I-FIT: Improve Your Mix Durability

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57th Illinois Bituminous Paving Conference
December 12th-13th, 2016
Champaign, Illinois

Acknowledgements

- Eileen Sheehy, former Chief of Materials Bureau of NJDOT
- Paul Hanczaryk, current Chief of Materials Bureau of NJDOT
- Robert Blight and Susan Gresavage, NJDOT Pavement Design and Management
- Rutgers Laboratory Staff
  - Ed Wass Jr., Ed Haas, Chris Ericson, Brett DiFrancesco
Presentation Overview

- Introduction – NJ’s Interest
- Validation Work – Field Performance Comparisons
  - FHWA ALF
  - Newark & JFK International Airports
  - Comparison to Overlay Tester
- Future Implementation
  - NJDOT Performance-Related Specifications
  - Port Authority of NY/NJ Runway Mixtures
  - Industry Usage
- Final Thoughts

NJ’s Interest in HMA Durability Improvements
NJ’s Durability Issues

- No new pavements being built – mostly all rehab work.
- Pavement life through rehab projects
  - NJ highways generally stiff structures from continual overlays
  - Mill 2”, Pave 2” – 7 to 8 years
  - Mill 2”, Pave 4” – 8 to 9 years
  - Composite Pavements – 4 to 6 years
    - Over 50% of NJDOT network is composite (HMA/PCC)
- Predominant pavement distress = top-down longitudinal cracking
  - Reflective cracking in composite pavements
  - Current mixtures are dry and stiff
- Reason for NJ’s Performance Related Specifications (PRS)
- In addition, industry pushing for higher recycled asphalt contents
  - RAP up to 40%
  - RAS conversation has started

NJ’s Durability Issues

- NJDOT utilizes the Overlay Tester (OT) for asphalt mixture durability evaluation for PRS
  - Good success with OT to date, but always comes with industry complaints
    - Repeatability (variability)
    - Equipment expense
- Looking for a potential test that provides same ranking/correlation to field performance, yet something less expensive or could be conducted on common equipment
I-FIT Validation Work for NJDOT

NJ’s I-FIT Validation Work

- Examples of some of the validation work to date
  - FHWA ALF Experiment on Recycled Asphalt
  - PANYNJ’s Airfield Durability
  - I-FIT to Overlay Tester Correlation
    - Resultant Proposed Criteria
FHWA Accelerated Loading Facility (ALF)

- ALF Loading Conditions
  - Controlled 20°C @ 20mm depth
  - Loading only in one direction
  - Lateral wander
  - 425 Super Single Tire
  - 100 psi inflation
  - 14,200 lb load

<table>
<thead>
<tr>
<th>ALF Lane</th>
<th>% RBR</th>
<th>Virgin Binder PG</th>
<th>WMA Process</th>
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<tbody>
<tr>
<td></td>
<td>RAP</td>
<td>RAS</td>
<td></td>
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<tr>
<td>Re-running</td>
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<td>1</td>
<td>0</td>
<td>-</td>
<td>64-22</td>
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<tr>
<td>2</td>
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<td>58-28 Water</td>
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<td>Re-running</td>
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<td>20</td>
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<td>11</td>
<td>40</td>
<td>-</td>
<td>58-28 Chemical</td>
</tr>
</tbody>
</table>
Cracking performance measured and quantified in two indices:
- Number of cycles until 1\textsuperscript{st} Crack observed
- Cracking Rate

Question: How well do asphalt mixture and binder tests correlate to field measured fatigue performance?
- RAP, RAS, WMA
- 10 cores taken from each lane
- Mixture and binder testing conducted on bottom 2 inches of field core to minimize surface aging
**SCB FI vs Cycles to 1\textsuperscript{st} Crack**

![Graph showing the relationship between SCB Flexibility Index and ALF Loading Cycles to 1\textsuperscript{st} Crack with R\textsuperscript{2} = 0.7725.]

**SCB FI vs Cracking Rate**

![Graph showing the relationship between SCB Flexibility Index and ALF Cracking Rate with R\textsuperscript{2} = 0.6505.]

SCB FI (Mixture) vs Glover-Rowe (Binder)

\[ y = 523.71x^{1.271} \]
\[ R^2 = 0.5898 \]
\[ y = 3058.6x - 1.275 \]
\[ R^2 = 0.842 \]

SCB FI (Mixture) vs DENT CTOD (Binder)

\[ y = 7.0426x^{0.2792} \]
\[ R^2 = 0.8403 \]
\[ y = 7.8335e^{0.0351x} \]
\[ R^2 = 0.7457 \]
FHWA ALF Conclusions

- I-FIT provided best ranking to field cracking
  - Good correlation to both
    - # of cycles to 1st crack
    - Cracking rate
  - Also evaluated Overlay Tester and LTRC SCB
- I-FIT results also ranked well with binder “fatigue” testing
  - DENT CTOD & Glover-Rowe parameters
  - Potential to include both in specifications
    - Binder “fatigue” test for a PG Plus purchase specification
    - I-FIT for QC/QA mixture test

PANYNJ – Newark and JFK Runway Fatigue Cracking

- Evaluate different runway P401 mixtures for their respective fatigue cracking performance
  - 6 different mixes (1 seal coated so eliminated from analysis)
  - Different asphalt binders
  - Different field performance
    - 3 years – performing poorly
    - 15 years – performing well
- “Fatigue” asphalt binder testing
- Mixture fatigue cracking tests
- Ultimately – can we find a binder parameter for purchase specification and mixture specification for Quality Control to promote durable asphalt mixtures
PANYNJ Field Observations

- No rutting
- Longitudinal and transverse cracking observed
- Cracking top-down
  - Stops approximately 0.5” to 0.75” below surface

Newark and JFK Mixture Info

<table>
<thead>
<tr>
<th>Runway</th>
<th>Binder Type</th>
<th>Supplier</th>
<th>Visual Observations</th>
<th>Aggregate Type</th>
<th>Date Placed (Age)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EWR 11-29 (Core Set 1)</td>
<td>PG76-22 (PG64-22 + 7% Vestoplast)</td>
<td>Mt. Hope, Tilcon B Plant</td>
<td>Not performing well; Excessive cracking</td>
<td>Gneiss</td>
<td>9/20/2008 (6 Yrs, 10 Months)</td>
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<td>PG76-22 (PG64-22 + 7% Vestoplast)</td>
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<tr>
<td>JFK 4R-22L (Core Set 3)</td>
<td>PG76-22</td>
<td>Willies Pt Asphalt, Flushing, NY</td>
<td>Performing well; No cracking</td>
<td>Trap Rock (From Tilcon, Haenstraw)</td>
<td>9/5/2002 (12 Yrs, 9 Months)</td>
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<tr>
<td>JFK 4L-22R (Core Set 4)</td>
<td>PG76-28</td>
<td>Willies Pt Asphalt, Flushing, NY</td>
<td>Performing well; Very few cracks</td>
<td>Trap Rock (From Tilcon, Haenstraw)</td>
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<td>PG76-28</td>
<td>Mt. Hope Rock Products, Flushing NY</td>
<td>Performing well; some cracking</td>
<td>Gneiss</td>
<td>6/4/2000 (15 Yrs)</td>
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</table>

<table>
<thead>
<tr>
<th>Runway</th>
<th>Asphalt Content</th>
<th>QC Air Voids</th>
<th>QC VMA</th>
<th>QC VFA</th>
<th>ER AC by Vol (%)</th>
<th>Stability (lb)</th>
<th>Flow (0.01”)</th>
<th>% Finer #200</th>
<th>In-Place Voids (%)</th>
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</thead>
<tbody>
<tr>
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<td>5.4</td>
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<td>15.8</td>
<td>78.8</td>
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<tr>
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</table>
**Semi-circular Bend (SCB) Flexibility Index (FI) – Corrected for Thickness**

**PANYNJ Newark and JFK Cores**

- I-FIT clearly showed difference between good and poor performance
  - I-FIT > 7.0 correlated with good fatigue performance for airport runways in NJ/NY area
- Paper at TRB (TRB Paper 17-06277)
NJDOT relies on the Overlay Tester for Performance Related Specifications (PRS)
NJDOT evaluating the potential use of the I-FIT for either:
1. Guide for asphalt industry on how well their asphalt mixtures will perform in the Overlay Tester; and/or
2. Replacing the Overlay Tester within their PRS

Developing a database on various projects where Overlay Tester and I-FIT are being used
Separating comparisons between
- Plant Mixed, Lab Compacted (PMLC)
  - Reheated then compacted
  - Compacted immediately after sampling
- Plant Mixed, Field Compacted (PMFC)
- Lab Mixed, Lab Compacted (LMLC)
All Data

- Grouping results by ALL conditions show a “moderate” correlation
- Specimen condition type results in better correlations
- Individual projects even better

Plant Mixed, Lab Compacted (Reheated)

- Compacted specimen before cutting varied from 77 mm to 120 mm
- Final specimens cut to 50 mm
Plant Mixed, Field Compacted (Cores)

- Final specimen thickness’ ranged between 35 mm cut to 50 mm

Overlay Tester to l-FIT Correlation

- Relationship appears dependent on specimen fabrication method
- Adopting criteria for QC/QA may need to take into consideration different values based on specimen fabrication type
Future I-FIT Implementation in NJ

NJDOT’s Performance Related Specifications – Example: HRAP

- NJDOT utilize PRS for a number of different performance based mixtures
- Most popular is the High RAP (HRAP)
- Fatigue performance (Overlay Tester) requirements dependent on traffic and location in pavement
  - For Plant Produced, Lab Compacted
    - OT 150 cycles ≈ I-FIT 7.0

<table>
<thead>
<tr>
<th>Test</th>
<th>Requirement</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Surface Course</td>
</tr>
<tr>
<td></td>
<td>PG 64-22</td>
</tr>
<tr>
<td>APA @ 8,000 loading cycles (AASHTO T 340)</td>
<td>&lt; 7 mm</td>
</tr>
<tr>
<td>Overlay Tester (NJDOT B-10)</td>
<td>&gt; 150 cycles</td>
</tr>
</tbody>
</table>
Port Authority of NY/NJ (PANYNJ) Runway Mixtures

- Starting 2017, PANYNJ will include I-FIT (AASHTO TP124) during QC
- Loose mix sampled at plant and compacted
- Specimens brought back to PANYNJ labs for prep and testing
- Initial criteria
  - I-FIT > 8.0
I-FIT for HMA Supplier Guidance

- Most common complaint of PRS by asphalt suppliers is equipment availability
- Most plants still have Marshall equipment
  - TSR’s
  - FAA work
- Proposing the use of Marshall equipment for I-FIT evaluation

SCB Using Marshall Machine

- Developing database to validate use of Marshall machine for I-FIT.
- Total cost of equipment investment approximately $500
Final Thoughts

- HMA Durability is a nationwide crisis
  - Function of binder properties, mix design, volumetrics, aging, field conditions, etc.
- Currently a need exists for a reliable mixture cracking test that correlates to field performance
  - Mixture design (PRS, Balanced Mix Design)
  - QC/QA
- I-FIT shows great potential
  - Correlates to observed field performance
  - Correlates to current Overlay Tester results (NJ conditions)
  - Less expensive than conventional equipment
    - Marshall machine potential

Thank you for your time!

Questions?

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