



# ILLINOIS CENTER FOR TRANSPORTATION



Where Transportation & Excellence Meet

UNIVERSITY OF **ILLINOIS**  
AT URBANA-CHAMPAIGN

## Mixing HMA for Performance

**David L. Lippert, P.E.**  
Sustainability Implementation Engineer  
Illinois Center for Transportation  
University of Illinois at Urbana-Champaign

---

# Disclaimer

---

This presentation is based upon work in progress under project:

## ICT-R27-161- CONSTRUCTION AND PERFORMANCE MONITORING OF VARIOUS ASPHALT MIXES

**Project Chair:** James S. Trepanier

This work is sponsored by the Illinois Department of Transportation through funding by the Federal Highway Administration. The contents of this presentation reflect the views of the authors, who are responsible for the facts and accuracy of the data presented herein. The content does not necessarily reflect the official views or policies of the Illinois Department of Transportation. This presentation does not constitute a standard, specification or regulation.

---

# ACKNOWLEDGMENTS

---

**Co-Investigators/Authors:** Shenghua Wu, Hasan Ozer, Imad L. Al-Qadi,  
James F. Meister, Greg Renshaw, Students: Maxwell K. Barry, Izak M. Said,  
Arturo F. Espinoza Luque, Fazal R. Safi

**Illinois Center for Transportation**  
University of Illinois at Urbana-Champaign

**Timothy R. Murphy**  
Murphy Pavement Technology, Inc.

**James S. Trepanier, Joseph W. Vespa**  
Bureau of Materials and Physical Research  
**George Houston and Dist 1 Materials Staff**  
R1/D1  
Illinois Department of Transportation



## Outline

---

- **SuperPave Controls for HMA**
- **Performance Measure in HMA Pavement**
- **Distress Seen in Total Recycle Asphalt Section**
- **Typical HMA Project Types**
- **Performance of Various Asphalt Mixes (IHR 161)**
- **Thoughts for Future Specification Development Using Flexibility Index**

*"Where Excellence and Transportation Meet"*



## SuperPave Specification Controls

---

- **VMA, N-Design, Air Voids, Density and Asphalt Grade**
- **Each Impacts Performance**
  - **Raveling/Weathering/Segregation**
  - **Block Cracking**
  - **Transverse Cracking**
  - **Rutting**
  - **Centerline Joint Distress,**

*"Where Excellence and Transportation Meet"*



## Additional Controls

- TSR (AASHTO T-283) – Rutting (Stripping)**
- Minimum Tensile – Rutting**
- Maximum Tensile – Cracking**
- Hamburg – Rutting (Stripping)**
- Material Transfer Devices (MTD) and Anti-Segregation Controls**
- Smoothness Incentive/Penalty**

*"Where Excellence and Transportation Meet"*



## HMA Performance Measures

### Construction Related Distresses

- Ride
- Raveling/Weathering/  
Segregation
- Longitudinal Cracking  
(Paver Segregation and  
Roller Tears)
- Centerline Joint Distress



### Mix Related Distresses

- Rutting
- Transverse Cracking
- Block Cracking
- Raveling/Weathering/  
Segregation
- Centerline Joint Distress

### Design Related Distresses


- |  |  |
|--|--|
| <ul style="list-style-type: none"> <li><input type="checkbox"/> Rutting (Remaining<br/>Layers)</li> <li><input type="checkbox"/> Reflective Transverse<br/>Cracking</li> </ul> | <ul style="list-style-type: none"> <li><input type="checkbox"/> Fatigue/Alligator<br/>Cracking</li> <li><input type="checkbox"/> Ride (Lifts)</li> </ul> |
|--|--|

*"Where Excellence and Transportation Meet"*



 Illinois Center for Transportation  
University of Illinois at Urbana Champaign 

# Distress Driving Rehabilitation

## Block Cracking




*"Where Excellence and Transportation Meet"*

 Illinois Center for Transportation  
University of Illinois at Urbana Champaign 

# Distress Driving Rehabilitation

## Centerline Cracking



*"Where Excellence and Transportation Meet"*

# Distress Driving Rehabilitation

## Raveling/Weathering/Segregation



*"Where Excellence and Transportation Meet"*


# Distress Driving Rehabilitation

## Rutting



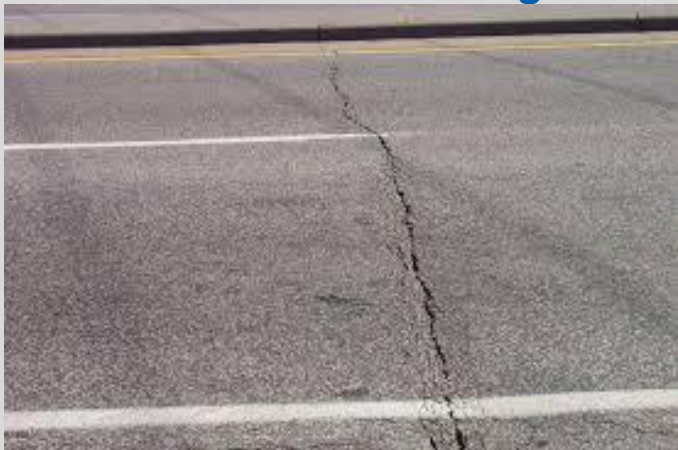
*"Where Excellence and Transportation Meet"*

Illinois Center for Transportation  
University of Illinois at Urbana Champaign



# Distress Driving Rehabilitation

## Transverse Cracking



*"Where Excellence and Transportation Meet"*

Illinois Center for Transportation  
University of Illinois at Urbana Champaign



# 2013 TRA Project Distress Surveys

	2014	2015	2016
26 <sup>th</sup> Street			
Harrison Street			

*"Where Excellence and Transportation Meet"*



 Illinois Center for Transportation  
 University of Illinois at Urbana Champaign




## 2013 TRA Project Distress Surveys

	2014	2015	2016
<b>Richards Street</b>			
<b>Wolf Road</b>			

*"Where Excellence and Transportation Meet"*


 Illinois Center for Transportation  
 University of Illinois at Urbana Champaign



## HMA Project Types

- New Full-Depth HMA
- New Composite (HMA over PCC)
- Overlays of Existing
  - Bare PCC
  - Mill and Fill of Existing Overlay (2.25-3.0")
    - Existing Thick OL (3-8+" HMA) over PCC
    - Existing Thin OL (2.25-3") over PCC
    - Full-Depth HMA
    - Other Stabilized Base (Cement or Pozzolanic)

*"Where Excellence and Transportation Meet"*



Illinois Center for Transportation  
University of Illinois at Urbana Champaign

# Typical HMA Rehabilitation Designs

Existing Thick & Thin HMA/PCC/Bare PCC and Full Depth HMA

6-8" HMA

2.5-3" HMA

Old PCC

HMA

*"Where Excellence and Transportation Meet"*

Illinois Center for Transportation  
University of Illinois at Urbana Champaign

# Typical HMA Rehabilitation Designs

Rehabilitated Thick & Thin HMA/PCC/Bare PCC and Full Depth HMA


6-8" HMA


2.5-3" HMA

Old PCC

HMA

*"Where Excellence and Transportation Meet"*

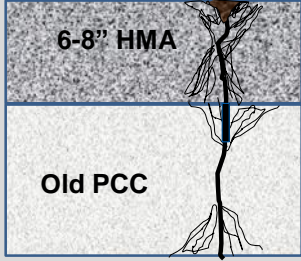

 Illinois Center for Transportation  
 University of Illinois at Urbana Champaign



## Typical HMA Rehabilitation Designs

### Existing Thick HMA/PCC

**Before**

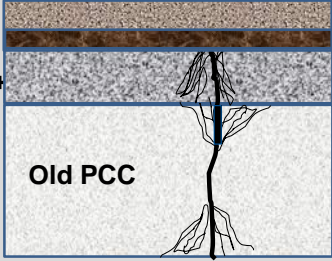


6-8" HMA

Old PCC


Mill ~2.25"    1.5" HMA  
 0.75" Poly 4.75"  
 3.75" - 5.75" +


**After Improvement**



Old PCC

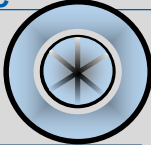
"Where Excellence and Transportation Meet"

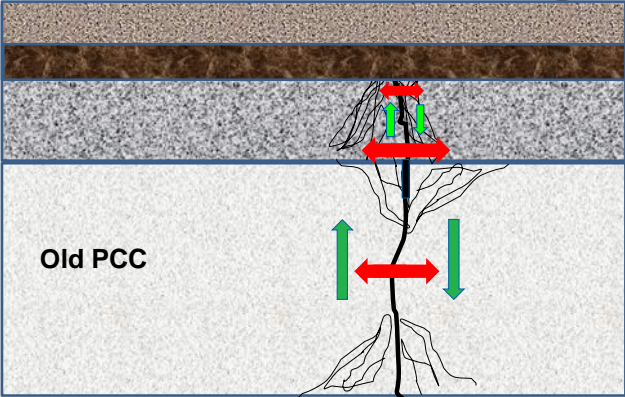

 Illinois Center for Transportation  
 University of Illinois at Urbana Champaign



## Crack Initiation

### Existing Thick HMA/PCC





Old PCC

"Where Excellence and Transportation Meet"

Illinois Center for Transportation  
University of Illinois at Urbana Champaign

# Crack Initiation

HMA on PCC (Bare or HMA Milled Off)

Old PCC

*"Where Excellence and Transportation Meet"*

Illinois Center for Transportation  
University of Illinois at Urbana Champaign

# Crack Propagation

HMA on PCC (Bare or HMA Milled Off)

Old PCC

*"Where Excellence and Transportation Meet"*



Illinois Center for Transportation  
University of Illinois at Urbana Champaign



# 161 EXPERIMENTAL MIXES

ASPHALT PG		ABR %		RAP %		RAS %	
64-22	58-22	LOW	HIGH	LOW	HIGH	LOW	HIGH
58-28	58-34	15	60	5	51	0	5
52-28	52-34						

*"Where Excellence and Transportation Meet"*



Illinois Center for Transportation  
University of Illinois at Urbana Champaign



# Material Sampling

**Plant Mix  
Lab Compacted (PMLC)**

**Cores**



*"Where Excellence and Transportation Meet"*



# Testing

Binder PG Grading



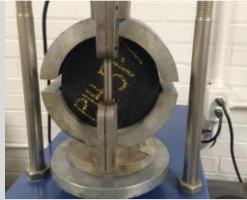
Asphalt Content/Mix Verification



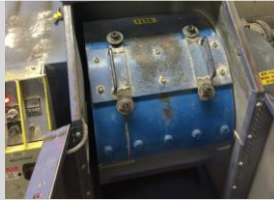
Moisture Damage (TSR)



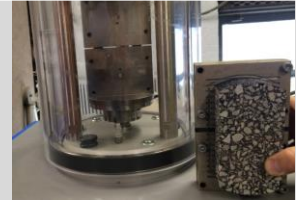
Marshall Stability



Cantabro Loss



Texas Overlay



"Where Excellence and Transportation Meet"



# Testing

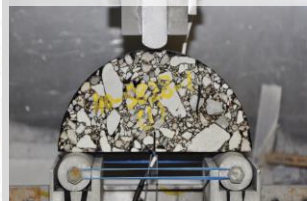
Complex Modulus Test



Hamburg Wheel Track



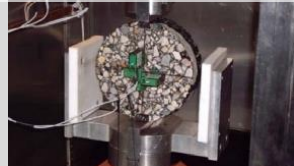
Semi Circular Bending Beam



Flow Number



IDT Fracture / Creep Compliance



Beam Fatigue



"Where Excellence and Transportation Meet"



Illinois Center for Transportation  
University of Illinois at Urbana Champaign



# Texas Overlay Tester



*"Where Excellence and Transportation Meet"*

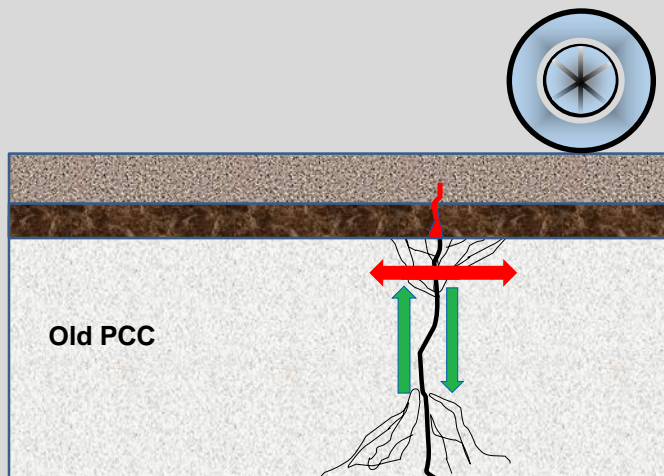


Illinois Center for Transportation  
University of Illinois at Urbana Champaign



# Crack Propagation

HMA on PCC (Bare or HMA Milled Off)



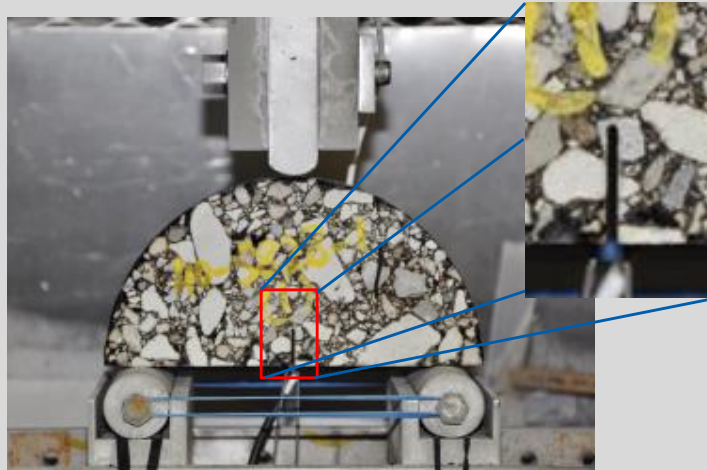
*"Where Excellence and Transportation Meet"*



Illinois Center for Transportation  
University of Illinois at Urbana Champaign



## Illinois Flexibility Index Test (I-FIT)



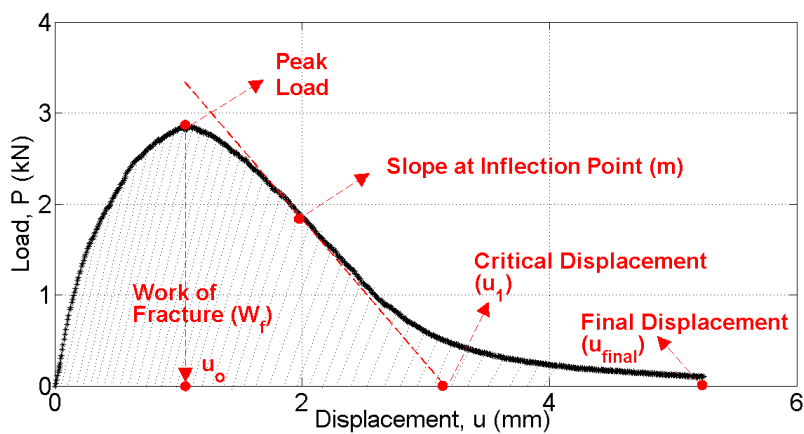
"Where Excellence and Transportation Meet"



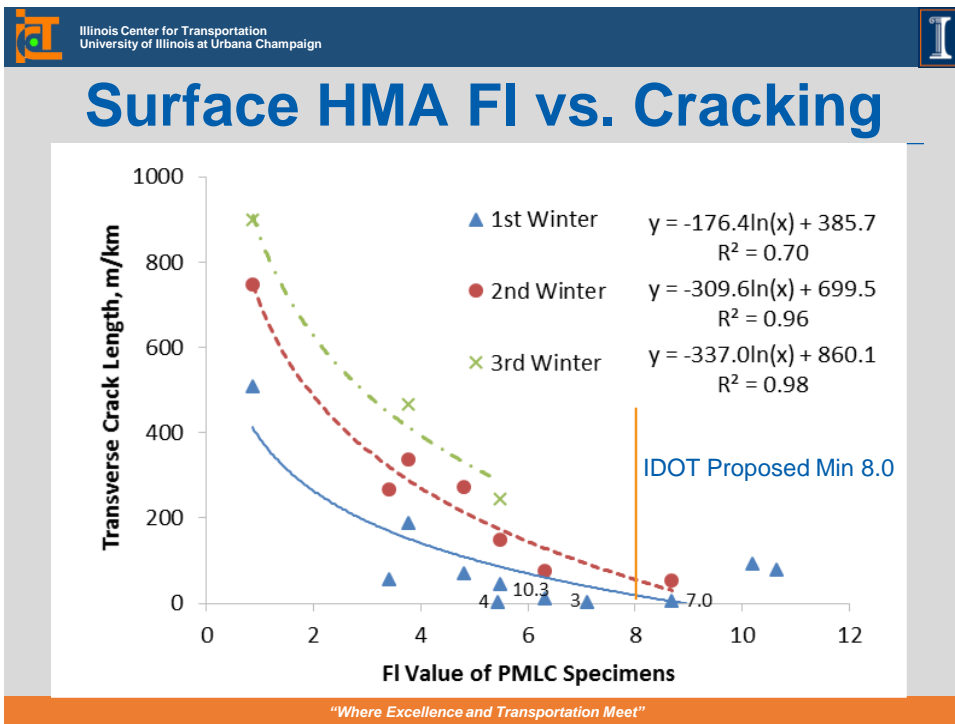
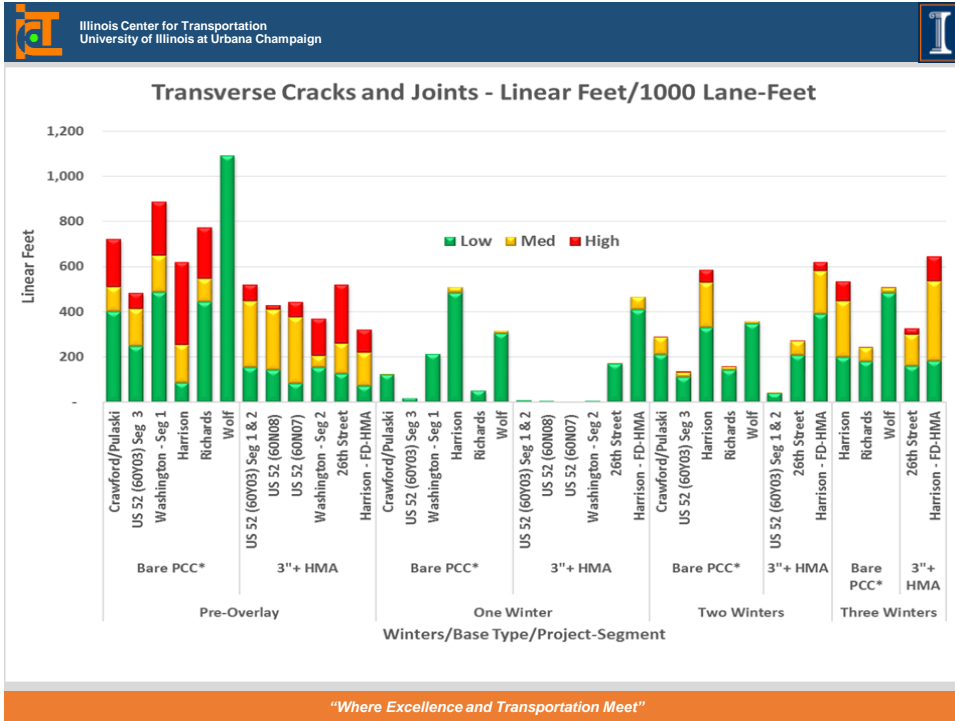
Illinois Center for Transportation  
University of Illinois at Urbana Champaign



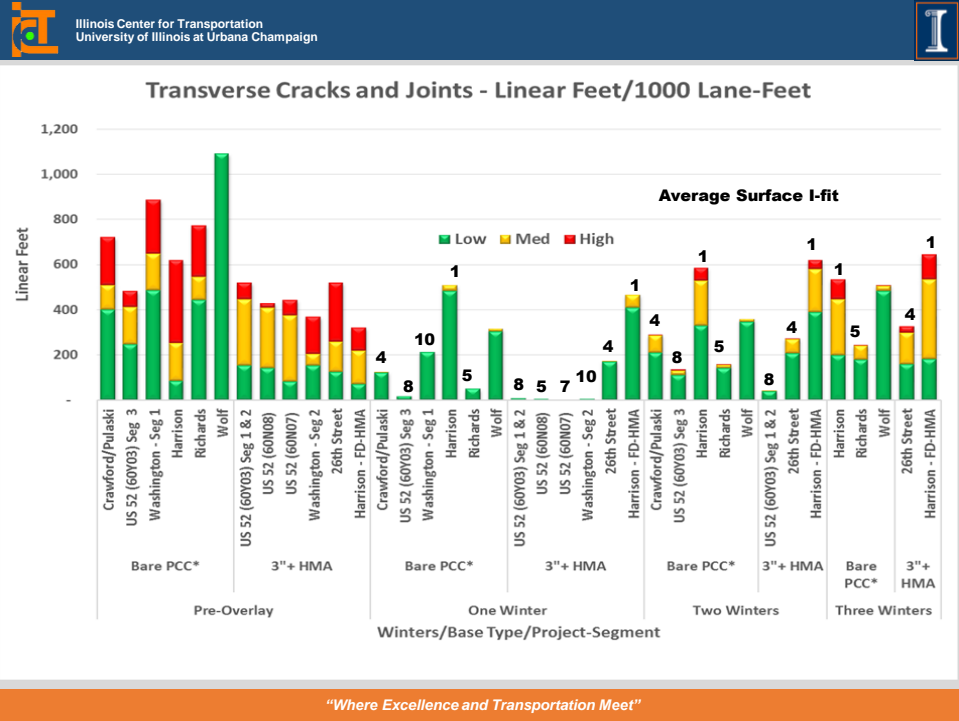
## Typical I-FIT Test Result



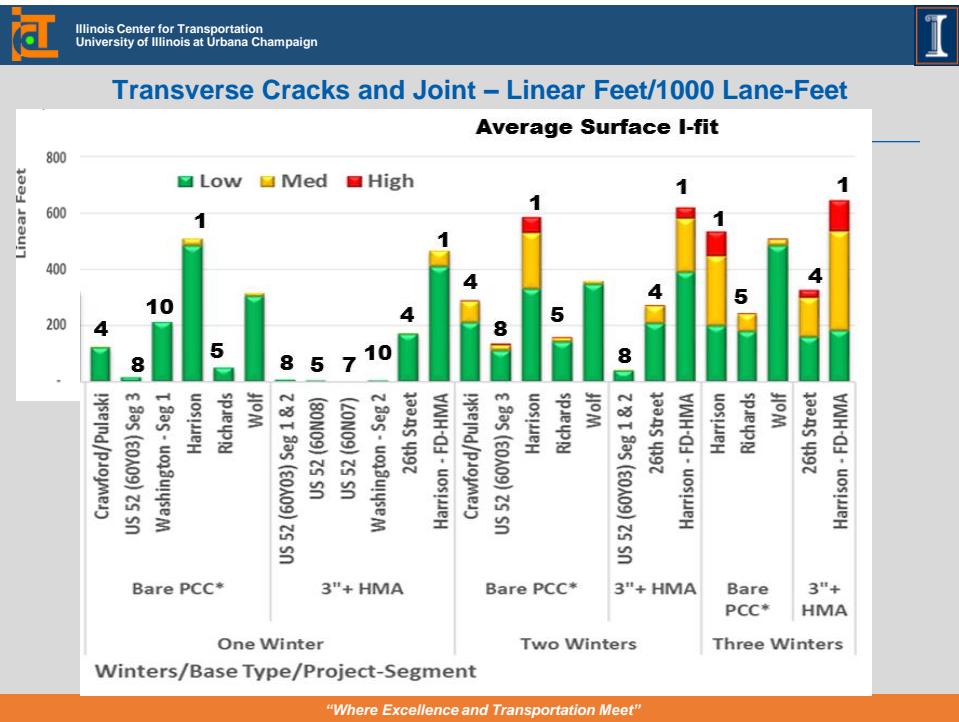
"Where Excellence and Transportation Meet"









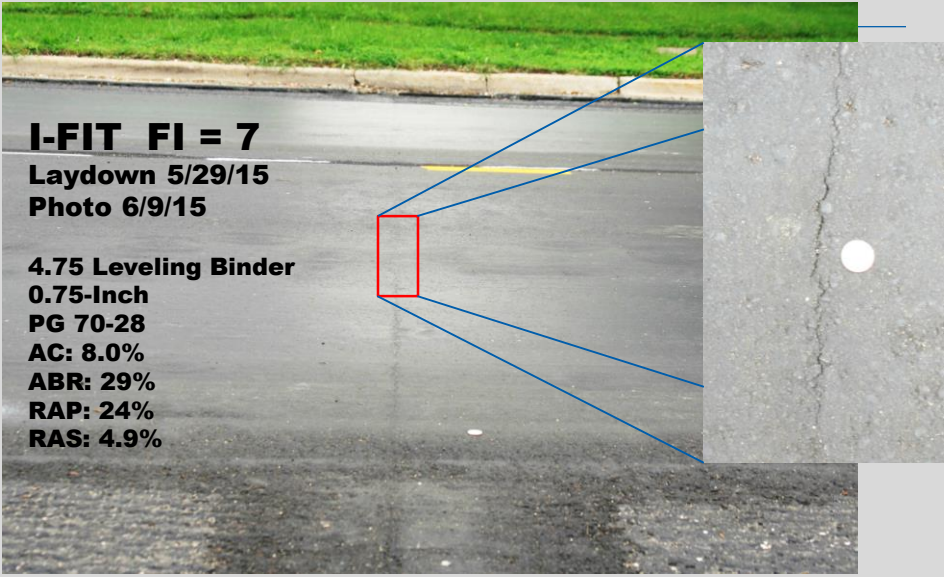
"Where Excellence and Transportation Meet"



"Where Excellence and Transportation Meet"

 Illinois Center for Transportation  
University of Illinois at Urbana Champaign 

## Washington St. Leveling Binder



**I-FIT FI = 7**  
**Laydown 5/29/15**  
**Photo 6/9/15**

**4.75 Leveling Binder**  
**0.75-Inch**  
**PG 70-28**  
**AC: 8.0%**  
**ABR: 29%**  
**RAP: 24%**  
**RAS: 4.9%**

*"Where Excellence and Transportation Meet"*

## HMA Testing "Book Ends"



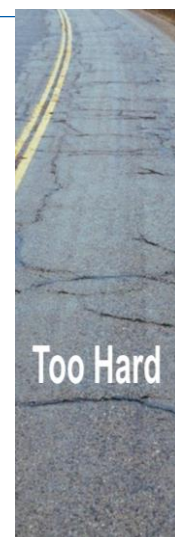
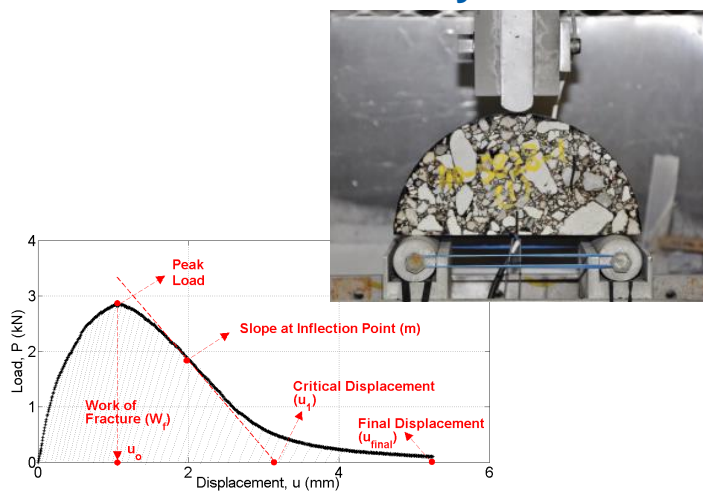
## Too Soft “Book End” Full Imp. 2014

### Hamburg Wheel Test



## The Other “Book End”

### □ I-FIT and Flexibility Index





## Research to Specification

- **Single FI for all mixes?**
  - **Simple Goal for all Mixes**
  - **Single Value may not be Best Engineering Approach to Obtain Desired Performance**
- **Multiple FI's**
  - **More Complex – Expands Number of Mixes**
  - **HMA Overlay Surface/Level Binder Values?**
  - **Full Depth HMA (Surface and Binder) Values?**
  - **HMA Shoulder Different Value?**

*"Where Excellence and Transportation Meet"*



## Mixing HMA for Performance

- **High Flexibility Demand**
  - **Level Binder Over PCC Pavement**
  - **Thin HMA Overlays**
- **Moderate Flexibility Demand**
  - **Thick Overlays of PCC Pavement**
  - **Thin Mill and Fill of Thick Overlay**
- **Low Flexibility Demand**
  - **Shoulders**

*"Where Excellence and Transportation Meet"*





## Design Possibilities

- **Leave HMA In-Place**
  - **No Milling –Existing Must be Stable**
  - **Hot-In-Place Recycle**
  - **Cold-In-Place Recycle**
- **Increase HMA Overlay Thickness**
  - **Must have Reasonable FI**
  - **Cost for Extra Material is Issue**


*"Where Excellence and Transportation Meet"*




## Mixing HMA for Performance

- **All Cross-Sections Benefit from Higher FI Mixes Resulting in Reduced Transverse Cracking**
- **Thin Overlays of PCC Pavement have High FI Demand**
- **Leveling Binder (Directly on PCC Pavement)**
  - **High Flexibility Demand**
  - **Could have Benefits from FI Value > 8.0**

*"Where Excellence and Transportation Meet"*




Illinois Center for Transportation  
University of Illinois at Urbana-Champaign



## Reports (IHR 27-161)

- **2-Interim Reports**
  - **2015 (Published)**
  - **2016 (Jan 2017 +/-)**
- **Final Report**
  - **Dec 2017**



CIVIL ENGINEERING STUDIES  
Illinois Center for Transportation Series No. 16-009  
ILL-ENG-2016-2009  
ISSN: 0197-9191

**CONSTRUCTION AND PERFORMANCE  
MONITORING OF VARIOUS ASPHALT MIXES IN  
ILLINOIS: 2015 INTERIM REPORT**

Prepared By  
David L. Lippert  
Hasan Ozer  
Imad L. Al-Qadi  
James F. Meister  
Greg Ranshaw

ASM Tamim Uddin Khan  
Illinois Center for Transportation  
University of Illinois at Urbana-Champaign

Timothy R. Murphy  
Murphy Pavement Technology, Inc.

James S. Trepanier  
Joseph W. Vespa  
Bureau of Materials and Physical Research  
Illinois Department of Transportation

Research Report No. FHWA-ICT-16-009

A report of the findings of  
ICT-R27-161  
**CONSTRUCTION AND PERFORMANCE  
MONITORING OF VARIOUS ASPHALT MIXES**  
Illinois Center for Transportation  
February 2016



**THANK YOU**



Main Quad – University of Illinois at Urbana-Champaign <sup>47</sup>