PA Initiative on IDEAL AND SCB CRACK TESTS

NEAUPG
North East Asphalt User/Producer Group

Annual Fall Meeting, October 24, 2019

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and
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DISCUSSION TOPICS

1. Performance Based Testing & Long Life Asphalt Pavements
2. Initiative on SCB/IDEAL-CT Testing in PA
3. Background on IDEAL-CT Tests
4. Discussion of Results, Summary & Conclusions
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Performance Test & LLAP driven by:

- TQI
- STIC
LLAP Best Practices

- SMA Wearing
- WMA/Antistrip
- MTV Required
- Longitudinal Joint Density Specification
- Ride Specification Optional
- Tack Coat Every Layer (New Section 460)
- % Within Tolerance (PWT) Acceptance
- Incentivize Critical Elements (i.e. Mat Density)
- Performance Tests
Examples of Performance Tests

DCT

IDEAL-CT

Wheel Tracking

SCB
Long Life Asphalt Projects – DCT data

DCT Performance Diagram

DC(T) Fracture Energy (J/m²)

Hamburg Rut Depth (mm)

Producer 1
Producer 2
Producer 3
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Industry SCB/IDEAL CRACK Testing: How Did It Start?

- Move to Performance Testing

- Initiated by Asphalt Quality Improvement Committee and PAPA

- Industry Interested in Accelerating Move to Performance Testing
Purpose of the Effort

- Bridge the Gap to Performance Testing
- Investigate Performance of PA Mixes in IDEAL as a follow-up to previous study
- Develop A Database of SCB/IDEAL Test Results
- Evaluate Sensitivity of the PA Mixes to the Test
- Evaluate Correlation with Field Performance
SCB
Mix Criteria and Variables

- Air Void: 5.5% (Final SCB Specimen)
- Design Binder Content (and +0.5%)
- Mixes with 15% RAP at Design BC and at 0.5% Higher Binder Content
- Mixes at higher RAP Contents
- NMAS: 4.75, 9.5mm, 12.5mm, 19mm, 25mm
- Lab vs Plant Produced
- Short term vs Long Term Aging
Data Range: Flexibility Index

STOA
Average = 8.1

LTOA
Average = 4.6
General Observations

1. Higher AC Content → higher F.I.
2. Higher RAP content lower F.I.
3. Longer aging → lower F.I.
4. Plant mix has higher F.I. than lab mix
5. Higher voids → higher F.I.
6. SMA mix delivers higher F.I.
7. Finer mix with high BC → higher F.I.
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Research Team

Dr. Xuan Chen

Mr. Scott Milander
NECEPT Lab Coordinator
IDEAL Cracking Test for Asphalt Concrete

Indirect Tensile Asphalt Cracking Test

IDEAL-CT

Proposed by Research at Texas Transportation Institute (TTI)
The Brazilian Test
(The Split Test or Indirect Tensile Test)

- Tensile Strength of Concrete (Carneiro, 1943)
- Tensile Strength of Stabilized Materials (Hudson, Kennedy, 1967)
- Tensile Strength of Asphalt (Kennedy et al., 1969)
- Tensile Strength of Rocks (ISRM, 1978)
Resilient Modulus, ASTM D7369
Repeated Haversine Loading

\[ \mu = \frac{3.588 + 0.2699 \frac{\Delta V}{\Delta H}}{0.0627 - \frac{\Delta V}{\Delta H}} \]

\( \Delta V \) = recoverable vertical deformation
\( \Delta H \) = recoverable horizontal deformation
\( \mu \) = Poisson’s ratio

P = load
\( t \) = thickness
\( M_r \) = Resilient Modulus

\[ M_r = \frac{P}{(\Delta H)xt} (0.2699 + \mu) \]
Asphalt Concrete
Creep & Strength Test at Low Temperature
(for example, as input for Pavement ME)

Indirect Tensile Test
Indirect Tensile Strength Test
(for AASHTO T 283, Tensile Strength Ratio (TSR))

\[ S_t = \frac{2P}{\pi tD} \]
Indirect Tensile Test at Low Temp.

IDT Test, -20°C, 12.5 mm/min

Stress, psi

Strain, %
Fracture Work = Area under the curve

Fracture Energy $G_f = \frac{\text{Fracture Work}}{\text{Area}}$

$G_f = \frac{\text{Fracture Work}}{(tD)}$

t = specimen thickness
D = specimen diameter
IDEAL – Test Results

Criteria established based on $CT_{Index}$

$$CT_{Index} = \frac{G_f}{\bar{P}} \times \left( \frac{\bar{l}_{75}}{\bar{D}} \right)$$

$$\frac{P}{l} = |m_{75}| = \frac{P_{85} - P_{65}}{l_{85} - l_{65}}$$
Index based on 0.65 and 0.75 Peak Load

Index based on 0.75 Peak Load
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Source of Mixes & Conditioning

Sources 1 and 2

Lab Prepared Mix → Long Term Aged (5 days @ 185°F) → LTOA

Source 3

Plant Prepared Mix → Short Term Aged → STOA
## Types of Mixes Tested (25 Mixes)

<table>
<thead>
<tr>
<th>Source</th>
<th># of Mixes</th>
<th># of Plugs</th>
<th>Mix Origin</th>
<th>Mix Condition</th>
<th>NMAS, mm</th>
<th>Binder Grade</th>
<th>Binder Content</th>
<th>RAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>9</td>
<td>27</td>
<td>Lab Prod.</td>
<td>LTOA</td>
<td>9.5</td>
<td>58-28</td>
<td>5.2 to 6.2</td>
<td>0, 15, 25</td>
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<td>64-22</td>
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<td>76-22</td>
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</tr>
<tr>
<td>02</td>
<td>9</td>
<td>27</td>
<td>Lab Prod.</td>
<td>LTOA</td>
<td>9.5</td>
<td>58-28</td>
<td>5.1 to 6.1</td>
<td>0, 15, 25</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>64-22</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>76-22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>03</td>
<td>7</td>
<td>35</td>
<td>Plant Prod.</td>
<td>STOA</td>
<td>6.3</td>
<td>64-22</td>
<td>6.3</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>76-22</td>
<td>6.9</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>9.5 (3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>64-22</td>
<td>5.9 &amp; 6.0</td>
<td>15.0, 20.0</td>
</tr>
<tr>
<td></td>
<td>19 (2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>64-22</td>
<td>4.8 &amp; 5.1</td>
<td>25.0, 28.5</td>
</tr>
</tbody>
</table>
Air Void Comparison

NECEPT Air Void, % vs. Reported Air Void, %
Breaking Specimens

Test Temperature: 25°C
Displacement Rate: 50 mm/min
Specimens C4, C5, C6

Source 1

NMAS: 9.5 mm, PG 64-22
Design Binder Content: 5.7%
Virgin Binder Content: 4.2%
Average Air Void: 5.3%
RAP: 25%
Long term aged: 120 hrs at 85°C

Average IDEAL CT: 35.8
COV: 4.4%

Displacement Rate: 50 mm/min
Test Temperature: 25°C

COV on Fracture Energy: 4.4%
Test Repeatability

Displacement Rate: 50 mm/min
Test Temperature: 25°C

Specimens: T1, T2, T3

Source 2

NMAS: 9.5 mm, PG 64-22
Design Binder Content: 5.6%
Virgin Binder Content: 5.6%
Average Air Void: 5.4%
RAP: 0%
Long term aged: 120 hrs at 85°C

Average IDEAL CT: 125.4
COV: 10.9%

Displacement Rate: 50 mm/min
Test Temperature: 25°C

COV on Fracture Energy: 1.0%
Specimens T16, T17, T18

Source 2

NMAS: 9.5 mm, PG 64-22
Design - 0.5% Binder Content: 5.1%
Virgin Binder Content: 5.1%
Average Air Void: 5.4%
RAP: 0%
Long term aged: 120 hrs at 85°C

Average IDEAL CT: 68
COV: 12.8%

Displacement Rate: 50 mm/min
Test Temperature: 25°C

COV on Fracture Energy: 1.0%
Test Repeatability

Source 3

Displacement Rate: 50 mm/min
Test Temperature: 25°C

Specimens 6, 7, 8, 9, 10

NMAS: 9.5 mm
Total Binder Content: 5.9%
Virgin Binder Content: 4.9%
PG 64-22
Average Air Void: 5.7%
RAP: 20%
Plant Produced Mix
Short Term Aged

Average IDEAL CT: 121
COV: 21.6%

COV on Fracture Energy: 4.4%
Test Repeatability

Displacement Rate: 50 mm/min
Test Temperature: 25°C

Specimens 31, 32, 33, 34, 35

NMAS: 6.3 mm
Total Binder Content: 6.9%
Virgin Binder Content: 6.9%
PG 76-22
Average Air Void: 5.3%
RAP: 0%
Plant Produced Mix
Short Term Aged

Average IDEAL CT: 233
COV: 18.3%

COV on Fracture Energy: 2.8%
NMAS: 9.5 mm, PG 76-22
RAP: 15%

Average IDEAL CT: 38.9
COV: 44.4%

NOTE: COV too high
Test Repeatability

NMAS: 9.5 mm, PG 76-22
RAP: 0%

Average IDEAL CT: 44.4
COV: 37.9%

If only 2 specimens, COV=13%
Test Repeatability

NMAS: 9.5 mm
PG 64-22
RAP: 15%

Average IDEAL CT: 192
COV: 74.1%

NOTE: COV very high, results not acceptable
Test Repeatability

- NMAS: 9.5 mm
- PG 64-22
- RAP: 15%

Average IDEAL CT: 210
COV: 43.5%

NOTE: COV too high
Test Repeatability

NMAS: 9.5 mm, PG 64-22, RAP: 15%

Average IDEAL CT: 32.9, COV: 45.0% (2 specimens)
What COV should we use?

<table>
<thead>
<tr>
<th>Criterion on COV</th>
<th>Number of Mixes</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 30%</td>
<td>5</td>
</tr>
<tr>
<td>≥ 25%</td>
<td>6</td>
</tr>
<tr>
<td>≥ 20%</td>
<td>7</td>
</tr>
<tr>
<td>≥ 15%</td>
<td>15</td>
</tr>
<tr>
<td>≥ 10%</td>
<td>20</td>
</tr>
</tbody>
</table>

COV: Coefficient of Variation

Total Number of Mixes: 23
Effect of Binder Content (Source 1)

<table>
<thead>
<tr>
<th>Binder Content, %</th>
<th>CT index</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.2</td>
<td>40</td>
</tr>
<tr>
<td>5.7</td>
<td>80</td>
</tr>
<tr>
<td>6.2</td>
<td>100</td>
</tr>
</tbody>
</table>

- PG 64-22
- No RAP
- NMAS 9.5 mm
Effect of Binder Content
(Source 2)

Binder Content, %

CT\text{index}

PG 64-22
No RAP
NMAS 9.5 mm

Binder Content, %

5.1
5.6
6.1
Effect of RAP Content
(Source 1)

NMAS 9.5 mm
Total Binder=5.7%
PG 64-22

Total Binder=6.2%
PG 64-22

CT\text{index}

RAP Content, %

LTOA
Total Binder=5.7%
PG 76-22
Effect of RAP Content
(Source 2)

NMAS 9.5 mm

Total Binder=5.6%
PG 64-22

Total Binder=6.1%
PG 64-22

CT_{index}

RAP Content, %

NMAS 9.5 mm

Total Binder=5.6%
PG 64-22

Total Binder=5.6%
PG 76-22

LTOA
Specimens T13, T14, T15

NMAS: 9.5 mm, PG 64-22
Design + 0.5% Binder Content: 6.1%
Average Air Void: 5.5%
RAP: 25%
Long term aged: 120 hrs at 85°C

Average IDEAL CT: 466
COV: 15.8%

Displacement Rate: 50 mm/min
Test Temperature: 25°C
% shown is binder content.

**Effect of RAP Content**
(Source 3)

<table>
<thead>
<tr>
<th>RAP Content, %</th>
<th>CT&lt;sub&gt;index&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>28.5</td>
</tr>
<tr>
<td>4.8%</td>
<td>6.0%</td>
</tr>
</tbody>
</table>

- NMAS = 19 mm
- PG 64-22
- CT<sub>index</sub> = 5.1%

- NMAS = 9.5 mm
- PG 64-22
- CT<sub>index</sub> = 6.0%

- NMAS = 6.3 mm
- PG 76-22
- CT<sub>index</sub> = 6.9%
Effect of Binder Grade & RAP
(Source 1)

NMAS 9.5 mm
Binder Content: 5.7%

Binder Grade

CT\text{index}

0 20 40 60 80 100

58-22 64-22 64-22 64-22

25% RAP 64-22 15% RAP 25% RAP

No RAP
Effect of Binder Grade & RAP
(Source 2)

Binder Grade

- 58-28
- 64-22

CT_index

25% RAP
No RAP
15% RAP
25% RAP

NMAS 9.5 mm
Binder Content: 5.6%
Summary & Conclusions

- Trend of Data very similar to SCB

- IDEAL-CT Range: **33 to 460**

- In most cases, the test is very repeatable

- COV mostly under 25%
Summary & Conclusions

- Increasing binder increases flexibility

- Increasing RAP over 20% decreases flexibility

- Use of soft binder with high RAP: mixed results (RAP binder stiffness effect?)
Recommendations

- Use four replicates

- Need a limit on COV
  - Round robin testing needed
  - Recommendation: 20% to 25%
Thank You!

Photo: October 19, 2019