Illinois
Flexibility
Index
Test

79th IAPA Annual Meeting

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Illinois Department of Transportation
I-FIT

- Background on I-FIT
- Development of FI Threshold
- Implementation
- IDOT Experience with I-FIT
- CTL Experience with I-FIT
Next Step in HMA Improvement

- FRAP
- PFP
- QCP
- Hamburg Wheel
- Tack Coat
- Long. Joint Seal
- Implement I-FIT
Book-End Performance Tests

One for Stability

One for Flexibility
Book-End Performance Tests

Hamburg Wheel for Stability

I-FIT for Flexibility
Illinois Flexibility Index Test  I-FIT

- A Performance Test Like Hamburg Wheel
- Developed thru ICT Research R27-128 
  \textit{(Testing Protocols to Ensure Performance of High Asphalt Binder Replacement Mixes Using RAP & RAS)}
- Uses Semi-Circular Bend (SCB) Configuration w/ Gyratory or Core Specimens @ Room Temp
- Test Can Be Completed in a Day
What Minimum FI Should We Use?

- As Part of the ICT R27-128 Research
  - Cores from Good & Bad Performing Pavements submitted from each District for FI testing
  - Dividing Line was FI ≈ 4

- So does that mean we should we set our Min. FI at 4?
Fl Decay

Fl vs Time

STA  LTA  ELTA
FI Decay

![Graph showing FI decay over time with labels STA, LTA, and ELTA on the x-axis and FI on the y-axis. The graph shows a downward trend from STA to ELTA.]
What Should the Minimum FI Value Be?

- U of I obtained plant mixes used in FHWA Research @ Turner Fairbanks
  - Mixes were designed to have wide range of flexibility
  - Mixes were tested to fatigue failure w/ the ALF
- Fatigue Failure = Rapid Onset of Cracking
FI -vs- FHWA Accelerated Loading Facility Fatigue Cycles

Flexibility Index (FI) vs. FHWA ALF Fatigue Cycles
Severe Production Induced Damage
Possible Causes for Production Induced Reduction of FI

- Cold/Wet Stockpiles
- Cold/Wet RAP & RAS Stockpiles
- High Production Temps
- Extended Silo Storage Time
- Long Haul Time
- Lower AC Content from Design
- Increased Dust Content
- Time/Temp of Asphalt Binder Storage
2016 Pilot Projects (11 Statewide)
- Targeted January → April 2016 lettings for Experimental Feature Projects:
  - I-FIT Design Verification & Production Testing Requirements (Mixes must have FI ≥ 8)
  - Contractor DCT Design Verification & Production Testing (for Informational Purposes)
  - Excludes: Pavement Patching & Incidental HMA
  - RAP/RAS spec revised (for Pilot Projects Only) to allow 5% increase in ABR (except D1 Poly mixes)
I-FIT Implementation

2016 Cont’d
- Districts 1 & 9 received new I-FIT’s
  - District 1 will cover Pilot Testing for Dists 1-3
  - BMPR will cover Dists 4-6
  - District 9 will cover Dists 7-9

2017 Implementation
- Purchase I-FIT Devices & Tile Saws w/Jigs for Remaining Districts
- More Pilot Projects
Future I-FIT Testing

- Evaluate Use of I-FIT to Screen/Allow Asphalt Modifiers through Long Term Aging Protocol
Fl vs Aging  (ReOB vs Unmodified)
Future I-FIT Testing

- Mix Design Verification for I-FIT
  - 1 Sample STA to verify FI ≥ 8.0
  - 1 Sample LTA to verify FI ≥ X.x

- Production
  - 1 Sample As-Produced to verify FI ≥ 8.0
  - 1 Sample LTA to verify FI ≥ X.x

- LTA Protocol to be Developed thru ICT Research
BMPR Priorities

1. PFP Dispute Samples
2. I-FIT Pilot Project Testing
3. I-FIT Mix Characterization Testing
4. Other BMPR Projects
Thank You!
I-FIT at BMPR

79th IAPA Annual Meeting
Tom Zehr – IDOT BMPR
03-14-16
I-FIT Specimen
- Background
- Initial Testing
- Specimen Prep
- Voids
- Aging
- Mixes Tested
Background

– Test Loading Rate is Fast – 50 mm per min
– Test Temp = 77°F
– DRAFT AASHTO spec on May 17, 2015
  • Balloted & Now Being Published
– Also Developed IL Test Procedure 405
  • Attached to Spec for Pilot Projects
– Received Initial Machine in July 8, 2015
– “Re-designed” Machine delivered July 23, 2015
Initial Testing

– All Mixes Plant Mix (Aged on shelf for varying times (bags of specimens)
– 1\textsuperscript{st} Testing to Evaluate & Learn About Machine
– Round Robin Study
– Compared Springs –vs- Pivoting Bearing Base
  • 4.75 Level Binder Mix (6 gyros each)
  • 2) 9.5 Surface Mixes (3 gyros each)
  • 24 Gyro Bricks & 96 Test Specimens
Roller & Spring
Bearings & Pivot
Springs -vs- Bearings with Pivot

<table>
<thead>
<tr>
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<th>Avg Flexibility Index</th>
<th>AVG</th>
<th>COV</th>
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<tr>
<td>Springs</td>
<td>14.4</td>
<td>7.55</td>
<td>8.32</td>
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<td>4.75 LB 29% ABR</td>
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<td>Bearings &amp; Pivot</td>
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<td>9.5 Surf 29% ABR</td>
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<tr>
<td>Springs</td>
<td>13.88</td>
<td>4.6</td>
<td>5.6</td>
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<tr>
<td>9.5 Surf 48% ABR</td>
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<tr>
<td>Springs</td>
<td>11.64</td>
<td>11.25</td>
<td>11.25</td>
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<tr>
<td>9.5 Surf 48% ABR</td>
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AVG and COV for springs and bearings with pivot.
Round Robin

- U of I ATREL, CTL, & BMPR
- Each Lab, 2 mixes
  - 4.75 Level Binder
  - 9.5 Surface
- BMPR Prepared ALL Specimens
- (2 gyros – 8 specimens) per mix
- Also Looking at Effect of Specimens Aging on Shelf (Extra Specimens)
  - 5 month (done)
  - Then 8 mo, 1 yr, & 1 ½ or 2 yrs
I-FIT Round Robin - 4.75 Level Binder (35% ABR)

Average Flexibility Index

ATREL  |  CTL  |  BMPR  |  Avg of 3  |  5mo Aging
-------|-------|--------|------------|-------------
8.8    | 6.8   | 10.6   | 8.7        | 7.1        
I-FIT Round Robin - 9.5 Surface (29% ABR)

Average Flexibility Index

<table>
<thead>
<tr>
<th></th>
<th>ATREL</th>
<th>CTL</th>
<th>BMPR</th>
<th>Avg of 3</th>
<th>5mo Aging</th>
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<td>2.7</td>
<td>2.5</td>
<td>2.5</td>
<td>2.6</td>
<td>2.9</td>
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</table>

2.7
2.5
2.5
2.6
2.9
Future Round Robin

- When Funding is Available, BMPR Intends to Purchase a Machine for Each District and Provide Training.
- BMPR is working on an Instruction Video on I-FIT Operation
- After Each District has Equipment, a Round Robin Study Will Be Conducted with Districts & Private Labs to Evaluate Variability
Specimen Prep
Specimen Prep

– Typical Gyro Brick Height is 160 mm
– However, 160 mm may not work for certain compactors, so at least 115 mm & cut 1 disk
– Saw Cuts need to be Accurate to ensure Flat Surfaces, Perpendicular, & Correct Dimensions
  • Disk Thickness – 50 ± 1 mm
  • Notch Length – 15 ± 1 mm
  • Notch Width – 1.5 ± 0.1 mm

– Consistent Specimen Prep is Important!
Voids –vs- FI

– Current Spec for Air Voids is $7.0 \pm 0.5\%$
– Common Sense says Voids should have large affect on FI,
– Our Testing so far does not indicate that FI is highly dependent on voids at $7.0 \pm 0.5\%$
Voids -vs- FL for 81Bit157M

$R^2 = 0.201$
Voids –vs- FI

– So, for 2016 Pilot Projects, the Air Void Goal is 7.0 ± 0.5% but 7.0 ± 1.0% will be considered

– Future Consideration: Contractor submit several Compacted Gyro Bricks at Same Air Void Level with Half Tested for I-FIT and Half Tested for Hamburg.
More Air Void Observations

- Voids Typically 0.2 - 0.3 Higher on the Top Disk than on Bottom Disk
- Voids Often Considerably Greater in 2 Halves of the SAME Disk than Top & Bottom
- Voids Req’t Is for Disk rather than for Each Individual Specimen
- 7.0 ± 0.5% Voids often easier for Level Binder than Surface or Binder
Ambient Aging

– Jim talked about Need for Oven Aging to Predict Long-Term Mix Flexibility Properties
– Also Need to Determine Effect on FI of Bags of Mix and Gyro-compacted or Prepared I-FIT specimens Sitting on the Shelf
– Plan to sample Mix
  • Compact Bricks & Saw Specimens, Keep on Shelf, and Test at Intervals for Up to 2 years
  • Keep Bags of Mix on Shelf Then Prepare and Test Specimens at Intervals for Up to 2 years
Mixes Tested

– Have tested 55 mix designs
– 178 gyro bricks
– Currently have a backlog of ≈ 20 mixes
– Report 3 most similar FI values from each Gyro Brick (after ‘Outlier’ Removed)
Average Flexibility Index
Thank You
The 79th Annual Convention
IAPA 2016

Abdul Dahhan, P.E.
Chicago Testing Laboratory

March 14th, 2016
Presentation Outline

1. CTL experience with I-FIT
2. Data Analysis & Observations
3. Summary
   - Takeaways
Air Void Control
Database

- Over 60 plant mixtures of varying parameters from different plants tested under the I-FIT test method.

<table>
<thead>
<tr>
<th>NMAS</th>
<th>N-Design</th>
<th>%ABR</th>
<th>%RAP</th>
<th>%RAS</th>
<th>PG Grade</th>
<th>Total AC Content</th>
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<tr>
<td>4.75-19.0 mm</td>
<td>N30-N90 (SMA)</td>
<td>Virgin-52.1%</td>
<td>Virgin-50.0%</td>
<td>Virgin-5.0%</td>
<td>[PG 58-28]-[PG 70-28]</td>
<td>4.6-8.2%</td>
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Flexibility Index

Higher Flexibility Index = Less Cracking
FI vs. NMAS

NMAS

Average FI

19 mm

9.5 mm

4.75 mm

0

10

15
I-FIT FI Repeatability

Less COV = More Repeatable Data

Flexibility Index COV

0% 10% 20% 30%
FI COV vs. NMAS

Less COV = More Repeatable Data

Average FI COV

<table>
<thead>
<tr>
<th>NMAS</th>
<th>0%</th>
<th>5%</th>
<th>10%</th>
<th>15%</th>
<th>20%</th>
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<td>19 mm</td>
<td></td>
<td></td>
<td></td>
<td>15%</td>
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</tr>
<tr>
<td>9.5 mm</td>
<td></td>
<td></td>
<td>10%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.75 mm</td>
<td></td>
<td></td>
<td>5%</td>
<td></td>
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</table>
Mix Types vs. Flexibility Index

- 9.5mm Surface
- SMA
- 4.75mm Level Binder
- 19.0mm Binder

Flexibility Index
Surface and Binder Mixtures

- **N50 SURFACE MIXES**: Flexibility Index 9.4
- **N70 SURFACE MIXES**: Flexibility Index 9.2
- **N50 BINDER MIXES**: Flexibility Index 4.8
- **N70 BINDER MIXES**: Flexibility Index 1.8
Polymer & Warm Mix Additive Effect

Average FI

Non-Polymer

Non-WMA Modified

Polymer

WMA Modified
Effect of Warm-Mix Additives

Flexibility Index vs. Hamburg Wheel Track Performance

- Low Volume (ESAL)
- Intermediate Volume (ESAL)
- High Volume (ESAL)

Poor Performing Mixes
What’s the data really telling us?

Hamburg Wheel Track Performance

Flexibility Index

High Volume (ESAL)
Intermediate Volume (ESAL)
Low Volume (ESAL)
Poor Performing Mixes
Performance Economics

- **Total Cost**
  - Decreases with increasing performance until the optimum point.

- **Maintenance Cost**
  - Increases with increasing performance.

- **Performance Level**
  - Decreases with increasing cost.

- **Optimum**
  - Point where total cost is minimized.

- **Cost**
  - Vertical axis.

- **Performance**
  - Horizontal axis.
Takeaways...

1. Importance of proper testing
   a) Need for a uniformity study across all facilities
      ➢ Consistency of compaction, fabrication, testing, analysis

2. Many mixes meet 8.0 F1 criteria

3. Importance of cost-effective design
   1. Multi-tiered approach for F1?
Thank you

Questions

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