Field Validation of NCHRP 9-22A QRSS Software in Rhode Island: Preliminary Results

October 6th, 2010

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Introduction

- NCHRP 9-22A Team
  - Dr. Edward Harrigan, Transportation Research Board, project sponsor
  - Mr. Jim Moulthrop, Fugro Consultants, principal investigator
  - Drs. Matt Witczak, Myung Jeong, Mohamed El-Basyouny, Mr. Joe Phillips, AMEC/Arizona State University, southwest operations
  - Dr. Leslie McCarthy and Dave Mensching, Villanova University, northeast operations

- *Validation Sites*: Rhode Island, Texas, Utah

Overall Goal of Project

- Achieving <u>Quality Assurance</u> for HMA that:
  - Better methods/more accurate
  - Quicker / easier
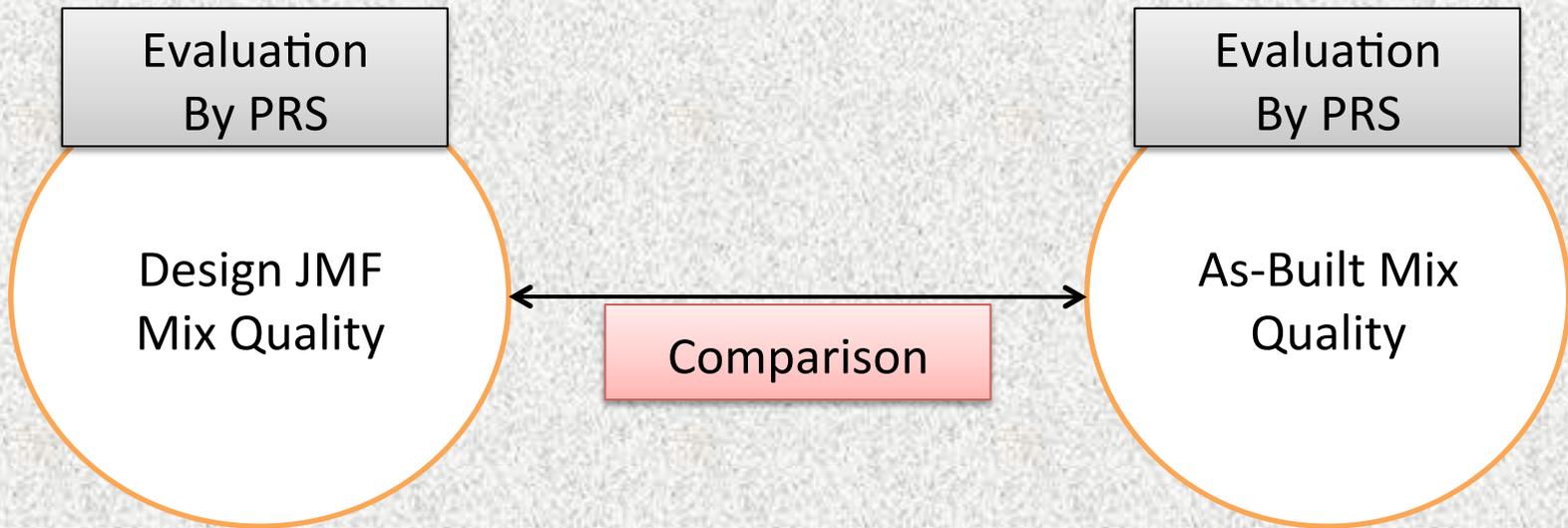 - Balanced with cost efficiency

QA Definition*

> *"All planned and systematic actions necessary to provide confidence that a product or facility will perform satisfactorily in service"*

*TRB, Glossary of Highway Quality Assurance Terms

Introduction to QRSS Software

- Quality Assurance (NCHRP 9-22)

Standard, Criteria

NCHRP 9-22 Characteristics

- Developed based upon Performance Related Specification (PRS)

- Incorporated three performance prediction models (MEPDG basis)

- Included major asphalt mix characterization properties: dynamic modulus and creep compliance

- Utilized stochastic methods: Monte Carlo simulation and Rosenblueth approach

- Used service life concept to describe the pavement quality

- Calculated pay factors from predicted service life differences

Existing method vs. proposed method

- 9-22 utilizes <u>mix volumetrics</u> in estimating dynamic modulus (E*) and creep compliance, and ultimately pavement performance

   *<u>Current:</u> Volumetric-Based Procedure*

- 9-22A <u>directly measures</u> E* and creep compliance from Simple Performance Test (SPT) equipment on field mix samples

    <u>Research:</u> Field-Based Procedure

General Comparison of Both Procedures

	Volumetric-based Procedure (9-22)	Field-based Procedure (9-22A)
Accuracy	Good	Better
E* and D Measurement	Use of Regression (Predictive) Models	Use of Actual Lab Test (E* and D Tests)
Supplemental Lab Test	Gradation Air voids Asphalt content Specific gravities	Air voids Asphalt Content Specific gravity (G_{mm})
Analysis Time	Faster	Fast
Software	QRSS (C# language basis)	PRS QA Computer Program (VBA – EXCEL basis)

How does a field-based method work?
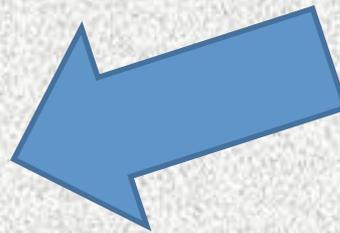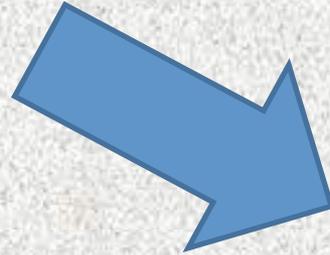
+ $ or -$

Considerations

- *Three main steps to get to pavement performance*
  1. **Obtain field mix during production**
     - Loose plant mix
     - Randomization (Sublots)
     - Field cores (<u>not on this job however</u>)

  2. **Manufacture test specimens in the lab with loose mix**
   - Simulation of field mix condition
     - Number of specimens

 3. **Conduct E* test**
   - Test condition (frequency and temperature)

Field-based Solution

- **Find *Mean and Variance of E* for As-Built Mix***
  - Manufacture Specimens w/ low and high air voids
  - Perform E* test at the SPT effective temperature and frequency
  - Develop an E^*_{eff} and air voids relationship
  - Separately for rutting and fatigue cracking
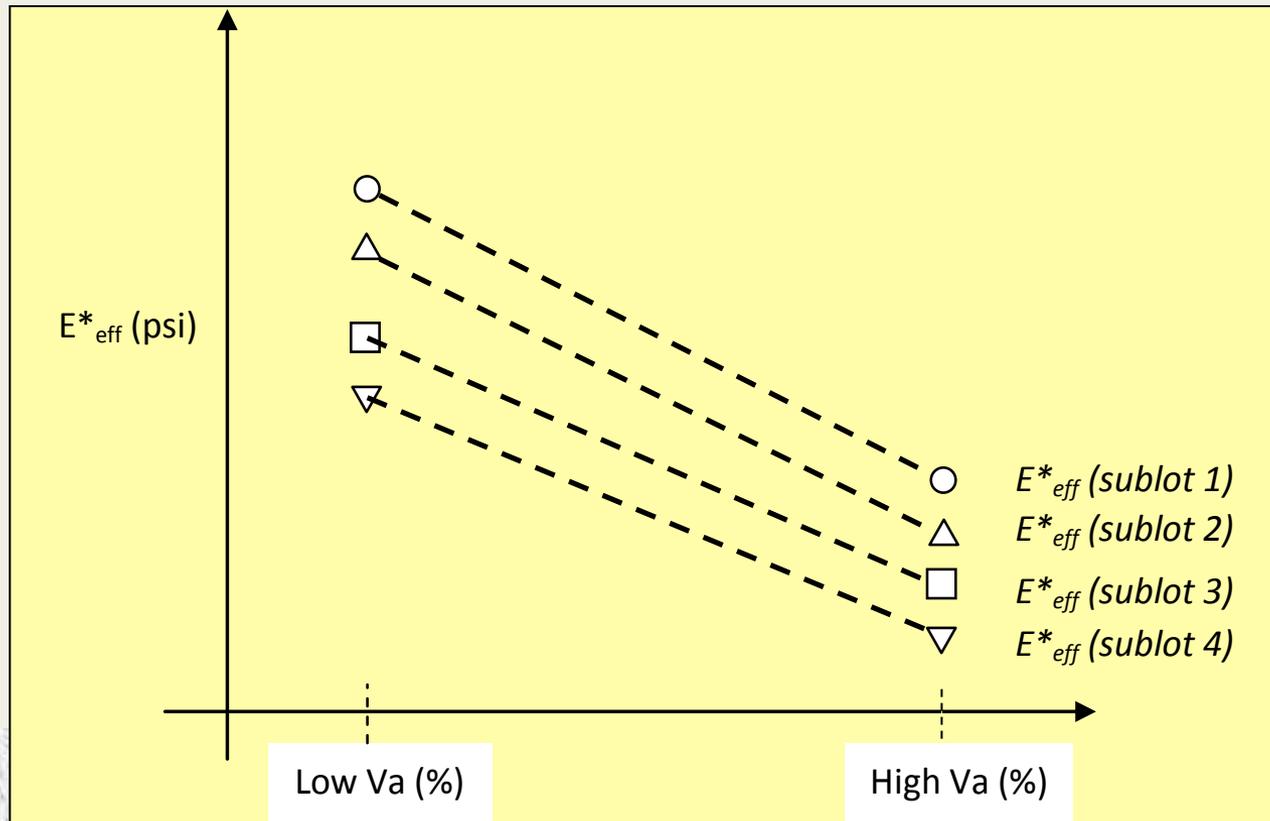
Comparison of Service Life (Each Lot) (As-Design Mix vs. As-Built Mix)
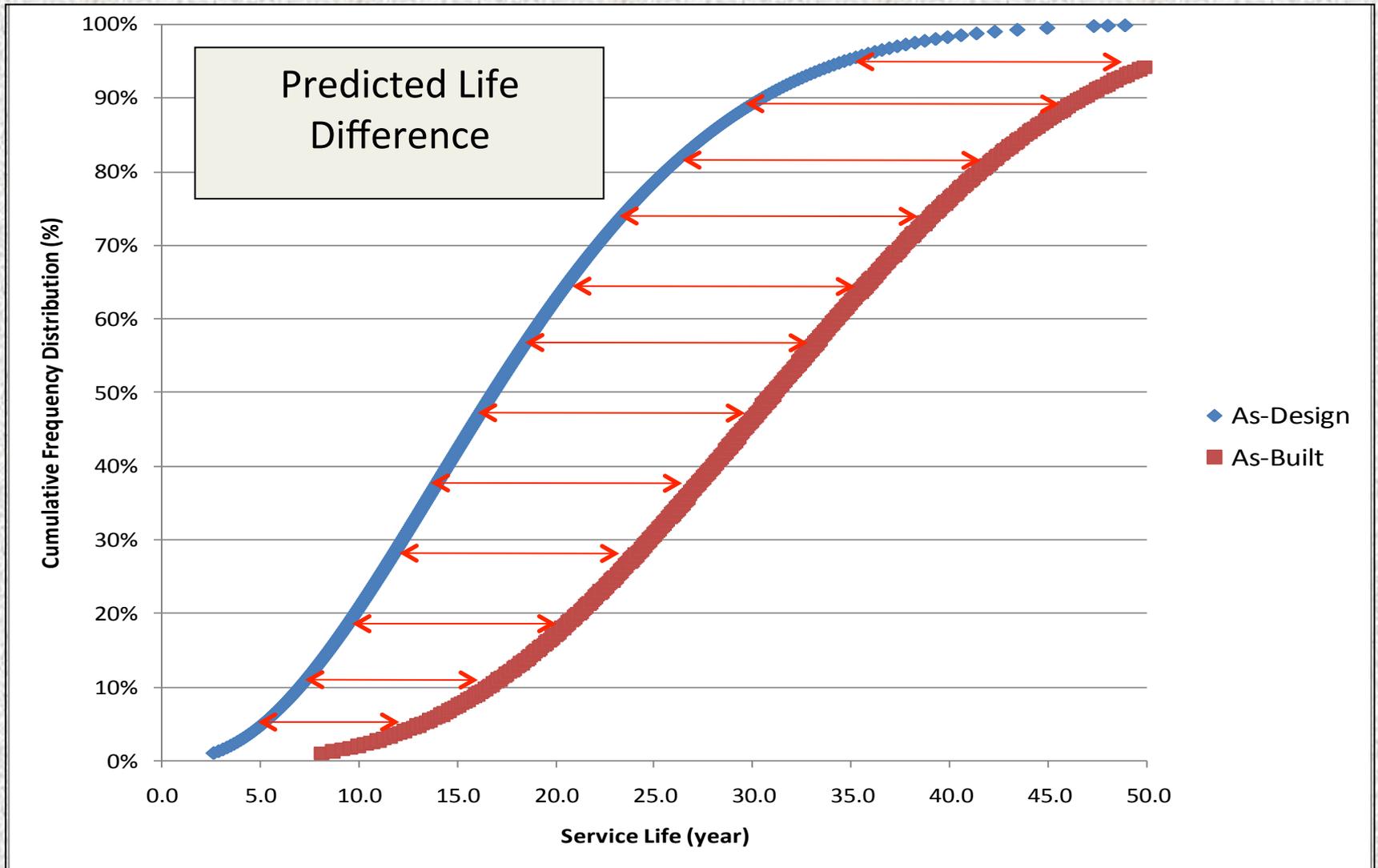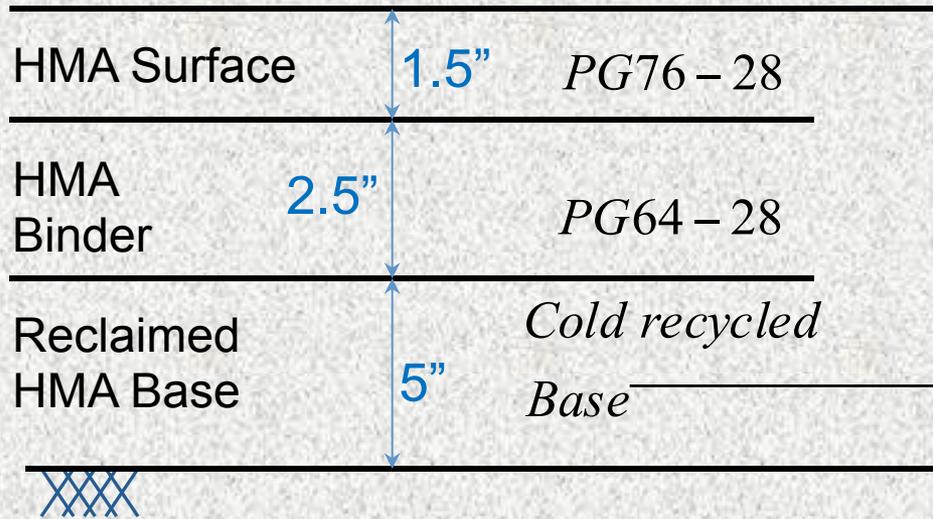
Computation of Pay Adjustment Factor (Each Lot)

Predicted Life Difference VS Penalty/Bonus Factor
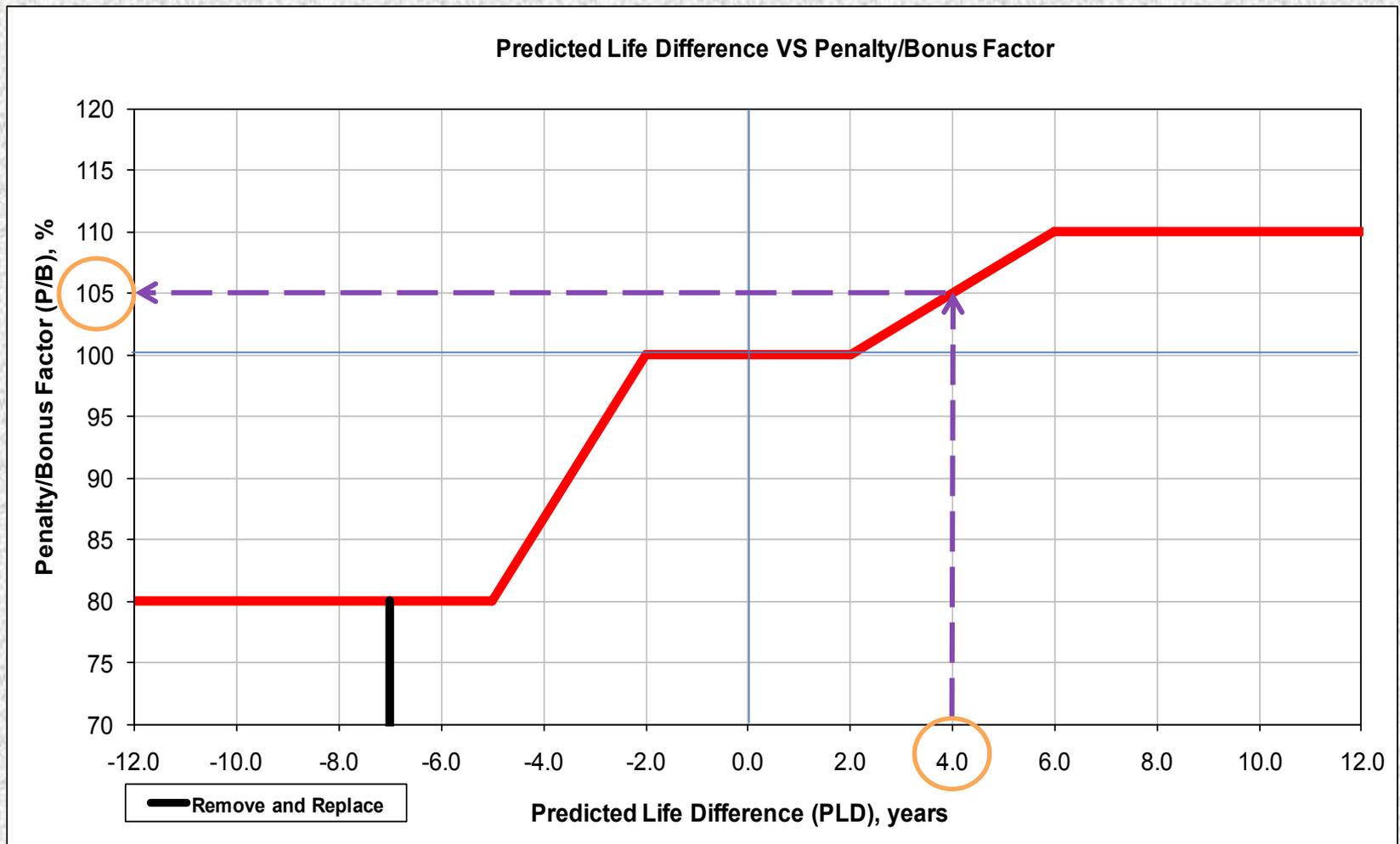
Field Validation in Northeast:
Rt 102 near Foster, Rhode Island

Preconstruction Operations

- Photographs of preconstruction condition

- Info on structural and performance history (from Pavement Management System at RIDOT)

- Info on contract cost estimates (from RIDOT Construction) & resources involved

- Info on JMF mix design, QA plan, specs, etc. (from RIDOT Materials)

Pavement Structure & Data

	1.5"	$PG76-28$
HMA Surface		

HMA Surface — 1.5" — $PG76-28$

HMA Binder — 2.5" — $PG64-28$

Reclaimed HMA Base — 5" — *Cold recycled Base*

	RI DOT Pavement Management System	RI DOT Construction	QA (RIDOT Materials)
RI 102 2010-CR-009	HPMS Project Length 1.2 mi. Crack Seal History Maintenance History/Costs Traffic Information (ADT) 3500 Year 1 daily ESALs 602	Bid package $###,### Final cost info	Structural Design Creep compliance results SPT test results QA data JMF Sample collection

	Traffic	Structure	Climate	Limits	QA/QC
RI 102 2010-CR-009	☒Design Speed ☒Growth rate unless specified, use 4% ☒Design Life 20 ☒Year 1 Daily ESALs 16,811	☒Thickness 1.5" surface, 2.5" base, 5" reclaimed base ☒Subgrade information FWD data ☒Design air-voids 4% ☒AC by Wt 19mm 5.3%, 9.5mm 6.7% ☒Binder Type surface 76-28 base 64-28 ☒Gb 1.03 ☒Design gradation ☒Target in-situ air-voids unless specified, use 7% ☒Target in-situ Gsb ☒Target in-situ Gmm ☐E* data (from AMEC) ☐Creep compliance data (from AMEC)	☒Location, Interpolation	☒Rutting 0.5" ☒Fatigue 25% ☒Thermal 2000 ft/mi Weighting factors, unless otherwise noted: 10 Rut 80 Fatigue 10 Thermal	☐Tonnage ☐Gradation ☐AC content ☐Gmm ☐In-situ Bulk Density ☐In-situ air-voids ☐Thickness ☐Gsb ☐E* from plant mix (AMEC) ☐Creep data from plant mix (AMEC)

Other Rt. 102 Data: QRSS Required Inputs

Why do we want to generate an estimate of cost to the Contractor & the DOT?

Is this field-based QRS approach going to be cost effective for both industry and state ?

Materials Quantities Collected

- Raw JMF Materials

  a) One 5-gallon bucket of baghouse fines

  b) Six 1-gallon cans of liquid binder

  c) Ten buckets of aggregate, per lift

    - Split on proportions in JMF

Use to replicate the mix design
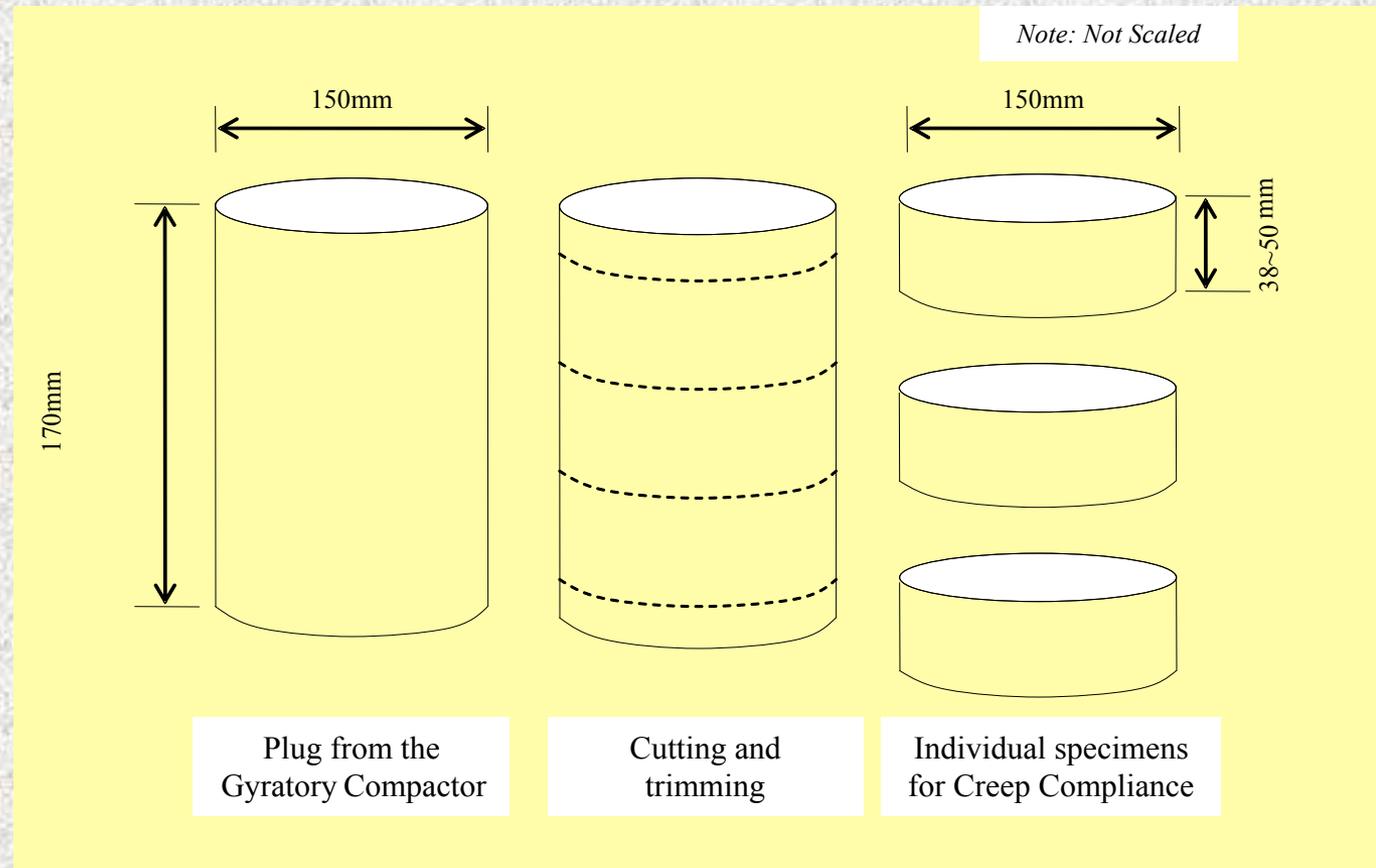Test in SPT

Materials Quantities Collected

- Field mix

  a) 5 Lots from each AC pavement layer

  b) 4 sublots from each Lot (4 samples per day)

- 50 buckets: 20 for base, 30 for surface lift

- Totals ~ 2500 lbs

  of hot mix

Compact and test in SPT

Prediction of potential thermal cracking

- *Obtain in-place Air Voids (mean and variance)*
- *Manufacture three plugs w/ air voids of*
  - *μ - 1.2 σ*
  - *μ*
  - *μ + 1.2 σ*

Note: Not Scaled

150mm

150mm

170mm

38~50 mm

| Plug from the Gyratory Compactor | Cutting and trimming | Individual specimens for Creep Compliance |

Test Matrix for Thermal Cracking

- *Creep Compliance Test*

In-place Va

$$\mu - 1.2\,\sigma \qquad\qquad \mu \qquad\qquad \mu + 1.2\,\sigma$$

Test Temp.

-20°C
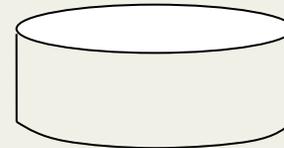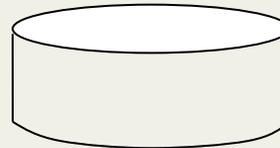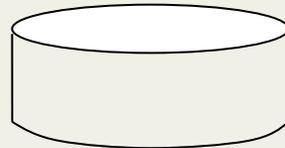
-10°C
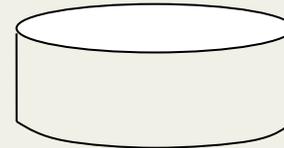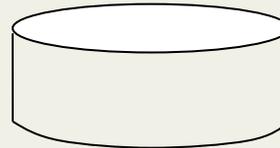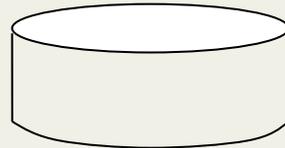
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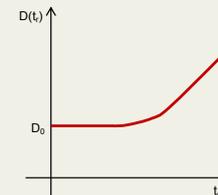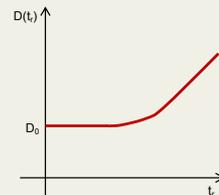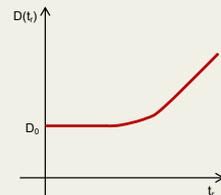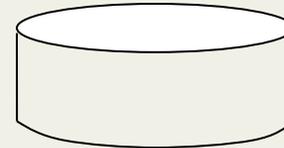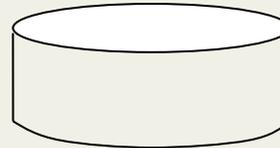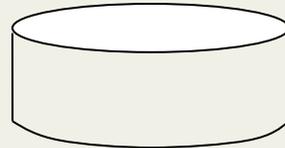
Post Construction Operations

- Ship raw materials & field mix to AMEC

- Average thickness of each lift paved

- **RI DOT:** FWD testing after completion of each layer (i.e., after reclaimed HMA base, after AC binder lift, then after AC surface placed)

- **RI DOT:** IRI at completion of construction (partner with Mass Highway)

Next Steps

- Estimate cost to RI DOT for implementing field-based QRS:
  - DOT QA cost / subcontracts to materials labs
  - Lab certification costs
  - Sampling
  - Density testing in field (nuclear gauge??)
  - Labor/cost for SPT testing
    - SPT equipment
    - Coring device
    - Environmental chamber
    - Labor/cost for SPT testing

Next Steps

1. JMF replication done at AMEC labs
2. Materials & SPT testing done at AMEC labs
3. Analysis using 9-22 QRSS software done at Villanova
4. Analysis using SPT-methodology software done at Villanova
5. Performance and pay factors (bonus, penalty) for Rt 102 job predicted & presented to RI DOT

THANK YOU, NESMEA & NEAUPG!!

Ed Harrigan, NCHRP

Jim Moulthrop, Fugro

Matt Witzcak, AMEC

Myung Goo Jeong, AMEC

Narragansett Improvement

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