Bituminous Materials in Military Applications

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INTRODUCTION

IMPROVED LONGITUDINAL JOINTS

FUEL RESISTANT ASPHALT

HIGHLY MODIFIED ASPHALT

INDUCTIVE HOT MIX ASPHALT (IHMA)

PERFORMANCE BASED SELECTION OF SURFACE TREATMENTS

SUMMARY

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INTRODUCTION

- Military Operations Around the World Require High Quality Paving Materials to Support Unique Military Vehicles and Aircraft in Challenging Environments
- High Tire Pressure (350 psi) and Heavy Wheel Loads (45-kips)
- Sustained Exposure to Petroleum, Oils, and Lubricants (POL) and High Heat
- Rapid Maintenance and Repair of Deteriorated Flexible Pavements
- Unique Challenges Driving Move to Exotic Materials




IMPROVED LONGITUDINAL JOINTS

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IMPROVED LONGITUDINAL JOINTS

- Objective: Improve Specifications Currently Used for Paving Longitudinal Joints of HMA
  - Document Best Practices for Construction of Longitudinal Joints
  - Evaluate Lab and Field Testing Protocols to Assess Quality of Longitudinal Joints
  - Monitor Performance of Constructed Longitudinal Joints
  - Provide Recommendations to Improve Specifications

- Tasks:
  - Review Alternative Longitudinal Joint Construction Techniques
  - Establish Laboratory Approach for Testing Longitudinal Joints
  - Evaluate Methods in a Field Test
  - Compare Performance

LONGITUDINAL JOINT CONSTRUCTION PRACTICES

- Construction techniques
- Cut-back joints
- Adhesive products
- Joint compaction
- Paving overlap and thickness
- Alternative construction tools







TEST SECTION CONSTRUCTION – CANNON AFB

TEST SECTION CONSTRUCTION – CANNON AFB

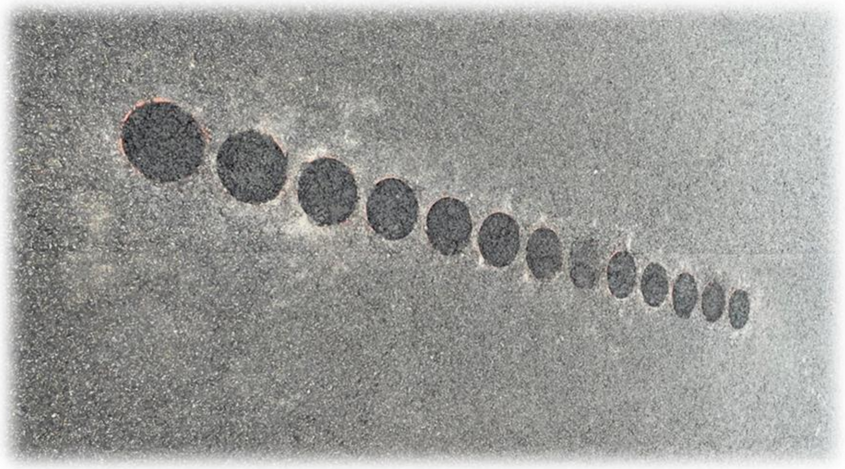
ID	Type	Temp	Cutting	Product	Screed Overlap*	Raking the Joint
L1	Butt	IR	---	Tack	1.5”-2”	Rake
L2	Cutback	IR	Cutting Wheel	Tack	1.5”-2”	Rake
L3	Cutback	IR	Cutting Wheel	Tack	1.5”-2”	Rake
L4	Cutback	Cold	Cutting Wheel	Tack	1.5”-2”	Rake
L5	Cutback	Cold	Cutting Wheel	Crafco	1.5”-2”	Rake
L6	Cutback	Cold	Cutting Wheel	VRAM	1.5”-2”	Rake
L7	Butt	Cold	---	VRAM	1.5”-2”	Rake
L8	Butt	Warm (Below 150 F)	---	Tack	1.5”-2”	Rake
R1	Notched Wedge	Cold	---	Tack	1.5”-2”	Rake
R2	Butt	Cold	---	Tack	Less than 1"	Do not Rake
R3	Butt	Cold	---	Tack	1.5”-2”	Rake
R4	Cutback	Cold	Cutting Wheel	Tack	Less than 1"	Do not Rake
R5	Cutback	Cold	Cutting Wheel	Tack	1.5”-2”	Do not Rake
R6	Cutback	Cold	Standard Milling	Tack	1.5”-2”	Rake
R7	Cutback	Cold	Micro Milling	Tack	1.5”-2”	Rake
R8	Butt	Hot (Above 200 F)	---	Tack	1.5”-2”	Rake

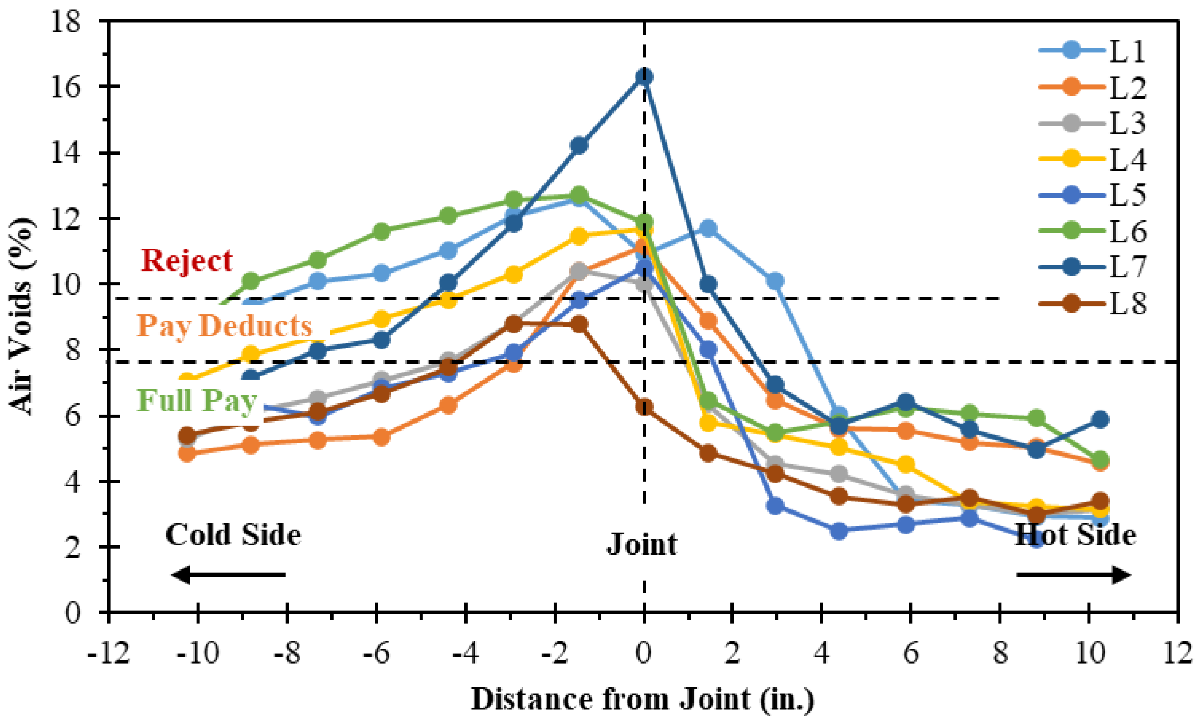
High Level Assessment Based on In-Place Density

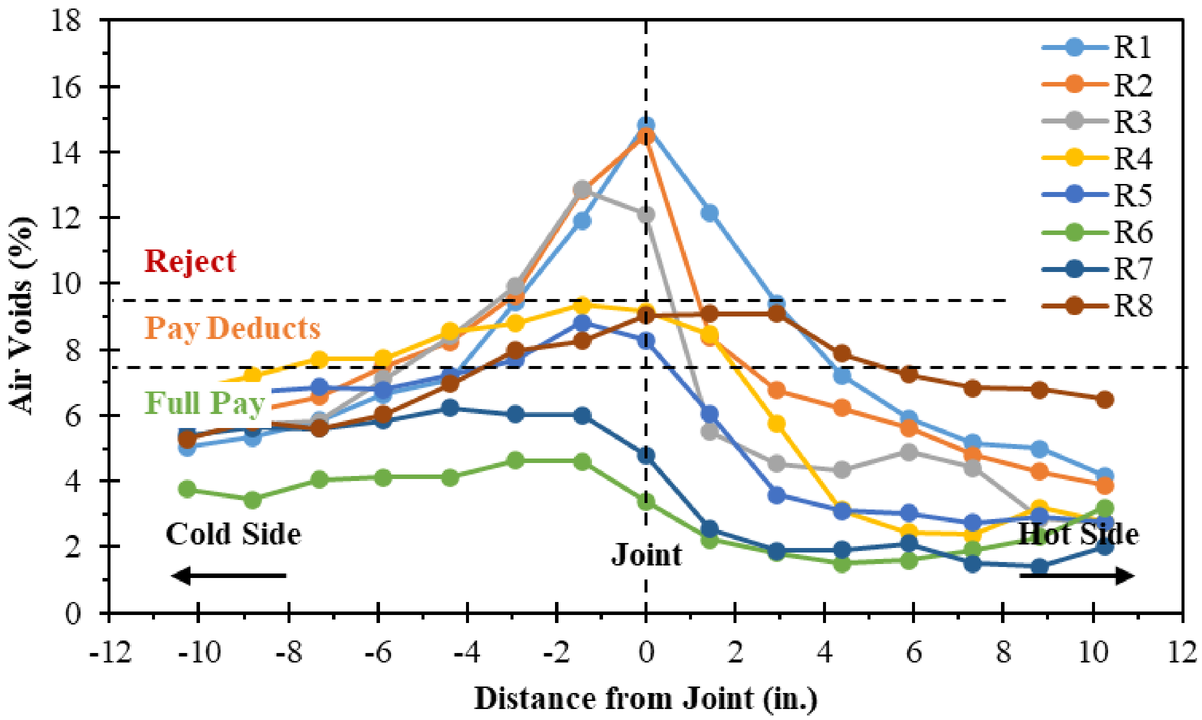
Good	Moderate	Poor
L8	L2	R1
R6	L3	R2
R7	L4	R3
	L5	L1
	R4	L6
	R5	L7
	R8	

LABORATORY EVALUATION

- Measured Density Gradient Across Joint Sections
  - Best Densities Achieved:
    - Warm Butt joint (L8) and
    - Milled joints (R6 and R7)
  - Current Practices (L4) Yielded Poor Densities







FUEL RESISTANT ASPHALT

FUEL RESISTANT ASPHALT

- Objective: Evaluate the Design and Performance of Fuel Resistant Asphalt (FRA)
  - Quantify Value as Purpose-specific Material
  - Create More Confidence in Specification and Use

- Tasks:
  - Evaluate FRA Projects During Construction
  - Perform Critical Review of Past Projects
  - Conduct Lab Testing on FRA Materials
    - Plant Mixed Asphalt – Perform Thorough Performance Characterization
    - Lab Mixed Asphalt – Allow for Adjustments to Mixture Formulations
  - Prepare Modifications to DOD Criteria for FRA

EVALUATING CURRENT SPECIFICATIONS

- Fuel Resistance Currently Assessed Based on Mass Loss Due to Fuel Immersion
  - No Comprehensive Assessment of Fuel Resistance Test Methods in Literature
  - Needed to Understand Sensitivity/Effectiveness of Fuel Resistance Characterization

- UFGS 32 12 17.19 Fuel Resistant Asphalt Paving for Airfields – Fuel Mass Loss (FML)
  - Test (3) specimens compacted at optimum binder content, 2.5% $\pm$ 0.7% V_a
  - 24-hour kerosene immersion
  - 24-hour drying under fan
  - Calculate % Mass loss using weight before kerosene soak and weight after soak and drying
  - Mass loss must be less than 1.5%

IMPROVING CURRENT SPECIFICATIONS

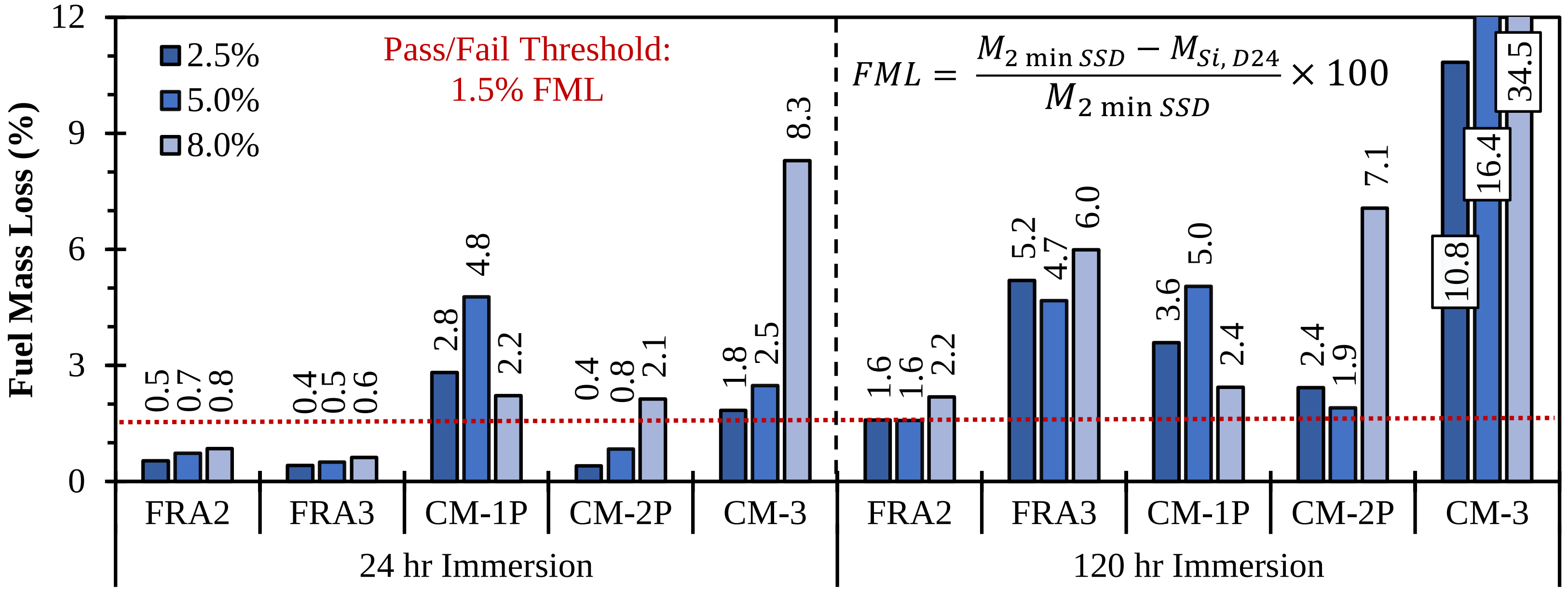
- Evaluate test parameters (i.e. fuel used, length of soak, inclusion of drying time) and benchmark FRA mixtures against other airfield mixtures

Fuel Type	Soak Time	Dry Time	Asphalt Mix
• Kerosene (Jet A) • AVGas • ROYCO 899	• 24 hours • 120 hours	• 0 hours • 24 hours	• 4 FRA • 3 conventional polymer modified (CM-#P) • 1 unmodified (CM-#)

IMPROVING CURRENT SPECIFICATIONS

- Following current FRA test methods outlined in UFGS 32 12 17.19
  - At 2.5% V_a, all FRA and (1) CM-#P Mix (PG 76-22) Meet Criteria
    - Can Mix using PG 76-22 be considered fuel resistant if meeting FML criteria?
  - FRA Mixes Meet Criteria at All V_a Levels
    - Can design V_a level be changed to more traditional 4.0%?

- Longer Immersion, Greater Differentiation Between FRA Mixes and Conventional Mixes
  - More Appropriate and Effective?



IMPROVING CURRENT SPECIFICATIONS

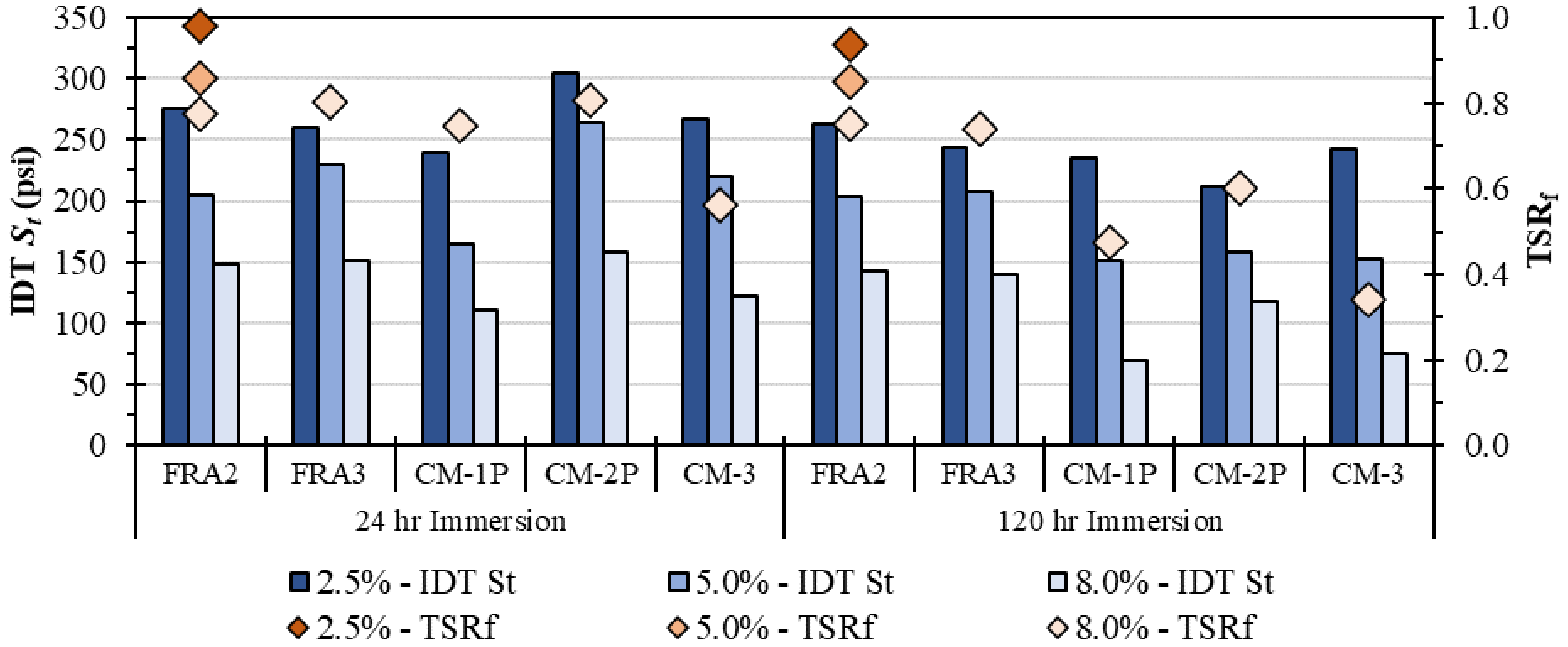
- Fuel exposure causes long-term damage to asphalt binder after drying or fuel evaporating
  - FML yields visible and quantifiable damage to mix
  - FML does not address effects of fuel damage to mechanical properties of mix
  - Include mechanical testing to understand extent of mixture’s ability to resist damage due to fuel exposure

- Mechanical tests considered:
  - I-FIT and DCT – mixture cracking resistance
  - APA – mixture rutting resistance
  - Cantabro – mixture durability
  - IDT – mixture moisture/fuel resistance

IDT emerged as most promising and simplest to integrate (benefits from familiarity)

IMPROVING CURRENT SPECIFICATIONS

- Establish Minimum Fuel-soaked Strength and Tensile Strength Ratio (TSR_f):
  - IDT Results Follow Rational Trends, Supporting Validity
  - TSR_f Indicates Mixtures Accumulate More Damage at Higher Va Levels
  - TSR_f Distinguished FRA Mixes and CM Mixes after 120-hr Immersion
  - Mechanical Testing Refutes Assumption No Mass Loss = No Damage



HIGHLY MODIFIED ASPHALT

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HIGHLY MODIFIED ASPHALT

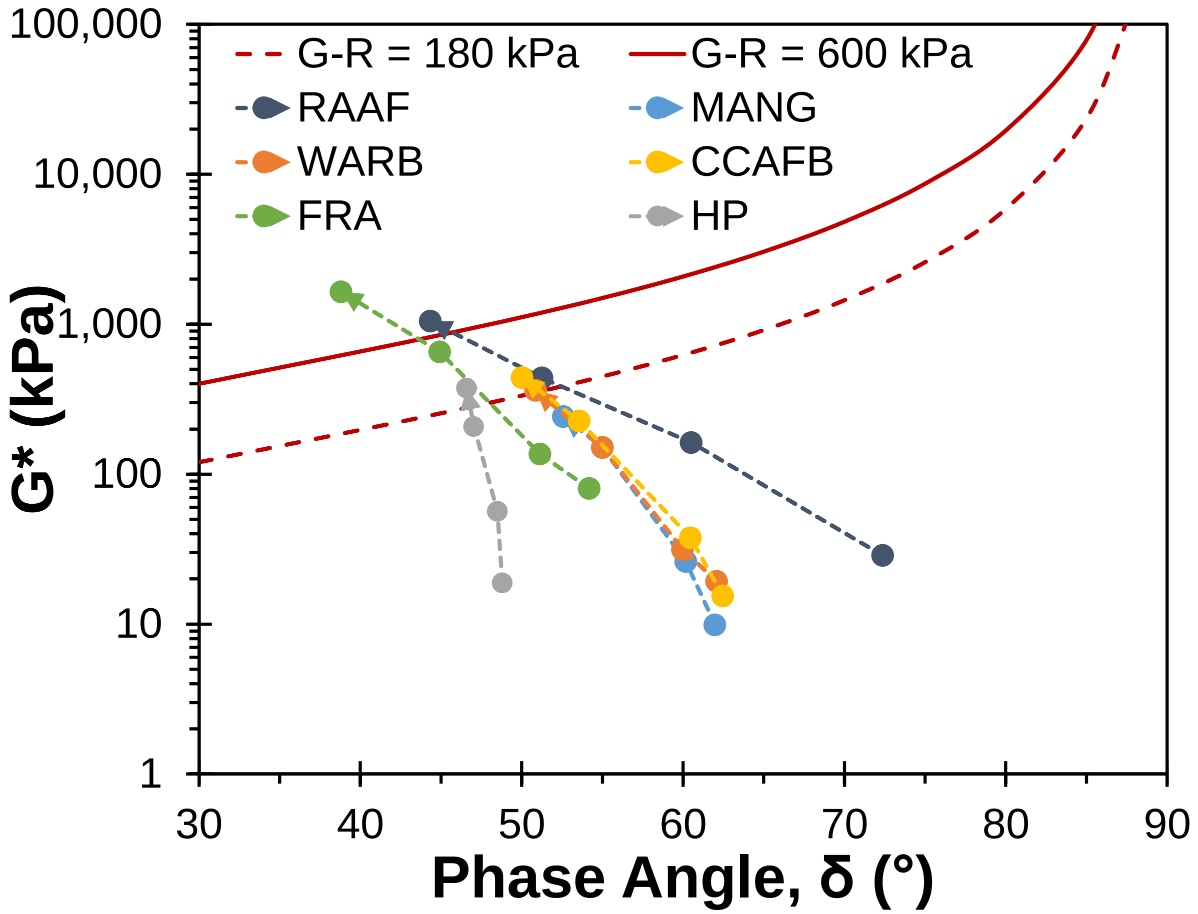
Objective: Develop Guidance for the Use of Highly Modified Asphalt Mixtures

- Review existing DOT Specifications and Literature
- Lab Evaluation of Binders and Plant Mix Samples from DOT Projects
- Lab Evaluation of Lab-prepared Mixes following UFGS Requirements
- Quantify Structural Benefits and Environmental Service Life Advantages
    - Dynamic Modulus, PCASE/FAARFIELD analysis
    - Resistance to Aging
- Specification Development

LABORATORY BINDER EVALUATION

- Emphasizing Rutting Properties for Their Obvious Benefit but Also Heavily Emphasizing Environmental Durability/Aging Characteristics

- Data to Date Illustrates Benefits of HP Binder with the PG 76E-28 (HP)



JBER ASSESSMENT

- Groove Collapse/Scuffing Occurred where C-17 was Towed on Apron
- Pavement Grooved at 7 days, not 28
- Utilized PG 64E-40

INDUCTIVE HOT MIX ASPHALT

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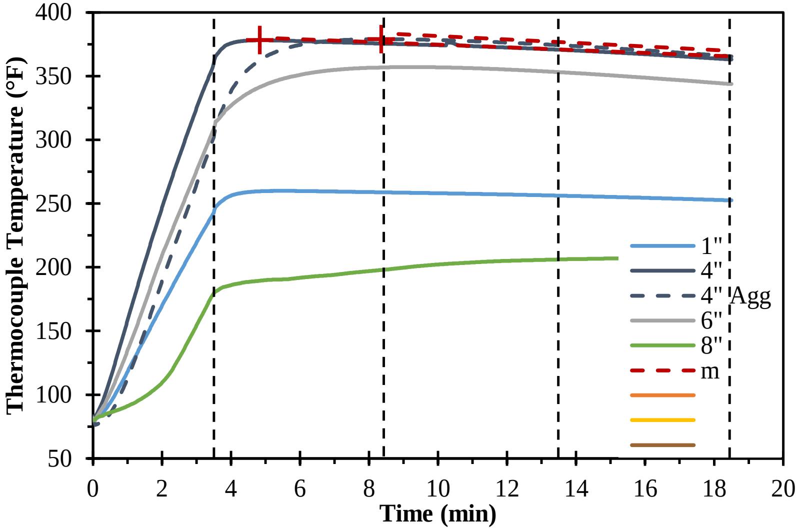
INDUCTIVE HOT MIX ASPHALT

Objective: Develop and Refine Inductively Heated Hot Mix Asphalt for Pavement Repair

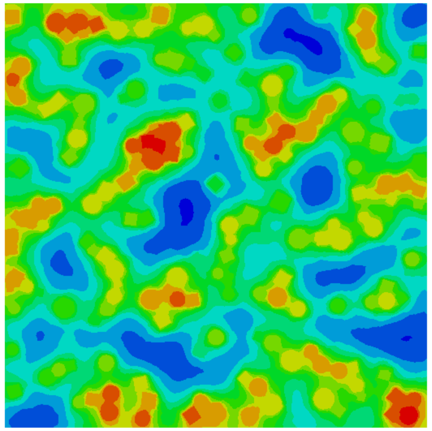
- Optimize Heating Performance
  - Conventional steel aggregate-based mixes
  - Alternative heating elements (e.g. steel rods, graphite rods, carbon fiber flakes, magnetite)
  - Modeling and physical experiments
- Optimize Mix Design and Performance Characteristics
  - Lab mix design and testing
  - Plant production of iHMA in partnership with NecoTech
- Optimize Full-scale Field Processes
  - Portable tack coat sprayer and heater
  - Hoist for loading mix into iHMA heater
  - Evaluate limits with respect to logistics
- Assess Long-term Durability Performance

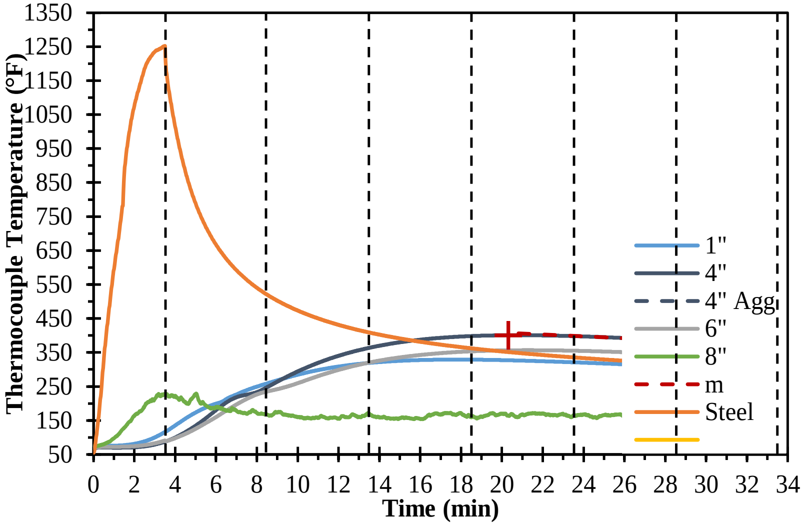
HEATING OPTIMIZATION

- Evaluated numerous low-cost alternatives such as rebar
- Difficult to regulate localized temperature at safe levels near areas where steel is concentrated

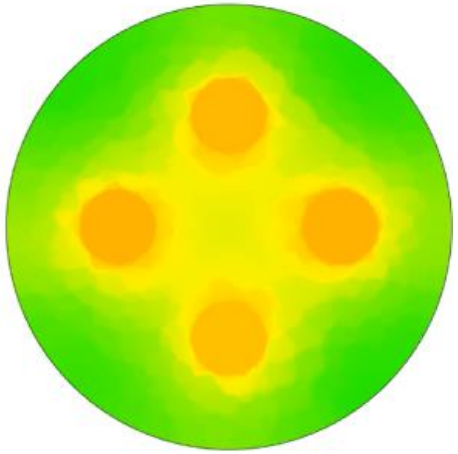


Control (15% Steel Agg)



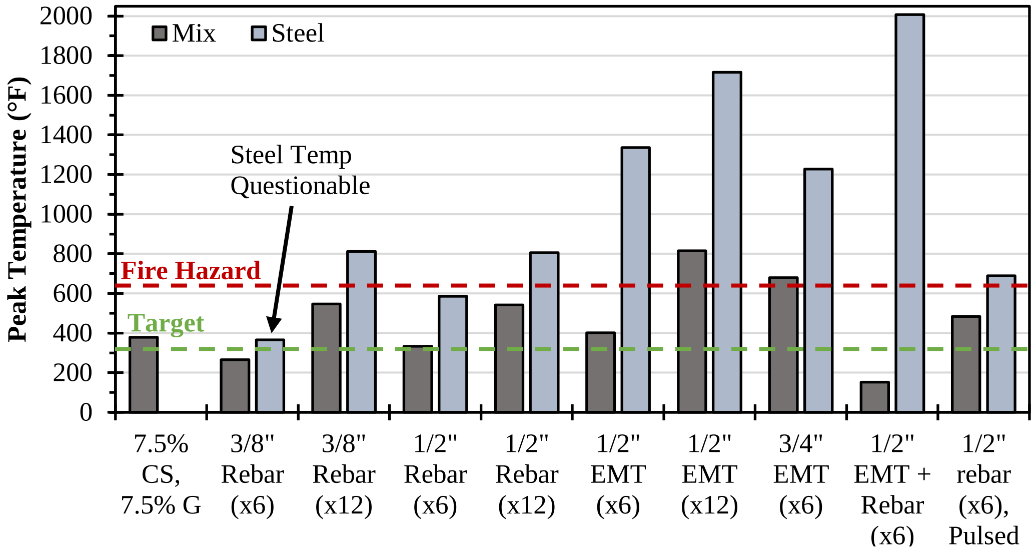


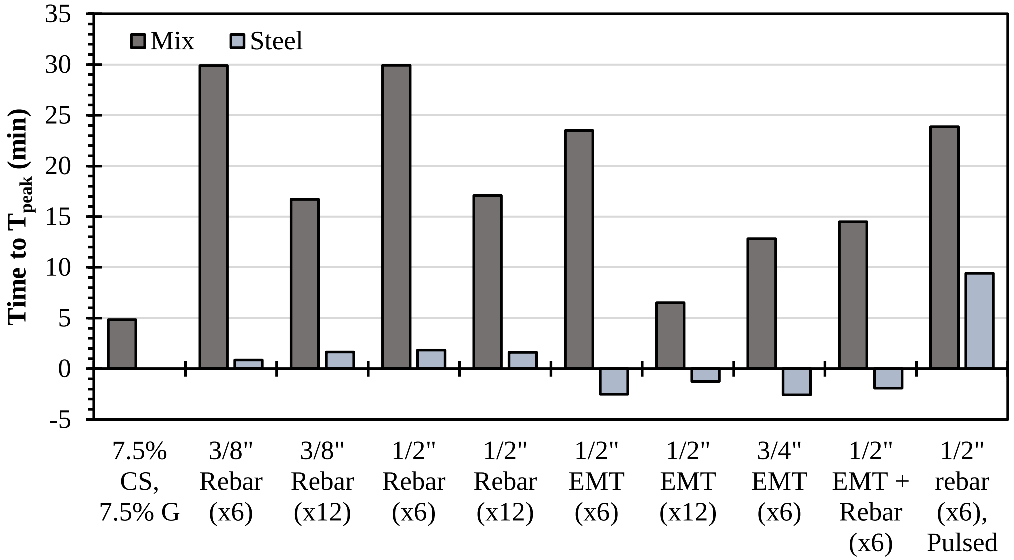
Alternative (1/2" Conduit)



HEATING OPTIMIZATION

- Control Mix with 15% Steel Aggregate Peaks at 379°F at 5 minutes Post-heating
- Alternative Heating Approaches:
  - Exceeded safe temperature limits
  - Required excessive time to heat mix uniformly
  - Reduced voltage (2/3 of full capacity) reduced T_{peak} values to roughly 65%
- Most Promising Alternative Approach was to Utilize a Pulsed Heating Cycle that Limited Steel Temperature to 650°F
  - Still presents safety concerns
  - Complex programming and feedback loop that would be challenging to implement in practice





MIX DESIGN AND CHARACTERIZATION

- Volumetric Mix Design and Performance Characterization Performed at ERDC, Provided to NecoTech for Full-scale Plant Production
- Received 200+ iHMA Containers from NecoTech to Date
- Conducted QC Characterization of Production Lots

FIELD PATCHING OPTIMIZATION

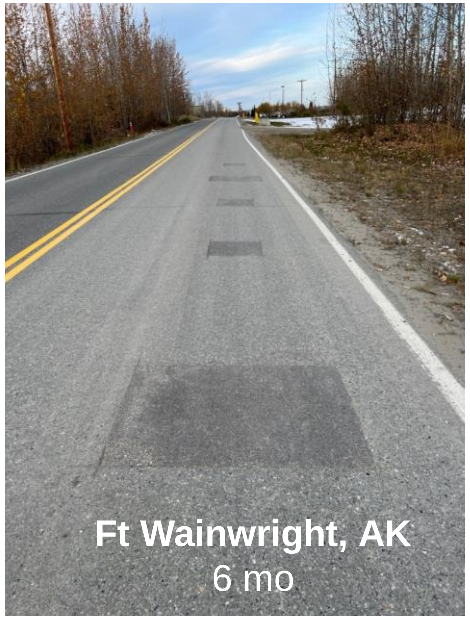
- Portable Constant-pressure Tack Coat Sprayer Developed for Uniform Application
- Includes Heated Storage Pot

FIELD PATCHING OPTIMIZATION

- Installed Hoist System for Loading Tubes

FIELD PATCHING OPTIMIZATION

- 128 iHMA Tubes Placed to Date
- Demonstrated Placement of 10 Tubes in Alaska
- Demonstrated “Centralized” Heating at “Shop” Coupled with Patching at Satellite Locations



LONG-TERM MONITORING

- Original iHMA Patches at ERDC Jan 2018 (~6 yr)

PERFORMANCE BASED SELECTION OF SURFACE TREATMENTS

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SURFACE TREATMENT SELECTION

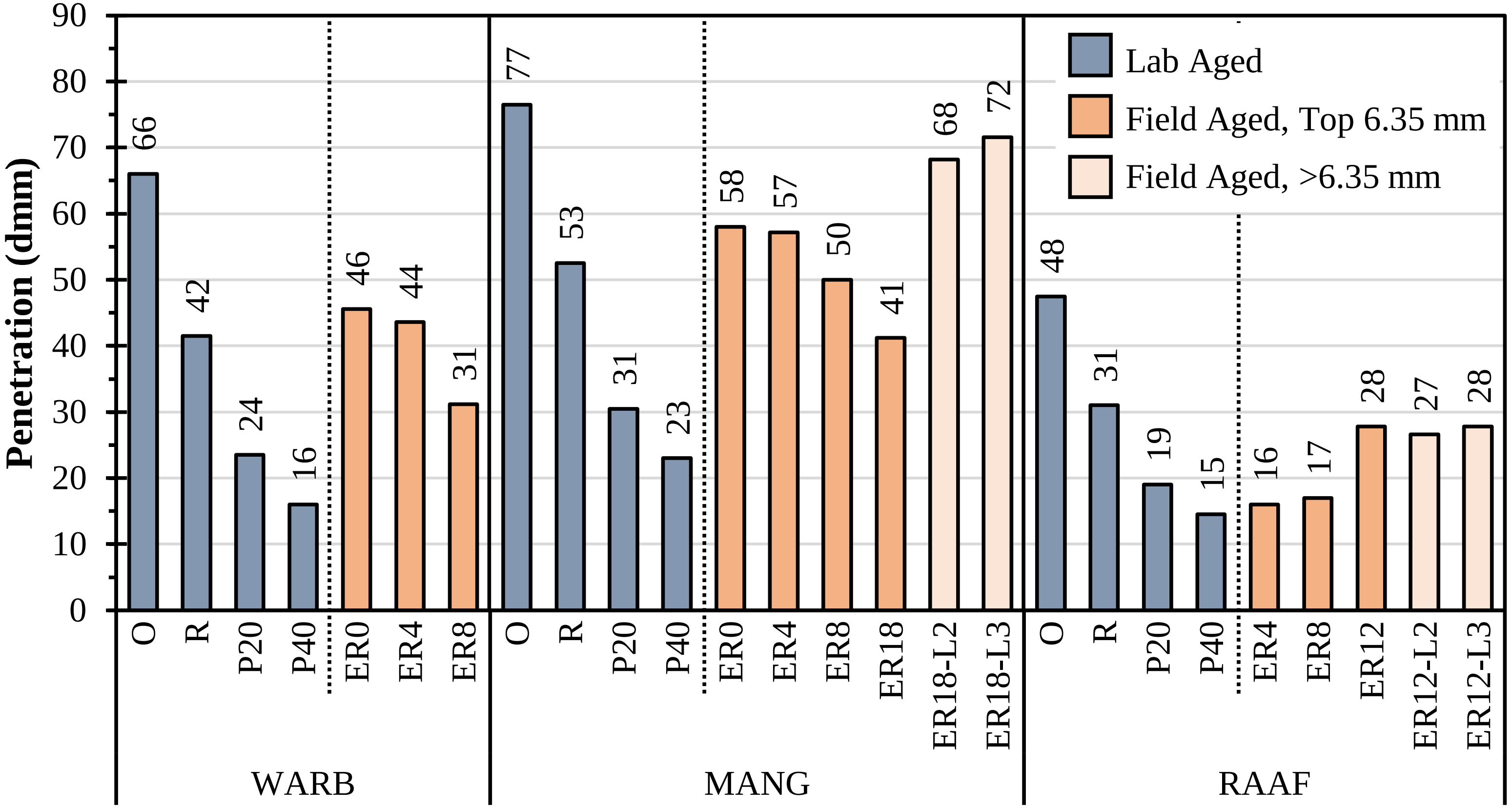
- True pavement preservation occurs before visible distresses emerge
  - What indicates need for preservation if not visible distresses?
  - How quickly after construction does meaningful oxidation occur?
  - To what degree do rejuvenators reverse the effects of oxidation?
  - To what degree do seal treatments prevent further progression of oxidation?
- How are surface treatments currently evaluated/approved for use on military airfields?
  - Empirical evidence of quality performance
  - Field friction testing
  - Laboratory testing of extracted and recovered (ER) asphalt binder (Rejuvenators only)
- Need quantitative method to approve/classify products
  - Measures impacts of product application to underlying pavement
  - Predicts life extension expected due to surface treatment application

INFORMING TIMING OF SURFACE TREATMENTS

- Oxidation in Top 6.3 mm Yielded Results Similar to 20-hour PAV (simulates 7-10 years) at Final Aging Assessment (12 to 18 months)

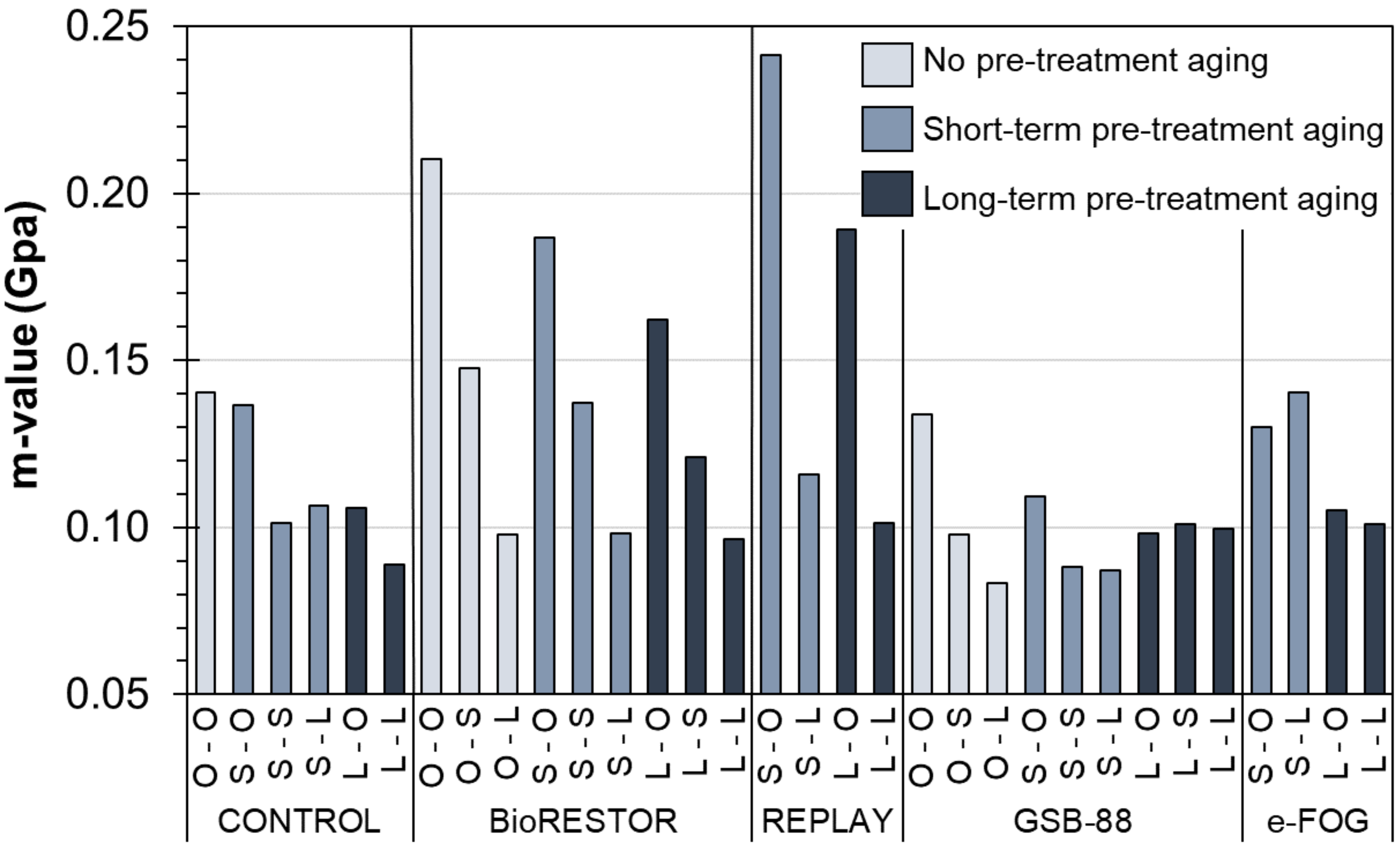
- Depths Greater than 6.3 mm: Aging Most Similar to RTFO (represents aging after production & construction)

- Within 18 months, degree of aging in Top 6.3 mm corresponds to 1 to 2 PG grade increases
  - PG 70-XX to PG 76-XX
  - Limited to top 6.3 mm of pavement structure



SELECTING SPECIFICATION TEST METHODS

- Similar Trends Observed Comparing BBR Beam Results to ER Binder Test Results
- BBR Beams Eliminate Concerns Associated with ER process and Blending Product with Asphalt Binder
- Changes in m-value Compared to Control Can be Used to Approve/Classify Products

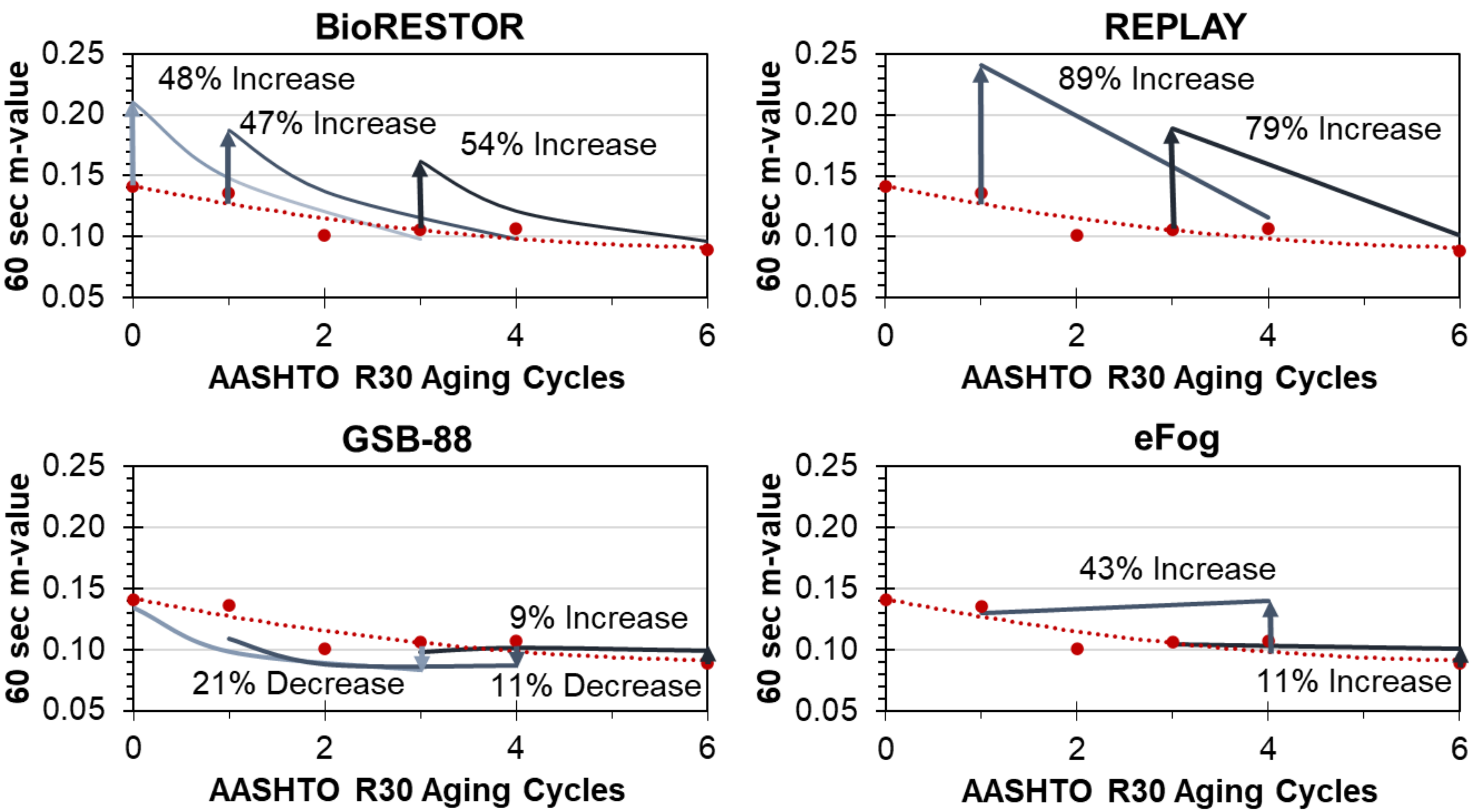


DEVELOPING SPECIFICATION CRITERIA

- Provide Insight on Immediate Benefits and Duration of Benefits to Underlying Pavement

- Expect Rejuvenator to Increase m-value:
  - Accept by initial change
  - > 25% increase across all pre-treatment ages
  - Classify by % initial increase or duration of benefit

- Expect Fog Seal to Slow Changes in m-value:
  - Accept by reduced change over time
  - > 20% increase compared to control after (3) R30
  - Classify by % increase from control after aging



SUMMARY

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SUMMARY

- Unique Challenges Forcing Routine Use of Premium Asphalt Materials
- Construction of Longitudinal Joints Key to Extended Service Life and Traditional Joint Construction Techniques are Inferior to Milled and Hot Butt Joints
- Mechanical Testing such as IDT Provides Improved Ability to Differentiate Performance of Fuel Resistant Asphalts Compared to Mass Loss Methods
- Highly Modified Binders Promise Improved Performance But Require Further Study to Refine Mix Design and Construction Specifications
- Inductive Hot Mix Asphalt Demonstrated Excellent Performance in Terms of Rutting Resistance and Environmental Degradation
- The m-value from BBR Tests Demonstrates an Ability to Distinguish Effect of Different Types of Surface Treatments and an Ability to Delay Near-Surface Oxidation

THANK YOU FOR YOUR TIME

QUESTIONS?

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