- **Target Production Temperature**:
  - 132 – 138°C (270 – 280°F)
  - 160 - 166°C (320 – 330°F)
- **Foamed WMA (WMA1)**
- **HMA¹**
Density vs Temperature for Virgin Mixes

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![Graph showing density vs temperature for Virgin Mixes with R² values for different data sets.](graph)

- **Virgin HMA**
  - R² = 0.45
  - R² = 0.82
  - R² = 0.24

- Linear (HMA)
- Linear (Foam 171C)
- Linear (Foam 124C)

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*Outlier*
Density vs Elapsed Time for Virgin Mixes

Theoretical Maximum Density

Elapsed Time after Sampling, minutes

Virgin

- HMA
- Foam 165C
- Foam 132C

- Linear (HMA)
- Linear (Foam 165C)
- Linear (Foam 132C)
Time vs. Temperature for Virgin Mixes

Virgin

- Compaction Temperature, degree C
- Elapsed Time after Sampling, minutes

Graph showing compaction temperature over time for Virgin mixes with different temperature settings:
- HMA
- Foam 165C
- Foam 132C
SGC Density vs Temperature for Virgin Mixes

Theoretical Maximum Density vs Compaction Temperature, degrees C

Virgin - SGC

% Theoretical Maximum Density

Compaction Temperature, degrees C

HMA  Foam 165C  Foam 132C
Density vs Temperature for RAP Mixes

R² = 0.27

R² = 0.82

R² = 0.65

89.0 90.0 91.0 92.0 93.0 94.0 95.0 96.0 97.0 98.0

70.0 80.0 90.0 100.0 110.0 120.0 130.0 140.0 150.0 160.0 170.0

% Theoretical Maximum Density

Compaction Temperature, C

HMA

Foam 168C

Foam 138C

Linear (HMA)

Linear (Foam 168C)

Linear (Foam 138C)
Study Conclusions

• Foaming improves density at both WMA and HMA temperatures.
• Foamed samples have a more consistent relationship with temperature.
• There is evidence of a time effect, compaction benefit decreases with longer storage.
• SGC relatively insensitive to compaction temperature.