28th Annual Regional Local Road Conference
Foamed Asphalt

Overview of Mix Design and Construction

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Foamed Asphalt – What is it?

- A small quantity of cold water (1-4% by weight) is injected into very hot asphalt (280-340°F)

- The water expands on contact with the hot asphalt – expanding (or foaming) the asphalt to 5-40 times its initial volume

- The expanded asphalt is then introduced to either RAP, RAP/Aggregate Base, or Aggregate Base to improve the material properties of the material
How the foaming process works
Foamed Asphalt – What is it?

- The purpose of asphalt foaming is to make it easier for asphalt to disperse into cold RAP and/or granular materials at ambient temperature.

- Liquid asphalt binder at high temperature without foaming would immediately become globules when it contacts cold aggregates – impossible to mix.

- Foamed asphalt, or asphalt bubbles can be dispersed into the mix fairly uniformly. An excellent analogue to this cold mixing process is to beat an egg white into foam, which can be mixed with dry flour (by Raffaelli, 2004).
Foamed Asphalt – What is it?

- The mixture of foamed asphalt and the treated aggregates (both loose and compacted) is termed a “foamed asphalt mix” or a “foamed asphalt material”, although the asphalt does not exist in a “foamed” state in the mixes.

- Foamed asphalt can be performed as either Cold in Place Recycling or Stabilized Full Depth Reclamation
Foamed Asphalt – What is it?

- Aggregate skeleton
- Bonded mineral filler
- Asphalt mastic droplet
- Mineral filler phase
Foamed Asphalt – What is it?

Well Distributed Foamed Asphalt in Aggregate Base
Foamed Asphalt – What is it?

Poorly Distributed Foamed Asphalt in Aggregate Base
Laboratory Mix Design Procedure
Asphalt

- Two parameters are widely used in engineering practice and in research:
  - The expansion ratio is calculated as the ratio of the maximum volume of foam relative to the original volume of asphalt binder.
  - The half-life is calculated as the time taken in seconds for the foam to collapse to half of its maximum volume.
Laboratory Mix Design Procedure

- Mix Design Parameters
  - Optimum foaming temperature and water addition
  - Optimum RAP/Aggregate compaction moisture content
  - Optimum asphalt addition rate
    - TSR
    - Marshall Stability
    - Resilient Modulus

- Additional mineral admixtures required
Asphalt Foaming Laboratory
Calibration of the foaming machine
Laboratory Mix Design Procedure

Asphalt

- The expansion ratio and half-life are characteristics of a "foam" (asphalt foam or foamed asphalt); they are not properties of an asphalt binder.

- The "foamability" or "foam potential" is a property of a given asphalt binder. It tells you the capability or potential of this binder to produce good quality foam.

- Not all asphalt foams well – oftentimes it requires more than one sample to perform a mix design.
Laboratory Mix Design Procedure
Asphalt

- One of the goals of mix design is to identify locally available asphalt binders with good foam potentials, and also to find the optimal foaming conditions for making good foam out of the selected binder.

- Typical specification is expansion of 10 times initial volume at a half life of 10 seconds.
BITUMEN CALIBRATION

BITUMEN
Source: Flint Hills Resources
Type: PG XX-34
Test temperature: 150

MACHINE SETTINGS
Bitumen pump
Calibration
Timer setting (sec) | 1 | 2 | 3 | 4
| 1 | 3 | 5 | 7 |
Pump output (g/sec) | 1 | 00 | 1 | 00 |

Setting
Quantity required (g): | 100 | 300 | 500 |
Pump output (g/sec): | 100 | 300 | 500 |
Timer setting (sec): | 1 | 00 | 1 | 00 |

Water
Quantity required (%): | 1 | 1.5 | 2 | 2.5 |
Flow meter setting (l/h): | 3.6 | 5.4 | 7.2 | 9 |

<table>
<thead>
<tr>
<th>% Water</th>
<th>Expansion</th>
<th>Half Life</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>13</td>
<td>13.87</td>
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<td>1.5</td>
<td>19</td>
<td>11.25</td>
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<td>2</td>
<td>24</td>
<td>10.19</td>
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<tr>
<td>2.5</td>
<td>24</td>
<td>9.59</td>
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Expansion / Half Life

OPTIMUM FOAM MOISTURE CONTENT

1.5
Laboratory Mix Design Procedure
RAP/Aggregate

- Obtain samples from the roadway to be stabilized
- Representative proportions of the actual planned project depth
- Crush RAP to a representative gradation that will occur during the reclamation process
  - Or perform mix design at more than one gradation
Laboratory Mix Design Procedure
RAP/Aggregate

- Determine optimum moisture content for compaction
  - Standard Proctor Density
  - Reduce to ~ 50% of optimum moisture content
    - Need to allow room for foamed asphalt
Pug Mill for Mixing Samples
Laboratory Mix Design Procedure

Optimum Asphalt Addition Rate

- Typically a 3-4 point mix design
- 1.5 – 3.5% foamed asphalt addition rate
- Optimize based on required test parameters
  - Indirect Tensile Strength (40-100 psi)
  - TSR (60-100%)
  - Resilient Modulus (70-200 ksi)
  - Marshall Stability (1250 – 1500 lbs)

- May require the addition of mineral admixture to achieve desired properties (cement, fly ash, lime, CKD)
Samples are made with 4” gyratory mold
Sample Number : Design Testing Date 7/23/2012

Material to be foamed
<table>
<thead>
<tr>
<th>RAP/Aggregate Base</th>
<th>Bitumen</th>
<th>Filler</th>
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</thead>
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Location / Source:
| Roadway | FHR |

Description
| Roadway Mix Design | PG 58-28 |

Optimum moisture content : 7.8
Maximum dry density : 117

Foamed bitumen requirements
| Percentage "foaming" water : 1.4 |
| Temperature of bitumen: 150˚C |

Foamed asphalt treated material characteristics

| Foamed bitumen added (%) : | 1.5 | 2.0 | 2.5 | 3.0 |
| Filler added (%) : | 0.0 | 0.0 | 0.0 | 0.0 |
| Diameter of specimen (mm) : | 100.0 | 100.0 | 100.0 | 100.0 |
| Height of specimen (mm) : | 63.8 | 63.9 | 63.4 | 63.5 |
| Mass of specimen (g) : | 1075 | 1089 | 1091 | 1092 |
| Bulk density (kg/m³) : | 2146 | 2171 | 2191 | 2188 |
| Bulk density (lbs/ft³) : | 134.4 | 136.0 | 137.2 | 137.1 |
| Resilient Modulus (ksi) : | 93.9 |
| ITS soaked (psi) : | 73 | 72 | 65 | 61 |
| ITS dry (psi) : | 70 | 72 | 65 | 62 |
| Retained ITS (%) : | 104.6 | 100.6 | 99.6 | 97.9 |
50/50 RAP/Base Samples
Construction
Field Validation of Foaming Characteristics
Construction
Field Validation of Foaming Characteristics
Construction - Full Depth Reclamation
Construction – Correct Oil Content
Construction – Too Much Oil
New Testing for AASHTO MEPDG

Simple Performance Test – Dynamic Modulus
Indirect Tensile Strength - Low Temp Cracking Resistance
Questions?