Brief Introduction to the Illinois Center for Transportation

Imad L. Al-Qadi
ICT Vision,

Since its inception in 2005

- Serve the transportation needs of IDOT, the State of Illinois, and the nation through research, education, and outreach
  - Rapid response to future scientific challenges in transportation
  - Adapt to changing needs
- Develop and implement innovative and cost-effective technologies
- Optimize the limited resources of IDOT
Initial Projects, 2005

- Pavements: 9 projects (76%)
- Structures: 1 project (8%)
- Safety: 1 project (8%)
- Traffic Ops./Maintenance: 1 project (8%)
Now - Transportation Diversity!

- Pavements: 20 (25%)
- Structures: 17 (21%)
- Construction: 2 (2%)
- Planning: 6 (7%)
- Public Trans.: 7 (9%)
- Traffic Ops./Maint.: 11 (14%)
- Safety: 10 (12%)
- Environment: 5 (6%)
- Other: 3 (4%)
Research Progress/ Status

- Total Projects Approved to Date = 93
  - 81 Regular Projects – Selected by Exec. Committee
  - 12 Special (Short-Term) Projects
- 29 Projects Are Completed
  - 19 Regular Projects
  - 10 Special (Short-Term) Projects
- 26 ICT Reports Published on Website
- 64 Active ICT Projects
Who’s Participating in ICT?

- 40 Academic Researchers (PI’s/ Co-PI’s)
- 50 Graduate Students
- 9 Universities
- 4 Private Consulting Firms
- 2 Federal/ Local Gov’t. Agencies
- Consultants
Served by a Top Facility - ATREL
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<th>Pub. No.</th>
<th>Proj. No.</th>
<th>Title</th>
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<td>ICT-08-025</td>
<td>ICT-R27-15</td>
<td>REGIONAL WAREHOUSE TRIP PRODUCTION ANALYSIS, Chicago Metro Area, September, 2009</td>
<td>Jon E. DeVries and Sofia V. Demissi</td>
<td>Oct-08</td>
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<td>FHWA-ICT-08-021</td>
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<td>Evaluation of HMA Overlays in Illinois</td>
<td>Angela S. Wolforo, Todd E. House, and Kurt D. Smith</td>
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<td>Non-destructive Pavement Analysis Using ILLI-PAVE Artificial Neural Network Models</td>
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<td>Task Coat Optimization for HMA Overlays: Laboratory Testing</td>
<td>Imad L. Al-Qadi, Samuel H. Carpenter, Zhao Li, Hasan Ozer, James S. Trespanier</td>
<td>Sep-08</td>
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<td>FHWA-ICT-08-017</td>
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<td>EXTENDED LIFE HOT MIX ASPHALT PAVEMENT (ELHMAP) TEST SECTIONS AT ATREL.</td>
<td>S.H. Carpenter</td>
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<td>FHWA-ICT-08-018</td>
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<td>Truckers’ Park/Rest Facility Study</td>
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<td>Carbon Monoxide Screen for Signalized Intersections COSIM, Version 3.0</td>
<td>Scott Peters</td>
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Bonding HMA to PCC
the Key to Overlay Performance

Imad L. Al-Qadi
Outline

- Introduction
- Objective
- Experimental Program and Lab Test Results
- HMA Overlay Construction
- Accelerated Pavement Testing (APT) Results
- Conclusions and Recommendations
Introduction

- Interface bonding between HMA overlays and PCC pavements is critical to overlay performance.

- Various pavement distresses can be caused by poor interface bonding.

- Most of the previous research studies have focused on the interface between HMA layers, and few field validated studies have been conducted.
To quantify the effectiveness of tack coat application between existing PCC pavement and HMA overlay.

- Laboratory Testing
- Accelerated Pavement Testing
Laboratory Testing

- A specially designed direct shear testing fixture was used.
- Experimental variables include tack coat type, tack coat application rate, HMA type, temperature, and moisture.

Traffic Direction
- Smooth
- Transverse Tining
- Longitudinal Tining
- Milling
Typical Interface Shear Stress-Displacement Curve

![Graph showing interface shear stress vs. shear displacement](image-url)
## Experimental Variables

<table>
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<tr>
<th>Variables</th>
<th>Levels (No. of Levels)</th>
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<tr>
<td>HMA Type</td>
<td>Surface, Standard Binder, Moisture-Sensitive Binder (3)</td>
</tr>
<tr>
<td>Tack Coat Type</td>
<td>SS-1hP, SS-1h, RC-70 (3)</td>
</tr>
<tr>
<td>Residual Tack Coat Application Rate</td>
<td>0, 0.02, 0.05, 0.09 gal/yd² (4)</td>
</tr>
<tr>
<td>Concrete Surface Texture</td>
<td>Smooth, Transverse-Tined, Longitudinal-Tined, Milled (4)</td>
</tr>
<tr>
<td>Temperature</td>
<td>50, 68, 86 °F (3)</td>
</tr>
<tr>
<td>Moisture Condition</td>
<td>Dry, Saturated (2)</td>
</tr>
</tbody>
</table>
Effects of HMA Type and Tack Coat Type and Application Rate

![Bar chart showing interface shear strength vs. residual tack coat application rate for different HMA types and tack coat types.](image-url)
Concrete Surface Texture Effect

![Graph showing the effect of different surface textures on interface shear strength against residual tack coat application rate. The graph includes lines for Smooth, Transverse Tining, Longitudinal Tining, and Milled surfaces, each represented by a different marker and color.](image-url)
Optimum Tack Coat Application Rate Determination

Three more rates were added to fine-tune the optimum rate

HMA: standard binder mix

Tack Coat: SS-1hP
Temperature Effect

![Graph showing the relationship between Interface Shear Strength (psi) and Temperature (°F).]
Moisture Conditioning

- AASHTO Designation T283-02 was modified to condition the HMA-PCC specimens
- Saturation degree: 70-80%
- Water bath at 140°F (60°C) for 24hrs
- Water bath at 68°F (20°C) for 2hrs
- Shear test at 68°F (20°C)
- Calculate interface shear strength ratio between dry and moisture conditioned specimens
Moisture Effect

Standard Mix: Strength Ratio = 57%

Stripping Mix: Strength Ratio = 34%

Testing Condition

Interface Shear Strength (psi)

Dry

Moisture Conditioned
Lab Testing Findings

- Surface mix provides better interface shear strength than binder mixes.

- SS-1hP and SS-1h provide better interface shear strength than RC-70; no significant difference between SS-1hP and SS-1h.

- The optimum residual tack coat rate for SS-1hP using standard binder mix is 0.04gal/yd² (0.18L/m²).
Lab Testing Findings (Cont’d)

- Milled PCC surface provides the highest interface shear strength.

- Lower temperature produces better bonding at intermediate to high temperatures.

- Moisture conditioning significantly reduces interface strength. The reduction is more pronounced when a stripping-vulnerable mix is used.
**APT Validation & Construction Layout**

**ATLAS Loading Facility**

**ATLAS Test 1**
(Total Length= 12.5'*5=62.5')

**ATLAS Test 3**
(Total Length= 12.5'*6=75')

**ATLAS Test 5**
(Total Length= 12.5'*5=62.5')

**ATLAS Test 2**
(Total Length= 12.5'*4=50')

**ATLAS Test 4**
(Total Length= 12.5'*4=50')

- A broom-cleaned milled surface
- An air-blast-cleaned milled surface

* ATLAS Test 3 compares the tack coat application rates.
* ATLAS Tests 1, 2, & 4 compare various surface textures with one tack coat application rate.
* ATLAS Test 5 compares the zebra distribution effect at various application rates.
PCC Surface Preparation

- Traffic Direction
- Transverse Tining
- Longitudinal Tining
- Smooth

- Milling Machine
- Powered Broom

- Surface Cleaning with Air Blast
Zebra/Striped Sections

Width of duct tape: 3”

Width between duct tapes: 3”
Field Tack Coat Application

Centennial variable-bar liquid distributor

Geotextile Pad for Tack Coat Application Rate Measurement
Tack Coat Application Rate Check

- **Smooth Surface**
- **Transverse Tining**
- **Longitudinal Tining**

**HMA Binder Mix 1 (Good)**

- **RC-70** at Optimum Rate
- **SS-1hP** at Optimum Rate

**HMA Binder Mix 2 (Stripper)**

- **SS-1hP** at Optimum Rate
- **RC-70** at Optimum Rate

**No Tack Coat**

**Measured Residual Rate (gal/yo)**

- **O** Optimum Rate;
- **L** Lower Rate;
- **H** Higher Rate;
Strain Gauge Instrumentation

H-type strain gauge

Level strain gauge

Strain gauge installation
Placement of HMA Overlay

HMA Overlay Material: standard binder mix and moisture-sensitive mix

Density check with nuclear density gauge
Accelerated Pavement Testing
ATLAS Test 3: Sections A2 - 14

- To compare different tack coat and tack coat application rates.
- Two tack coats: RC-70 and SS-1hP and each at three residual application rates: 0.02, 0.04 and 0.09 gal/yd².

Indicates a milled surface that is broom cleaned only.
Indicates a milled surface that is thoroughly cleaned with an air blast.

Optimum Rate; L Low Rate; H High Rate;
Test 3 – Rutting Depth Progress
Test 3 - Transverse Strain Response

Strain (micro)

Wheel Position (ft)

Optimum-Rate Section
High-Rate Section
Low-Rate Section

2 OptRate_Transverse 5 HighRate_Transverse 7 LowRate_Transverse
Test 3 - Slippage Strain Response

Optimum-Rate Section

High-Rate Section

Low-Rate Section

Wheel Position (ft)

Strain (micro)
Residual Strain Calculation

![Graph showing strain over time with various lines indicating different rates and transverse directions.](image-url)
Residual Transverse Tensile Strain

Residual Trans. Tensile Strain (micro)

- Optimum Rate
- High Rate Section
- Low Rate

10,000 cycles
40,000 cycles
70,000 cycles

Legend:
- 10,000 cycles
- 40,000 cycles
- 70,000 cycles
Residual Slippage Strain

Section

Residual Slippage Strain (micrco)

10,000 cycles
40,000 cycles
70,000 cycles

Optimum Rate
High Rate
Low Rate

10,000 cycles
40,000 cycles
70,000 cycles

Residual Slippage Strain (micrco)
Indicates a milled surface that is broom cleaned only.

Indicates a milled surface that is thoroughly cleaned with an air blast.

- **Optimum Rate**: O
- **Low Rate**: L
- **High Rate**: H

- **To compare different PCC surface textures.**
- **Four PCC surface textures**: smooth, broom cleaned milling, air blast cleaned milling, and transverse tinting
ATLAS Test 1 - Final Rutting Depth

- Rutting Depth

- PG64-22 Smooth
- No Tack Smooth
- RC-70 Milled Broom
- RC-70 Milled Air
- RC-70 Smooth
- RC-70 Trans Tining

Rutting (in)
ATLAS Test 2: Sections 6 - 9

- To compare various PCC surface textures.
- Four PCC surface textures: transverse tining, broom cleaned milling, air blast cleaned milling, and smooth.

Indicates a milled surface that is broom cleaned only.

Indicates a milled surface that is thoroughly cleaned with an air blast.

**O** Optimum Rate; **L** Low Rate; **H** High Rate;
Test 2 – Rutting Depth Progress

Number of Loading Cycles vs. Rutting Depth (in)

- SS-1hP_Trans Tined
- SS-1hP_Broom-cleaned Milled
- SS-1hP_Air-cleaned Milled
- SS-1hP_Smooth
Indicates a milled surface that is broom cleaned only.

Indicates a milled surface that is thoroughly cleaned with an air blast.

O Optimum Rate; L Low Rate; H High Rate;

• To compare zebra effects, i.e., effects of non-uniform tack coat distribution
Test 5 - Rutting Depth Progress

- Longitudinal Tined
- Zebra_OptRate
- Zebra_LowRate
- Zebra_HighRate
- No Tack Coat

Number of Loading Cycles vs. Rutting Depth (in)
Conclusions (1)

- Lab and field testing results suggest that asphalt emulsion provides better interface bonding than RC-70.
- Lab testing results didn’t show significant difference between SS-1hP and SS-1h.
- From lab testing, optimum SS-1hP tack coat residual application rate is 0.04 gal/yd². This value was validated in the field testing. Similar conclusion applied to RC-70.
Conclusions (2)

- Lab testing results showed that temperature and moisture affected interface shear strength.
  - At intermediate to high temperature range, the higher the temperature, the lower the interface shear strength.
  - Moisture reduces interface shear strength. It is more pronounced when stripping-vulnerable mixture is used.
- Milled PCC surface provides better interface shear strength than tined and smooth PCC surfaces.
- PCC surface cleanliness level affects rutting depth; air-cleaned surfaces performed better than broom-cleaned surfaces.
- Non-uniform tack coat distribution would cause higher HMA surface rutting.
Recommendations

- SS-1hP (or SS-1h from lab) is recommended for use as tack coat at the HMA-PCC interface.
- The recommended optimum residual tack coat application rate is 0.04 gal/yd².
- Milling PCC surface should be applied when possible.
- Thoroughly cleaning is recommended (air blast).
- Tack coat should be applied uniformly; zebra application should not be allowed.
- PCC surface tining may not add to the HMA-PCC interface bonding.
Acknowledgement

- This project was supported by IDOT and FHWA through ICT
- Technical Review Panel of ICT-R55 project: James Trepanier (Chair), Amy Schutzbach, Charles Weinrank, Patty Broers, Terry Hoekstra, Derek Parish, and Tom Winkelman.
- David Lippert
Thank you!

Comments/ Questions?