I-FIT: Improve Your Mix Durability

Thomas Bennert, Ph.D.
Rutgers University, NJ

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)

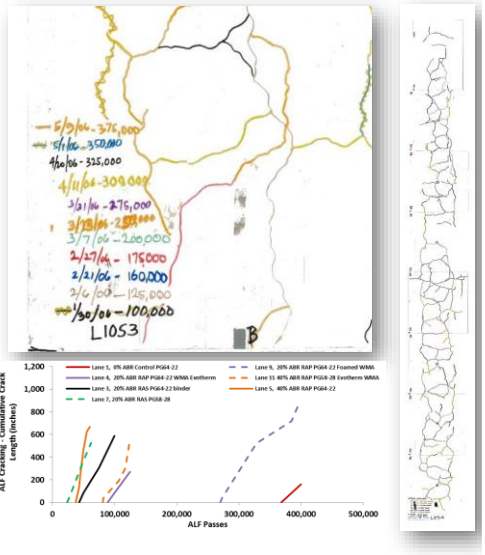
- ALF Loading Conditions
  - Controlled 20°C @ 20mm depth
  - Loading only in one direction
  - Lateral wander
  - 425 Super Single Tire
  - 100 psi inflation
  - 14,200 lb load

FHWA Accelerated Loading Facility (ALF)

	ALF Lane	% RBR		Virgin Binder PG	WMA Process
		RAP	RAS		
	1	0	-	64-22	-
Re-running	2	40	-	58-28	Water
	3	-	20	64-22	-
	4	20	-	64-22	Chemical
	5	40	-	64-22	-
	6	20	-	64-22	-
	7	-	20	58-28	-
Re-running	8	40	-	58-28	-
	9	20	-	64-22	Water
	11	40	-	58-28	Chemical

FHWA Accelerated Loading Facility (ALF)

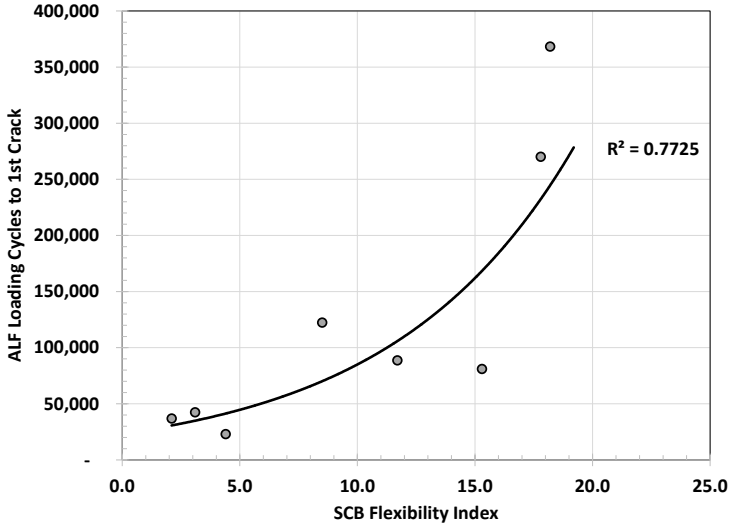
- Cracking performance measured and quantified in two indices
  - Number of cycles until 1st Crack observed
  - Cracking Rate



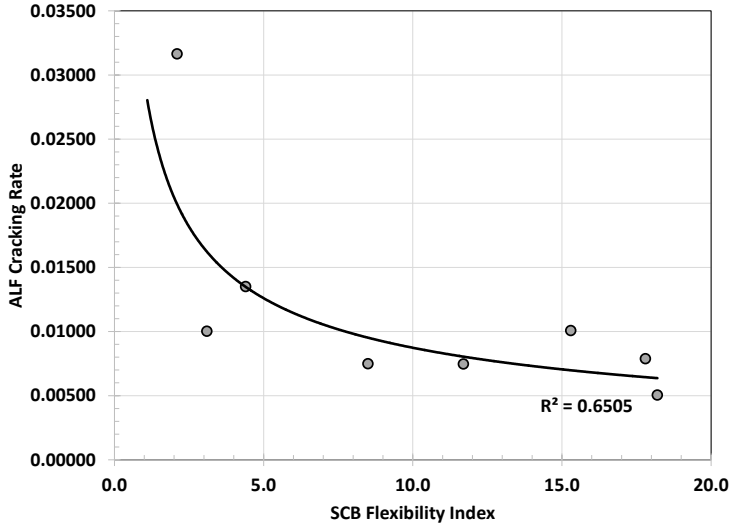
FHWA Accelerated Loading Facility (ALF)

- 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

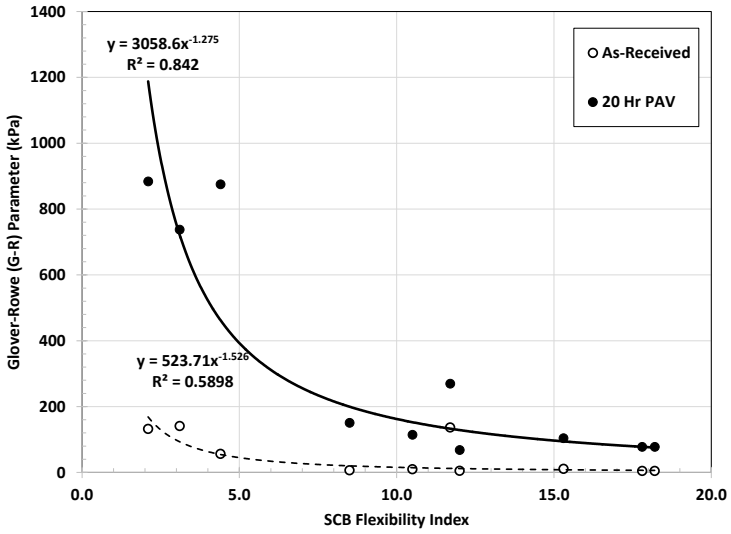
SCB FI vs Cycles to 1st Crack



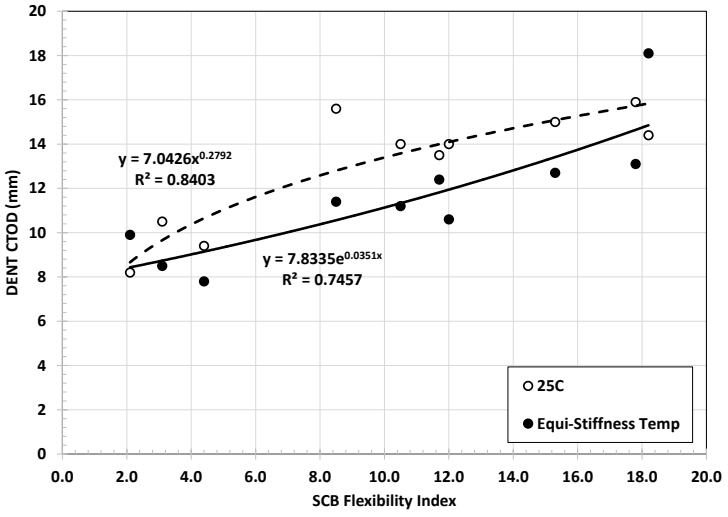
SCB FI vs Cracking Rate



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



SCB FI (Mixture) vs DENT CTOD (Binder)



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

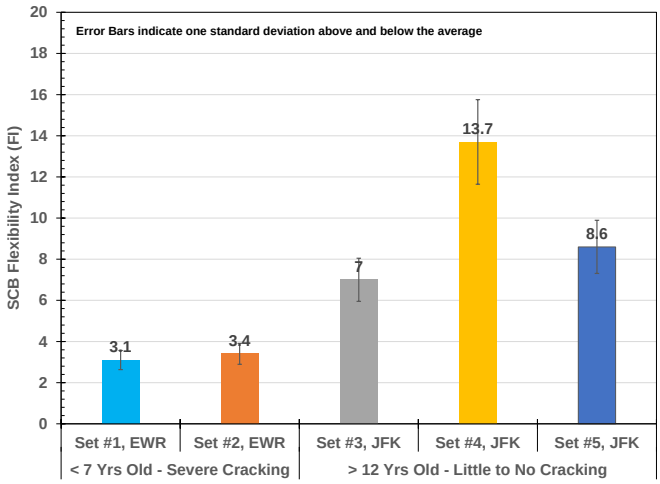
- No rutting
- Longitudinal and transverse cracking observed
- Cracking top-down
  - Stops approximately 0.5" to 0.75" below surface

Newark and JFK Mixture Info

Runway	Binder Type	Supplier	Visual Observations	Aggregate Type	Date Placed (Age)
EWR 11-29 (Core Set 1)	PG76-22 (PG64-22 + 7% Vestoplast)	Mt. Hope, Tilcon B Plant	Not performing well; Excessive cracking	Gneiss	9/20/2008 (6 Yrs, 9 Months)
EWR 11-29 (Core Set 2)	PG76-22 (PG64-22 + 7% Vestoplast)	Mt. Hope, Tilcon B Plant	Not performing well; Excessive cracking	Gneiss	8/9/2008 (6 Yrs, 10 Months)
JFK 4R-22L (Core Set 3)	PG76-22	Willets Pt Asphalt, Flushing, NY	Performing well; No cracking	Trap Rock (from Tilcon, Haverstraw)	9/5/2002 (12 Yrs, 9 Months)
JFK 4L-22R (Core Set 4)	PG76-28	Willets Pt Asphalt, Flushing, NY	Performing well; Very few cracks	Trap Rock (from Tilcon, Haverstraw)	6/4/2000 (15 Yrs)
JFK 4L-22R (Core Set 5)	PG76-28	Mt. Hope Rock Products, Flushing NY	Performing well; some cracking	Gneiss	6/4/2000 (15 Yrs)

Runway	Asphalt Content	QC Air Voids	QC VMA	QC VFA	Eff AC by Vol (%)	Stability (lb)	Flow (0.01")	% Finer #200	In-Place Voids (%)
EWR 11-29 (Core Set 1)	5.4	3.4	15.8	78.8	12.4	2723	11.8	4.5	5.5
EWR 11-29 (Core Set 2)	5.3	3.5	15.9	77.9	12.4	3056	11.0	3.9	5.2
JFK 4R-22L (Core Set 3)	5.1	4.9	17	71.1	12.1	3255	13.8	4.4	5.0
JFK 4L-22R (Core Set 4)	5.0	4.6	17	72.9	12.4	2606	13.3	4.8	4.1
JFK 4L-22R (Core Set 5)	5.1	4.6	16.4	72	11.8	3274	14.5	3.7	4.6

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)

I-FIT Correlation with Overlay Tester

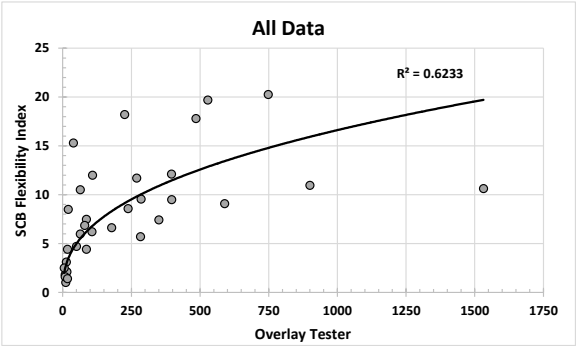
- NJDOT relies on the Overlay Tester for Performance Related Specifications (PRS)
- NJDOT evaluating the potential use of the I-FIT for either;
  1. Guide for asphalt industry on how well their asphalt mixtures will perform in the Overlay Tester; and/or
  2. Replacing the Overlay Tester within their PRS

I-FIT Correlation with Overlay Tester

- 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)

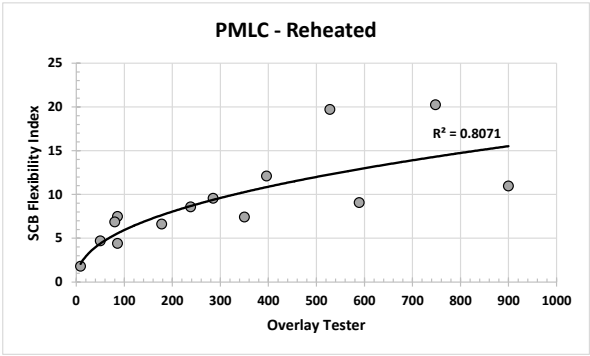
All Data

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



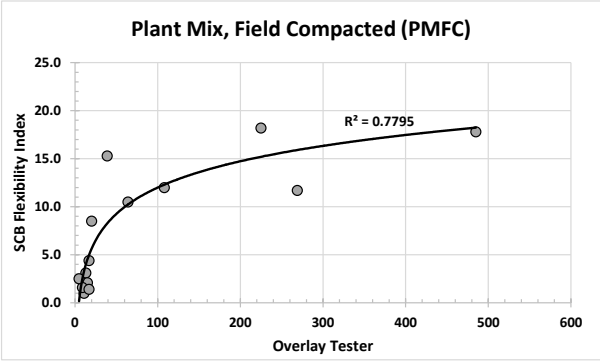
Plant Mixed, Lab Compacted (Reheated)

- 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 I-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

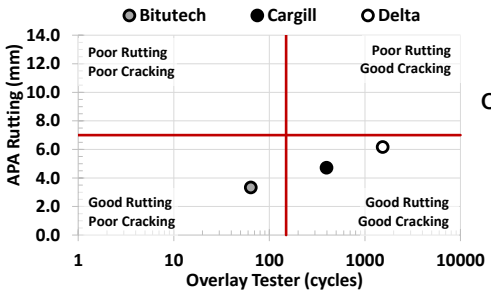
Future I-FIT Implementation in NJ

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

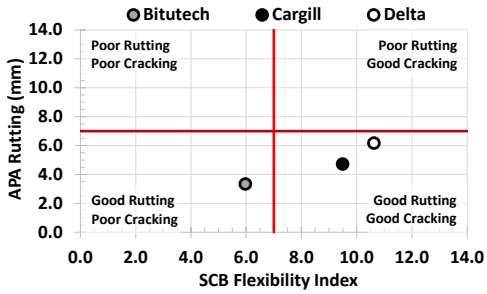
Test	Requirement			
	Surface Course		Intermediate Course	
	PG 64-22	PG 76-22	PG 64-22	PG 76-22
APA @ 8,000 loading cycles (AASHTO T 340)	< 7 mm	< 4 mm	< 7 mm	< 4 mm
Overlay Tester (NJDOT B-10)	> 150 cycles	> 175 cycles	> 100 cycles	> 125 cycles

NJDOT's Performance Related Specifications – HRAP Low/Med Traffic



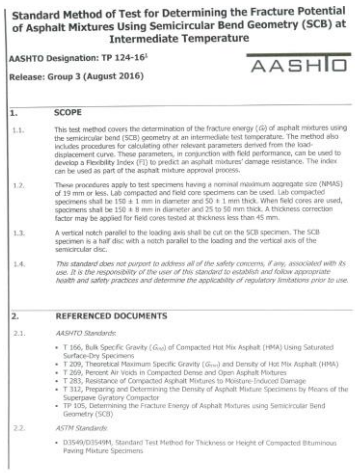
Overlay Tester Based PRS

I-FIT Based PRS



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



Standard Method of Test for Determining the Fracture Potential of Asphalt Mixtures Using Semicircular Bend Geometry (SCB) at Intermediate Temperature

AASHTO Designation: TP 124-16[1]

Release: Group 3 (August 2016)

AASHTO

1. SCOPE

1.1. This test method covers the determination of the fracture energy (G_f) of asphalt mixtures using the semicircular bend (SCB) geometry at an intermediate test temperature. The method also includes procedures for calculating other relevant parameters derived from the load-displacement curve. These parameters, in conjunction with field performance, can be used to develop a Flexibility Index (FI) to predict an asphalt mixtures' damage resistance. The index can be used as part of the asphalt mixture approval process.

1.2. These procedures apply to test specimens having a nominal maximum aggregate size (NMAS) of 19 mm or less. Lab compacted and field core specimens can be used. Lab compacted specimens shall be 150 ± 1 mm in diameter and 50 ± 1 mm thick. When field cores are used, specimens shall be 150 ± 8 mm in diameter and 25 to 50 mm thick. A thickness correction factor may be applied for field cores tested at thickness less than 45 mm.

1.3. A vertical notch parallel to the loading axis shall be cut on the SCB specimen. The SCB specimen is a half disc with a notch parallel to the loading and the vertical axis of the semicircular disc.

1.4. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish and follow appropriate health and safety practices and determine the applicability of regulatory limitations prior to use.*

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards:*

- T 166, Bulk Specific Gravity (G_{mb}) of Compacted Hot Mix Asphalt (HMA) Using Saturated Surface-Dry Specimens
- T 209, Theoretical Maximum Specific Gravity (G_{mm}) and Density of Hot Mix Asphalt (HMA)
- T 269, Percent Air Voids in Compacted Dense and Open Asphalt Mixtures
- T 283, Resistance of Compacted Asphalt Mixtures to Moisture-Induced Damage
- T 312, Preparing and Determining the Density of Asphalt Mixture Specimens by Means of the Superpave Gyratory Compactor
- TP 105, Determining the Fracture Energy of Asphalt Mixtures using Semicircular Bend Geometry (SCB)

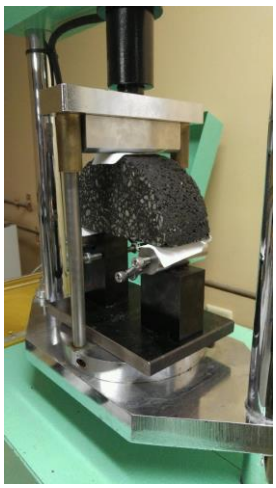
2.2. *ASTM Standards:*

- D3549/D3549M, Standard Test Method for Thickness or Height of Compacted Bituminous Paving Mixture Specimens

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

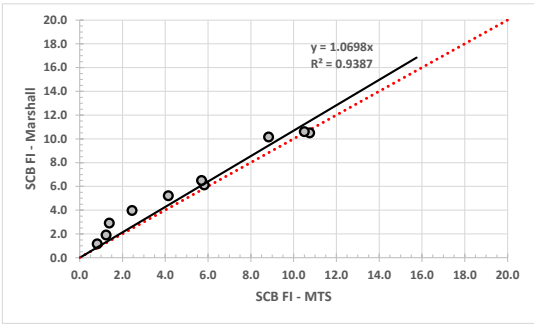
SCB Using Marshall Machine



SCB Using Marshall Machine

I-FIT: Servo-Hydraulic (MTS) vs Screw Machine (Pine 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