Presentation Overview

- All data presented is for dense graded asphalt (DGA)
  - MSU has performed 1500+ Cantabro tests on DGA to date
  - PFC/OGFC use documented by others for several years
- Objective: Generate discussion about Cantabro test for DGA to provide a mixture durability index
- Outline of Presentation
  1. Cantabro test method description
  2. Reference data set for traditional low RAP (mostly HMA)
  3. Testing RAP and WMA-RAP mixes
  4. Other recent and potential users of Cantabro test on DGA
  5. Summary—where does Cantabro test fit into bigger picture?

1. Overview of Cantabro Test

Three keys to Cantabro test
1. Cheap and easy
2. Cheap and easy
3. Cheap and easy

- Compacted specimen evaluated at 25 °C in an LA Abrasion drum for 300 revolutions without steel spheres
- Mass Loss (ML) = % mass change wrt original mass
- Some type of conditioning can be performed prior to testing (approaches vary)
- 64 °C for 7 d (MT-85), 85 °C for 5 d (R30), 60 °C for 28 d,......
2. Reference Data Set

• A wide assortment of mixes used by MDOT in the 2008 to 2010 time frame was tested (mostly low RAP HMA)

**MDOT Central Lab QA Specimens**

<table>
<thead>
<tr>
<th>NMAS</th>
<th>Mixes</th>
<th>Specimens</th>
<th>Avg RAP (%)</th>
<th>Avg ML (%)</th>
<th>St Dev ML</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.5</td>
<td>22</td>
<td>56</td>
<td>12</td>
<td>7.6</td>
<td>2.2%</td>
</tr>
<tr>
<td>12.5</td>
<td>16</td>
<td>54</td>
<td>16</td>
<td>9.8</td>
<td>3.0%</td>
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<tr>
<td>19.0</td>
<td>17</td>
<td>42</td>
<td>18</td>
<td>10.6</td>
<td>2.6%</td>
</tr>
</tbody>
</table>

2. Reference Data Set-Results of Testing 30 QC Replicates (9.5 mm) (APAC Mississippi, Inc.)

<table>
<thead>
<tr>
<th>Mix</th>
<th>Conditioning</th>
<th>Ndes</th>
<th>Total AC</th>
<th>RAP</th>
<th>ML Avg</th>
<th>ML COV</th>
<th>Va Avg</th>
<th>Va COV</th>
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<tbody>
<tr>
<td>1</td>
<td>None</td>
<td>50</td>
<td>6.2</td>
<td>15</td>
<td>7.3</td>
<td>10.8</td>
<td>3.3</td>
<td>15.8</td>
</tr>
<tr>
<td>1</td>
<td>R 30</td>
<td>50</td>
<td>6.2</td>
<td>15</td>
<td>10.6</td>
<td>12.3</td>
<td>3.6</td>
<td>16.5</td>
</tr>
<tr>
<td>2</td>
<td>None</td>
<td>65</td>
<td>6.0</td>
<td>15</td>
<td>7.6</td>
<td>15.8</td>
<td>4.2</td>
<td>26.0</td>
</tr>
</tbody>
</table>

--Mix 1 to Mix 2 (no conditioning) was not statistically different
--Mix 1 (no conditioning) to Mix 1 (R 30) was statistically different

2. Reference Data Sets-Aging (Needed for Comprehensive Durability Assessment)

A. **Complete-Outdoor Aging Experiment 1**
   - No protective sleeves-1 yr-Su 2011 to 12

B. **Ongoing-Outdoor Aging Experiment 2**
   - Protective sleeves & compacted test strips-3 of 5 yrs to date - Fa 11 to Fa 16 (planned)-Braden Smith’s PhD Work

C. **Ongoing-Laboratory Aging Experiment 1**
   - Evaluate existing conditioning protocols and as needed develop new ones to predict effects of outdoor aging on Cantabro ML-Robert James completed PhD work and Braden Smith’s ongoing and anticipated PhD work

2. Reference Data Sets-Aging (Outdoor Experiment 1 Results Were Promising)

**Outdoor Aging Experiment 1**

- Cores taken periodically from parking lot (12 test strips)
- Gyratory pills taken periodically that have been aging in the lot in PVC sleeves (USACE-ERDC & AFB's)

3. RAP Content Effects (Constant Raw Materials-Gravel Aggregates & PG 67-22)

- Airfield mixes (12.5 mm NMAS)
3. HMA (15% RAP) vs. WMA (50 to 75% RAP)
(RAP Content Isn’t Only Factor at Play for ML)

<table>
<thead>
<tr>
<th>ML (%)</th>
<th>15% RAP-1</th>
<th>15% RAP-2</th>
<th>15% RAP-3</th>
<th>10% RAP-1</th>
<th>10% RAP-2</th>
<th>50% RAP-1</th>
<th>50% RAP-2</th>
<th>75% RAP-1</th>
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</tbody>
</table>

ML (%): % Maximum Loss

3. 100% RAP and Virgin Binder

![Graph showing ML vs. Va for RAP and Virgin Binder]

4. DGA Cantabro Use by Others

A. Bob Frank, Brian Prowell have used Cantabro test for 100% RAP paving with rejuvenators (Discussed Further)
B. Brian Prowell has used Cantabro test to evaluate 25% RAP mixes in South Carolina (Discussed Further)
C. Mike Sullivan, Griffin Sullivan, et al. at MDOT Central Materials Laboratory have used for change requests during paving w/ SMA (Discussed Further)
D. Tim Aschenbrener at FHWA Resource Center in Lakewood, CO is examining Cantabro test to understand excessive raveling (Not Discussed Further)

4.A. Use by Others-100% RAP

- Mix produced in New York City by Green Asphalt
- 100% RAP (no virgin AC)-designed via Marshall-3 rejuvenators (REJ) included in the experiment
- For Cantabro, SGC compacted (~4.8 kg specimens) to 3.5 to 4.0% voids at 121 °C, tested at 25 °C and 300 revolutions
- Mix was reported to do very well

4.B. Use by Others 25% RAP

- South Carolina surface Mix (Ncompacted-
typical test parameters discussed previously)
- Plant Mixed-Lab Compactd (4.8% binder 3.2% avg voids, 13.1% avg ML)
- Lab Mixed-Lab Compactd (4.7% binder 2.5% avg voids, 10.0% avg ML)
4.C. Use by Others-SMA

- 9.5 mm SMA on I-55 in Yalobusha County, MS
  - 4 mix designs used (0% RAP, 0 to 64% crushed gravel, 0.3% fiber, 6.1 to 6.5% PG 76-22 from single source)
- There were questions about exceeding 171 °C mixing temperature
- Baseline testing was performed and 10% ML was determined as an acceptance upper limit
- 150 by 115 mm SGC specimens were produced during QC and tested for ML at 25 °C with 300 drum revolutions
  - minimum 2 specimens per 2 production days

### Cantabro Test Applications

- Applications Being Discussed or Considered
  (None are proven over time at present)
  - Quality control tool simultaneously evaluate combinations (e.g. what is the combined effect of, for example, RAP content being a little high, AC content being a little low, dust content being a little high...)
  - Detect RAP content, shingles....
  - Detect effects of design to production changes
  - Mix selection tool (thin lift joints)
  - Can be used during project for substitutions

### Where Does Cantabro Fit Into Bigger Picture?

- Asphalt concrete options keep expanding (WMT, WMA, RAP, GTR, Sulfur additives, Shingles....) Who knows what is next?
- Durability and non-load associated cracking resistance are often very pressing questions (especially with many sustainability and recycled materials driven mixes).
- Bottom Line: Industry needs an uncomplicated mixture test such as Cantabro to help evaluate durability of all mixes, especially those with tendencies toward brittleness and cracking!!!