FIELD EVALUATION OF DELTA-S

NAM TRAN, PhD, PE, MBA

2018 NCAT Test Track Conference
Surviving a Disruptive Innovation

As the photographic film market declined, Fujifilm started to diversify in 2002 while Kodak did not. As a result, Fujifilm is still in business today and Kodak declared bankruptcy in 2012.
Collagen constitutes about 70% of human skin and is a key ingredient in photographic film.

Nanotechnology helps make small particles to penetrate deep into the skin.

Fujifilm launched its skincare business in 2006. By 2010, its annual sales was over JPY10 billion ($94 million).

Source: http://www.fujifilm.com/innovation/achievements/skincare/
Cosmetics vs. Asphalt Rejuvenators

Rejuvenator has ingredients needed to improve performance of aged asphalt

Rejuvenerating seals

Rejuvenator needs to penetrate into asphalt film to make it work

Recycling agents

Source: Robert Boyer, 2012 National Pavement Preservation Conference
Collaborative Aggregates Products

Delta S:

- Bio-based recycling agent (rejuvenator)
- Rebalance chemistry of aged asphalt binder for improved field performance

Delta Mist
Objective of Test Track Evaluation

- Evaluate how Delta S improves the field performance of an asphalt mixture with high RAP contents
- Hypothesis (value-added)
  - On average, an asphalt mixture contains 20% RAP (ABR = 0.2)
  - If Delta S is used in this mix, the amount of RAP will be increased to offset the cost of Delta S
Experimental Design

- Experimental design
  - Control mix: 20% RAP mix with PG 67-22
  - Experimental mix: 35% RAP mix with PG 67-22 and Delta S (5% based on recycled binder content in RAP)

- Question for evaluation
  - Will these two mixes show similar field performance?
Structures of Two Test Sections

- N1: 20% RAP
- N7: 35% RAP + Delta S

- Same structures, except for the surface mix

Legend:
- Surface AC
- Binder AC
- Base AC
- Agg. Base
- Subgrade

0 2 4 6 8 10 12 14 16 18

Thickness (Inches)
### Surface Mix Properties

<table>
<thead>
<tr>
<th>Mixture</th>
<th>NMAS (mm)</th>
<th>RAP Binder Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>N1, 20% RAP</td>
<td>9.5</td>
<td>0.18</td>
</tr>
<tr>
<td>N7, 35% RAP</td>
<td>9.5</td>
<td>0.28</td>
</tr>
</tbody>
</table>

- Same virgin binder and virgin aggregates
- Similar volumetric properties
**Targeted Binder Properties**

The binder properties of N7 mix were designed to be similar to those of Section N1.

All extracted binders were 20-hour PAV aged.

<table>
<thead>
<tr>
<th>Mixture</th>
<th>Virgin PG</th>
<th>Extracted PG</th>
<th>$\Delta T_c$</th>
</tr>
</thead>
<tbody>
<tr>
<td>N1 20% RAP</td>
<td>64 – 22</td>
<td>88.6 – 16.6</td>
<td>-9.4</td>
</tr>
<tr>
<td>N7 35% RAP + Delta-S</td>
<td>64 – 22</td>
<td>94.5 – 16.4</td>
<td>-10.1</td>
</tr>
</tbody>
</table>
Fracture (Lab & Plant Mixes)

<table>
<thead>
<tr>
<th></th>
<th>Flexibility Index (FI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N1 20% RAP (Lab Mix)</td>
<td>4</td>
</tr>
<tr>
<td>N7 35% RAP + 5% Delta S (Lab Mix)</td>
<td>3</td>
</tr>
<tr>
<td>N1 20% RAP (Plant Mix)</td>
<td>4</td>
</tr>
<tr>
<td>N7 35% RAP + 5% Delta S (Plant Mix)</td>
<td>3</td>
</tr>
</tbody>
</table>
Rutting (Lab Mix)

Number of Passes

Hamburg Rut Depth (mm)

- ○ N7 No Lab Aging
- • N7 2-Hr @ 135C

- ○ N7 No Lab Aging
- • N7 2-Hr @ 135C
## Field Performance – IRI and Rutting

<table>
<thead>
<tr>
<th>Section</th>
<th>IRI (in/mi)</th>
<th>Rut Depth (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N1 20% RAP</td>
<td>70</td>
<td>1.8</td>
</tr>
<tr>
<td>N7 35% RAP + Delta-S</td>
<td>57</td>
<td>3.3</td>
</tr>
</tbody>
</table>
Field Performance - Cracking

Hairline cracking

Cracking %

Equivalent Single Axle Loadings (MESALs)

N1 (20% RAP)  N7 (35% RAP + Delta-S)
Hairline Surface Cracks

N1 (20% RAP)  
N7 (35% RAP + Delta S)
Close-up Pictures of Hairline Cracks
Summary

- Determine target performance
  - Matching binder & mix properties of a 20% RAP mix
- Determine dosage
  - Based on binder performance grade and $\Delta T_c$
- Mix design
  - Matching gradation & volumetric properties
  - Verifying fracture & rutting requirements
- Two sections have similar field performance thus far
Implementation Considerations

- Higher RAP contents
- Improved performance
- Convenient packages
  - Rejuvenator
  - Anti-strip
  - WMA
  - Modification
- Specification changes
- More testing required
- Field blending
  - In virgin binder at terminal
  - In virgin binder at plant
  - Pre-mixing with RAP
THANKS!

Any questions?
Reach me at
nht0002@auburn.edu

2018 NCAT Test Track Conference