Development of a Modified High Performance Thin Overlay HMA for NJDOT

Thomas Bennert
Center for Advanced Infrastructure and Transportation (CAIT)
Rutgers University, NJ

Association of Modified Asphalt Producers (AMAP)
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NJ's Thin-Lift Requirements

- New Jersey requirements
  - Thin-lift ≤ 25mm thick (Ideally)
    - Minimal change to existing infrastructure (bridge clearances, drainage, etc.)
  - Minimal Impact to Users (Coverage vs Unit Time)
  - Re-new and upgrade road surface
    - Ride Quality (Smoothness)
  - No "Cure-time" dependent materials (i.e. – cold applications)
    - Typical high ESAL's limit use

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High Performance Thin-Overlay

- **Focused Applications**
  - Preventative Maintenance – NJDOT
    - Placed after signs of initial surface distress
    - Also potential use of "Shim" course on PCC prior to Wearing Course
  - Pavement Overlay – Locals/Municipalities
    - Place immediately on surface of pavements showing signs of surface distress with or without milling
      - Low severity wheelpath alligator cracking (base issues)
      - Surface cracking with minimal rutting

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Potential Areas of Application

Low Severity Wheelpath

Low to Mod. Longitudinal Cracking

Low to Mod. Transverse Cracking

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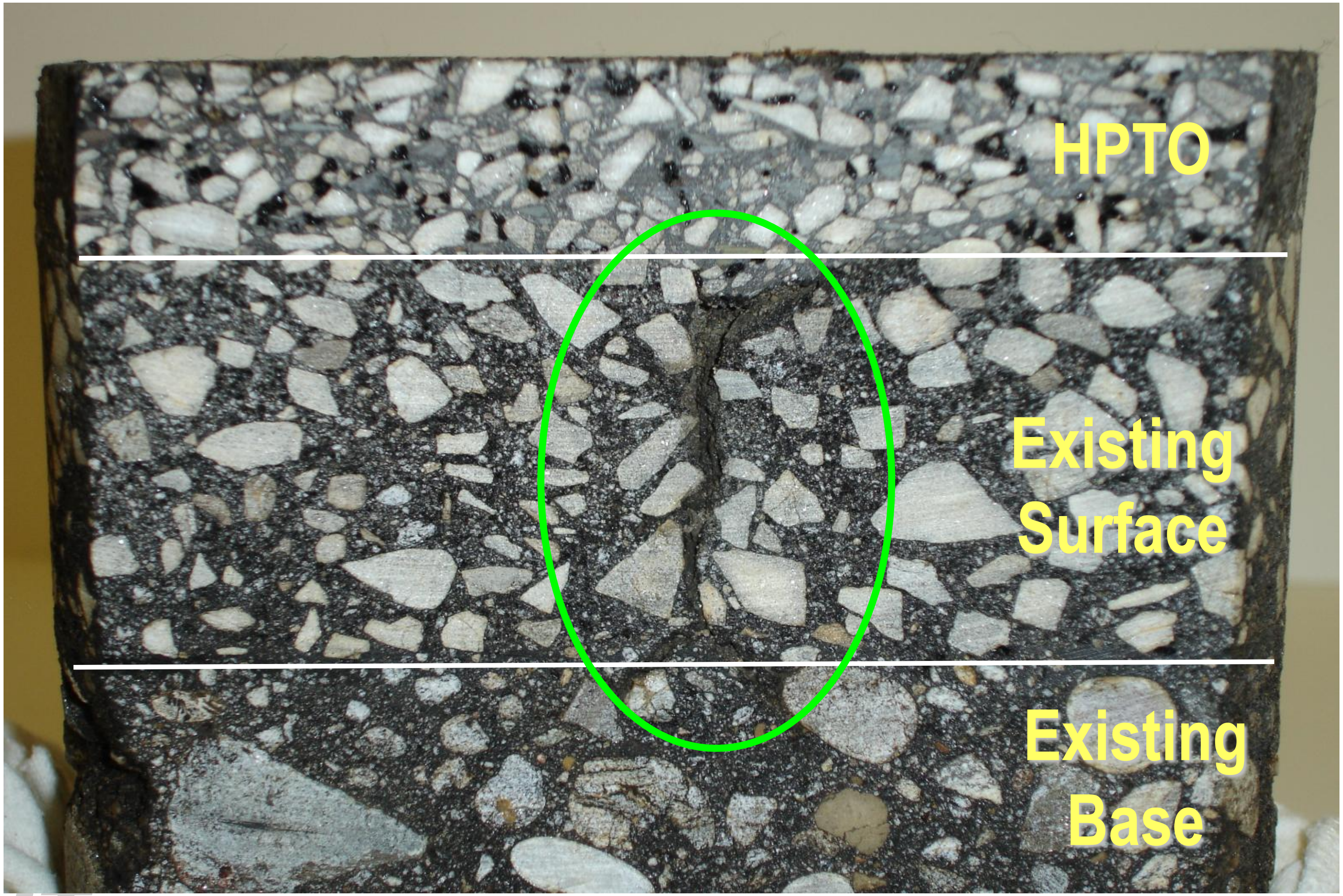
Direct Overlay – No Milling



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High Performance Thin-Overlay

Job Mix Formula Requirements	
Sieve Size	Percent Passing
3/8"	100
#4	65 - 85
#8	33 - 55
#16	20 - 35
#30	15 - 30
#50	10 - 20
#100	5 - 15
#200	5 - 8
Min. % Binder	7.0

FAA > 45% (AASHTO T304)
Fine aggregate of stone sand (no natural sands)

Sand Equivalency > 45% (AASHTO T176)

Volumetric Requirements for Design and Control of HPTO					
Requirements	Required Density (% of Max. Sp. Gr.)		Voids in Mineral Aggregate (VMA)	Dust to Binder Ratio	Draindown, AASHTO T305
	Ndes (50 Gyrations)	Ndes (100 Gyrations)			
Design	96.5	< 99.0	> 18.0%	0.6 - 1.2	< 0.1 %
Control	95.5 - 97.5	< 99.0	> 18.0%	0.6 - 1.2	< 0.1 %

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High Performance Thin-Overlay

- **Asphalt Binder**
  - Polymer-modified binder
    - PG76-22 (NJDOT Spec)
  - RTFO Elastic Recovery > 65% @ 25°C (AASHTO T301)
  - Separation Test < 4.5°C after 4 hrs (ASTM D5976)
- **Performance Specification**
  - Utilize the Asphalt Pavement Analyzer (AASHTO TP 63) for stability check
    - Mix design verification and production control (1st Lot and every other Lot after)

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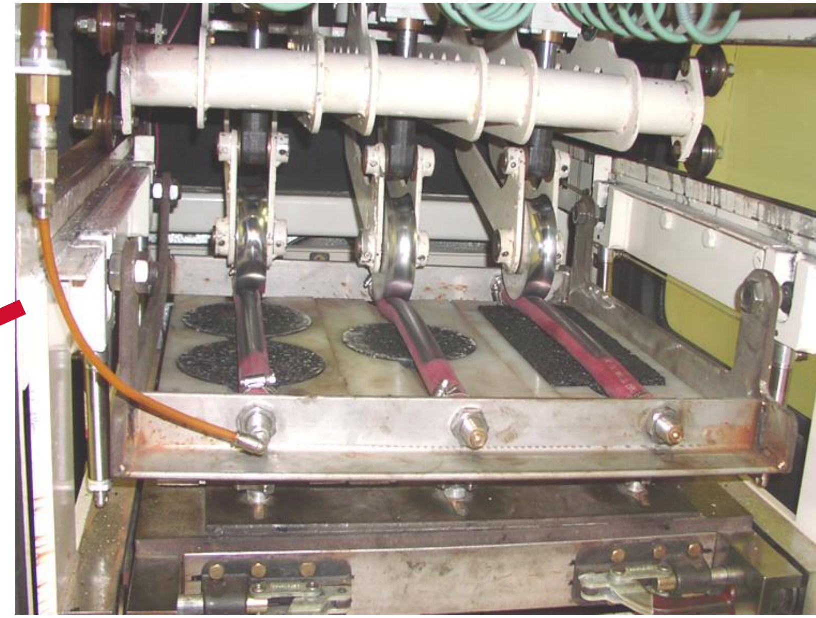
Asphalt Pavement Analyzer



- AASHTO TP 63
- 100 lb wheel load; 100 psi hose pressure
- Tested at 64^{o}C for 8,000 loading cycles
- Samples at 5 +/- 0.5% air voids
- APA Rutting < 4 mm to PASS

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HPTO Lab Performance Evaluation

- Mixture properties relative to field performance
  - Permanent Deformation Stability
    - Asphalt Pavement Analyzer (AASHTO TP63)
    - Repeated Load Simple Performance (NCHRP Report 465)
  - Fatigue resistance
    - Flexural Beam Fatigue (AASHTO T321)
  - Resistance to PCC Slab Horizontal Movement
    - Overlay Tester
  - Dynamic Modulus (AASHTO TP62)
    - HMA stiffness at various temperature and loading speeds
  - Permeability
    - Flexible Wall Permeability (ASTM D5084)

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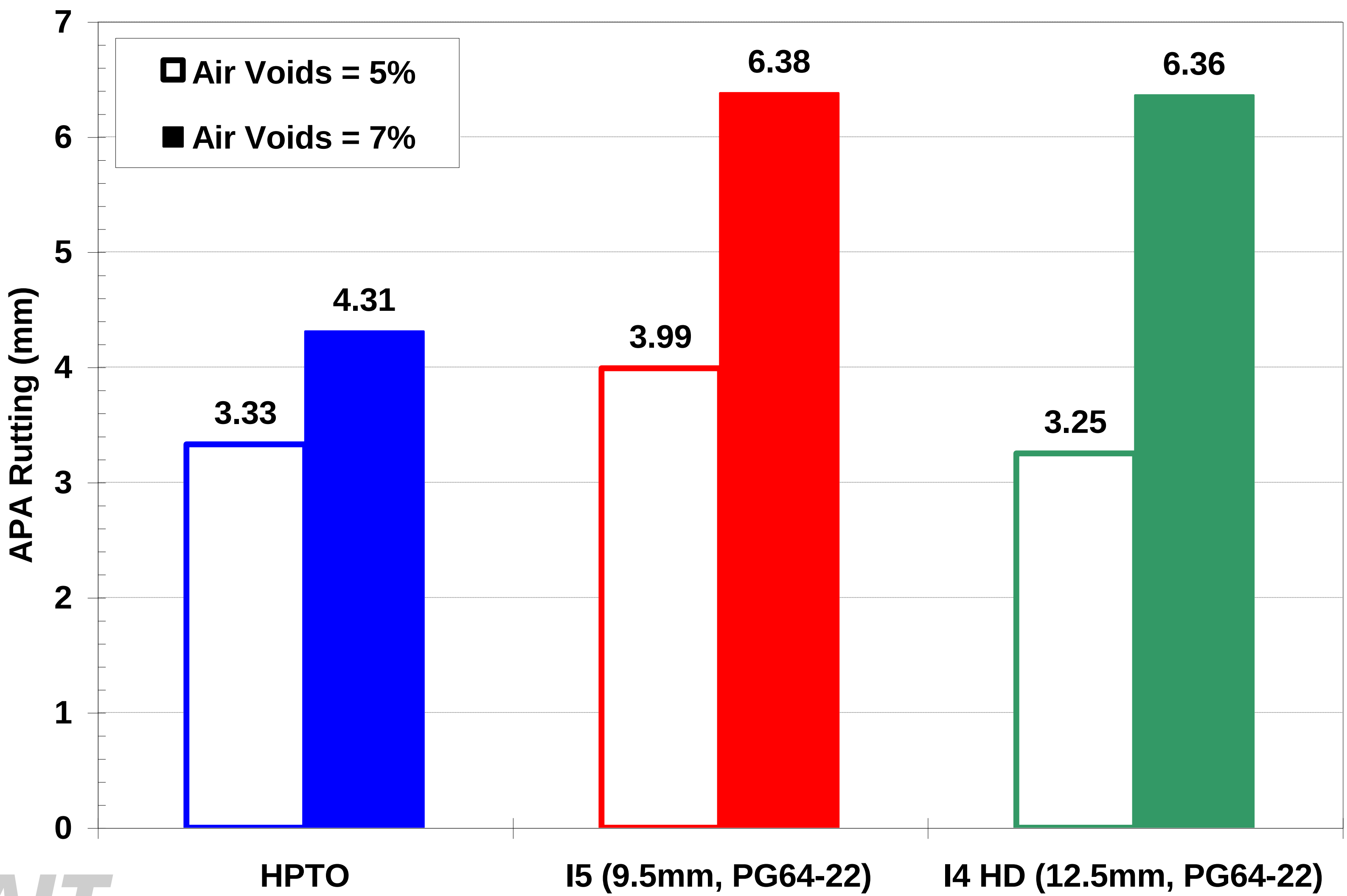
Rutting Stability – APA



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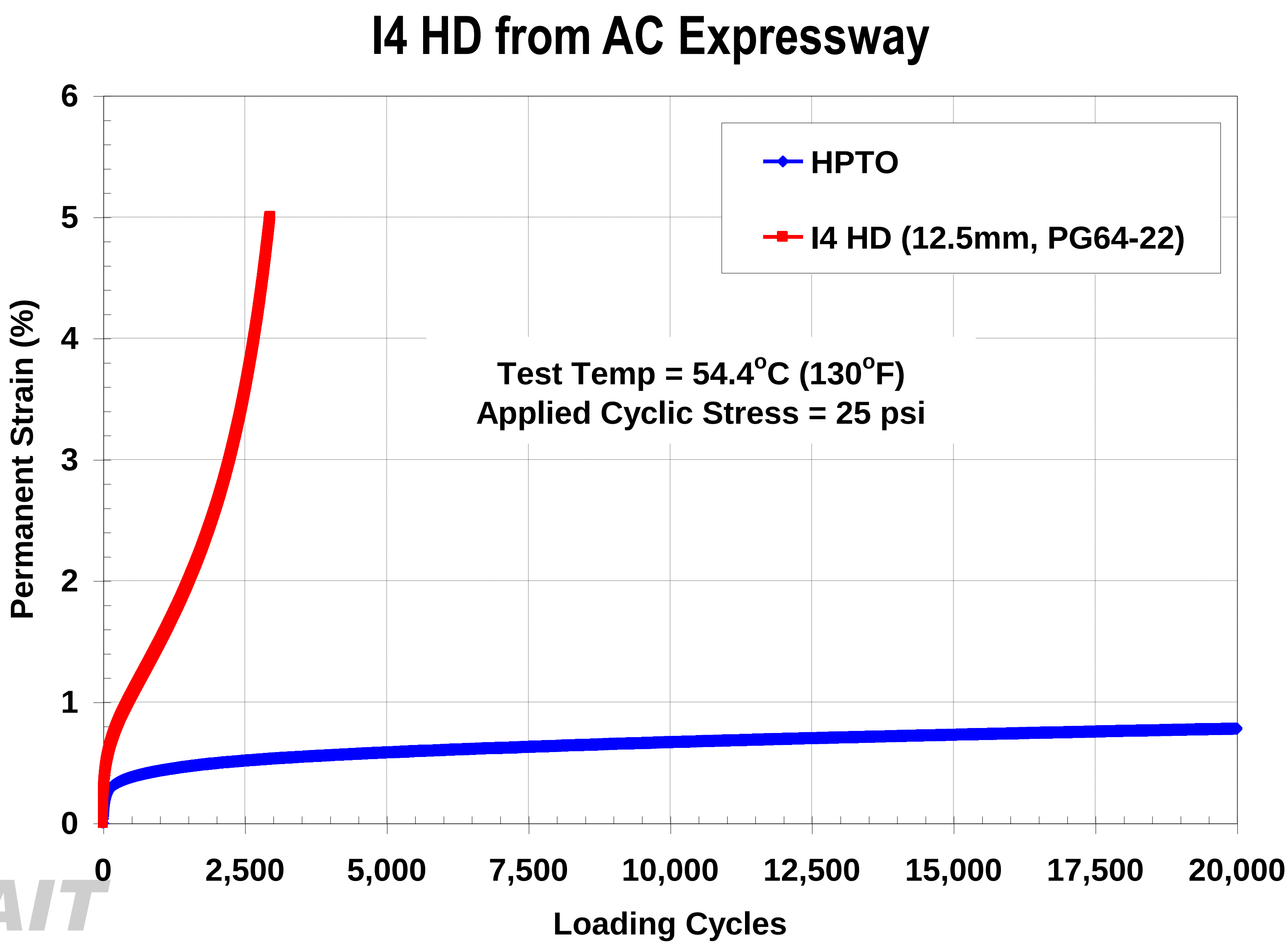
Repeated Load Test – NCHRP Report 465



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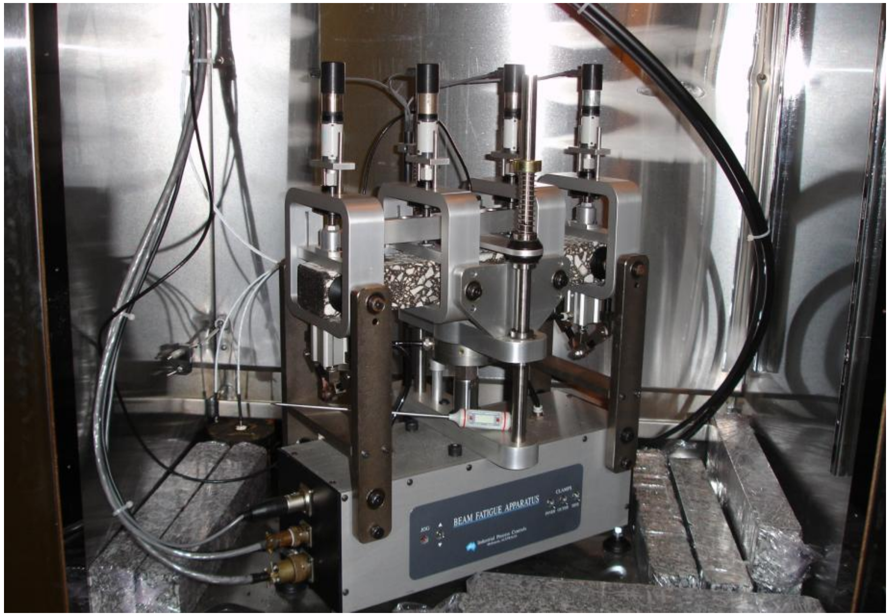
Fatigue Evaluation

- Flexural Beam Fatigue Device, AASHTO T-321
- Tests mix's ability to withstand repeated bending which causes fatigue failure
- Data = number of loading cycles to failure (loss of stiffness)
- Run at high level of tensile strain (1000 μ-strain) to simulate excessive bending, similar to movements @ PCC joints



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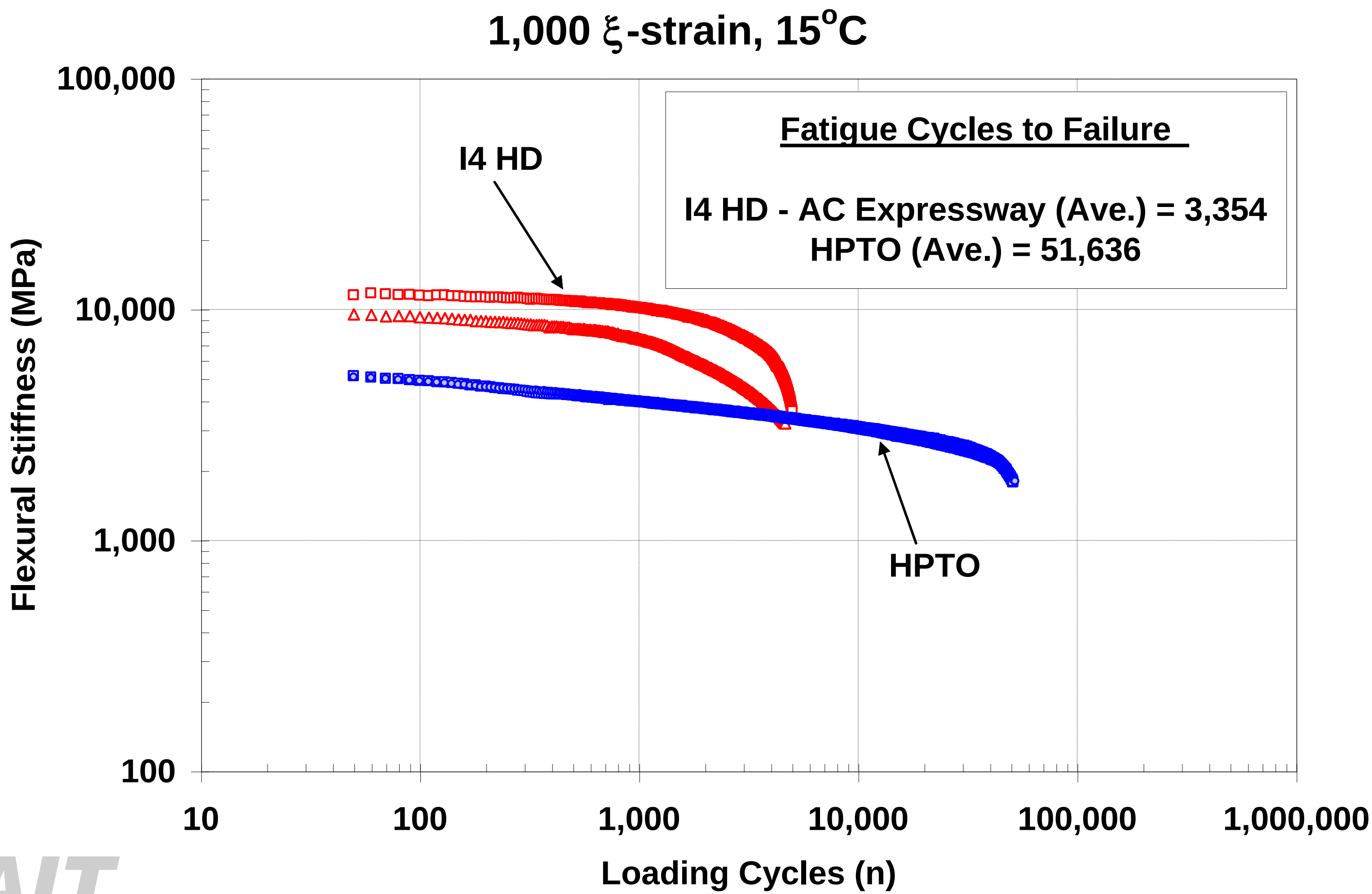
Fatigue Resistance

I4HD from AC Expressway



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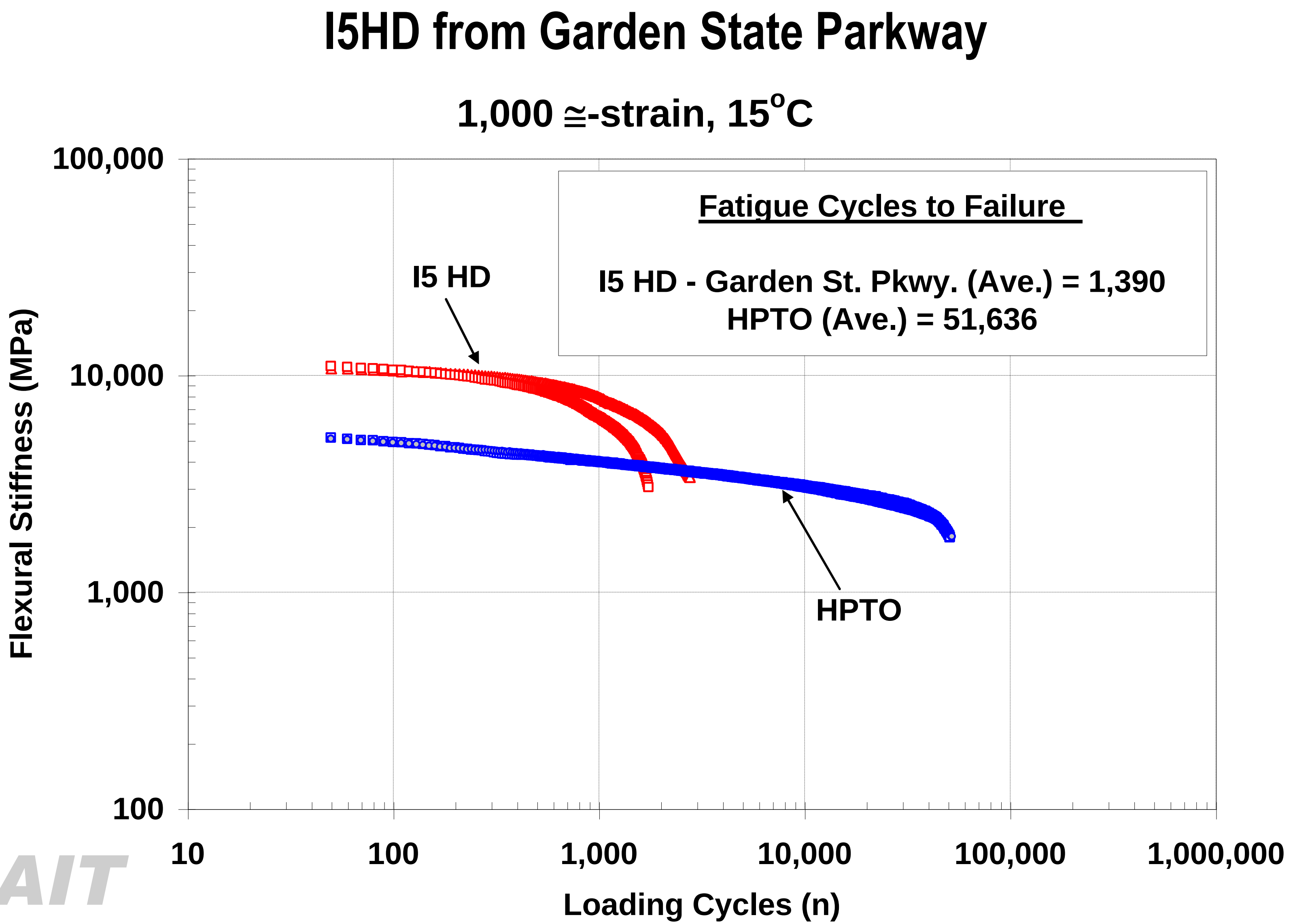
Fatigue Resistance



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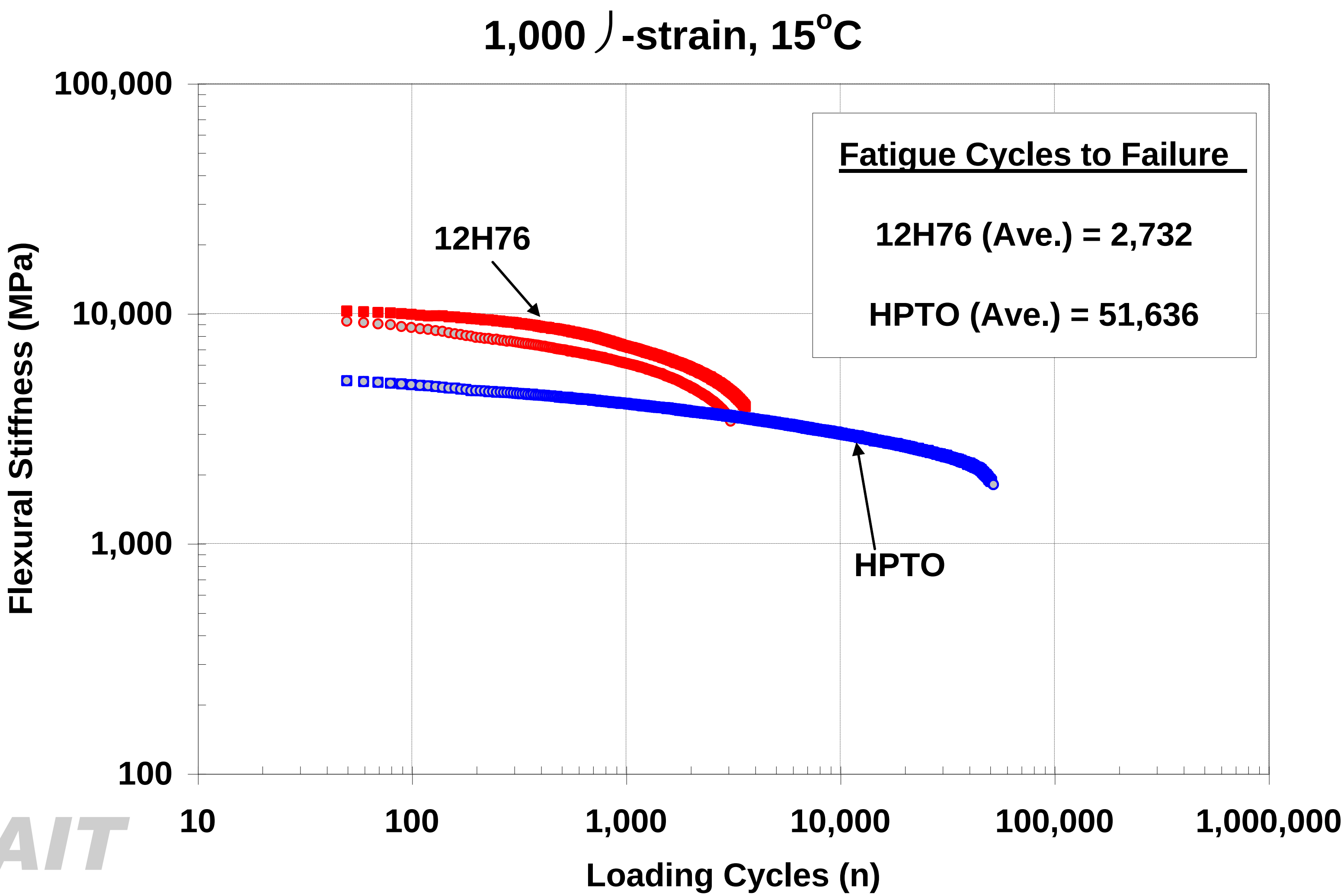
Fatigue Resistance

NJDOT 12H76 from Rt 31 & I95



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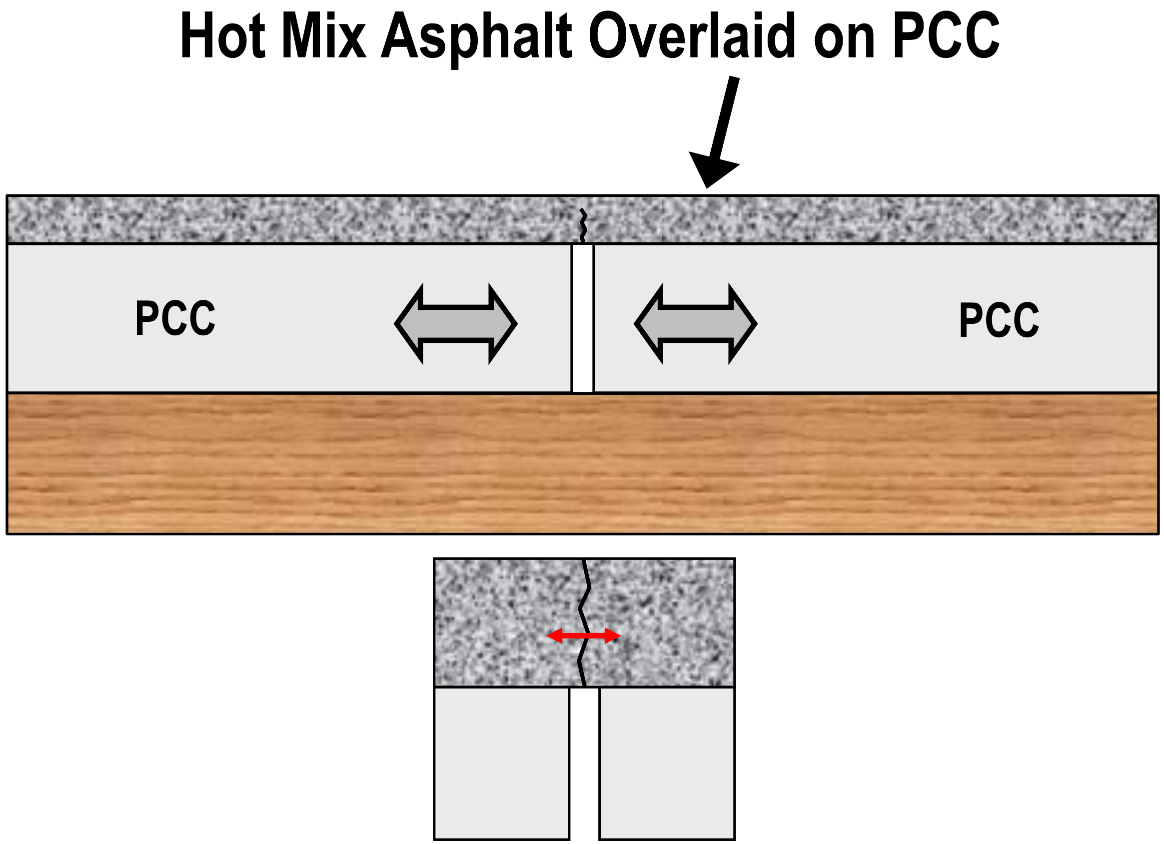
Climatic Loading – Horizontal Movement



Horizontal Tensile Stress due to Expansion/Contraction of PCC from Temperature

Horizontal Stress/Strain is modeled using Overlay Tester

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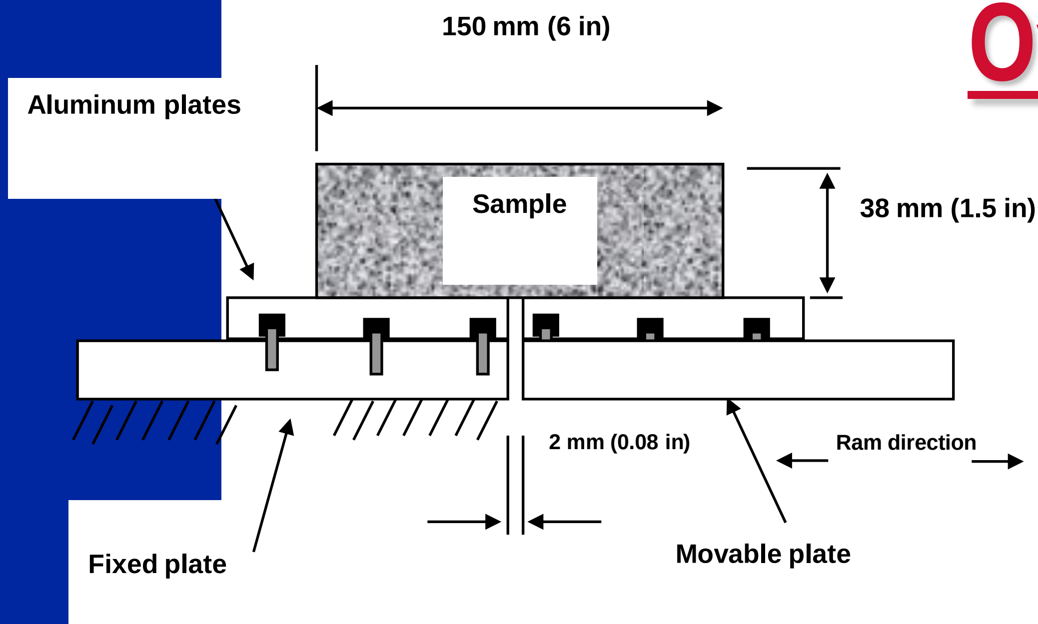
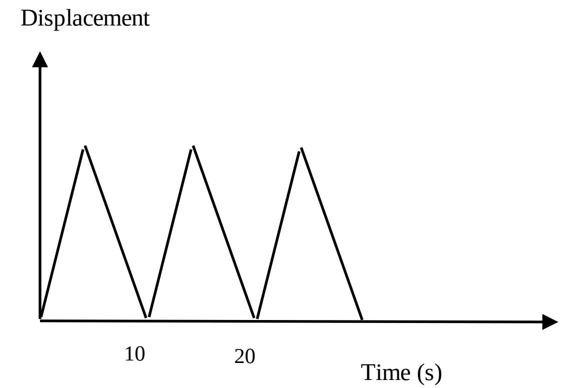
Overlay Tester

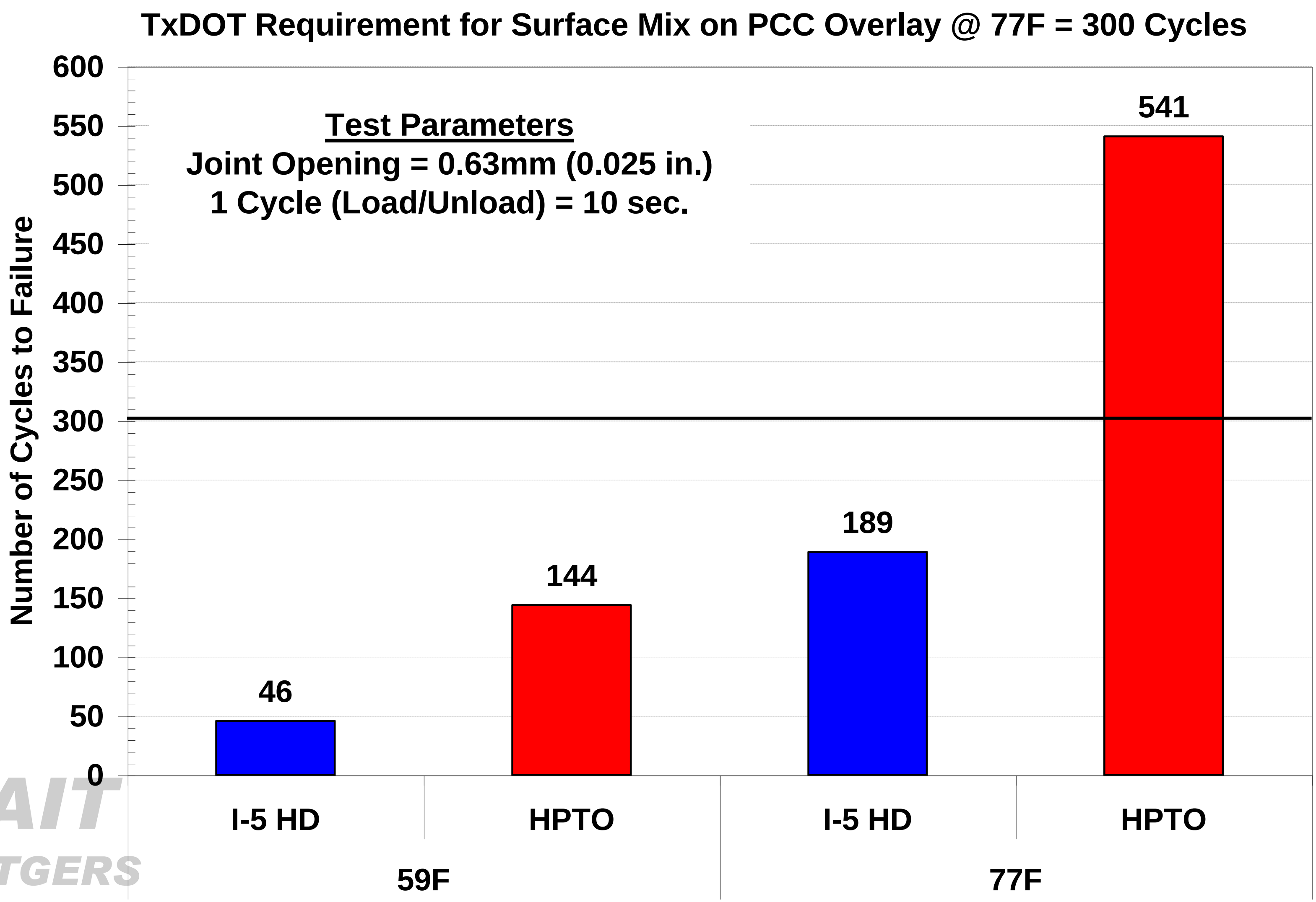




- Sample size: 6'' long by 3'' wide by 1.5'' high
- Loading: Continuously triangular displacement 5 sec loading and 5 sec unloading
- Standard Test Conditions (TxDOT)
  - Opening displacement: 0.025 in.
  - Two temperatures: 77 F (TxDOT) and 59 F
- Definition of failure
  - Discontinuity in Load vs Displacement curve
  - Visible crack on surface

Overlay Tester Results

I5HD from Garden State Parkway



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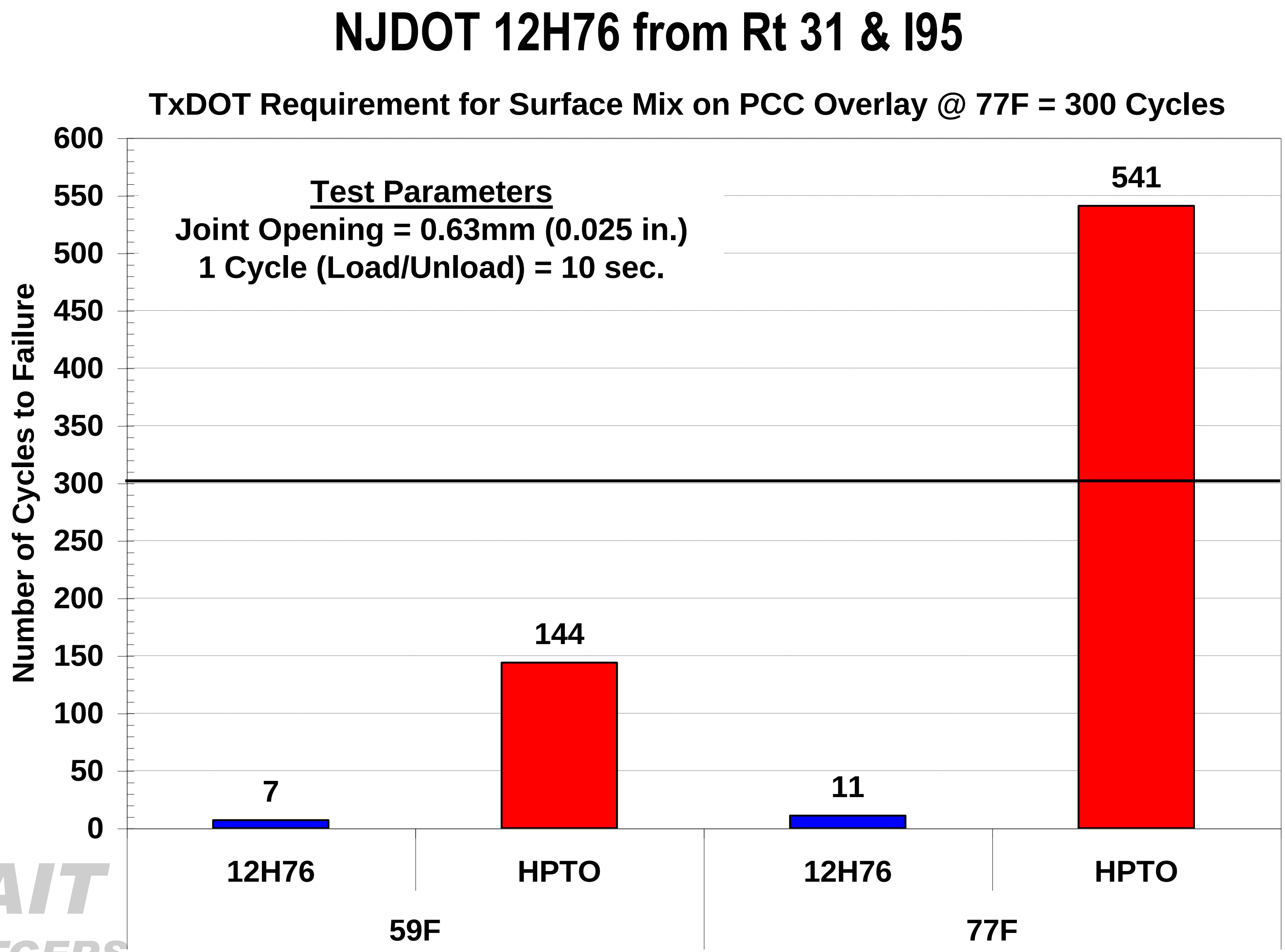
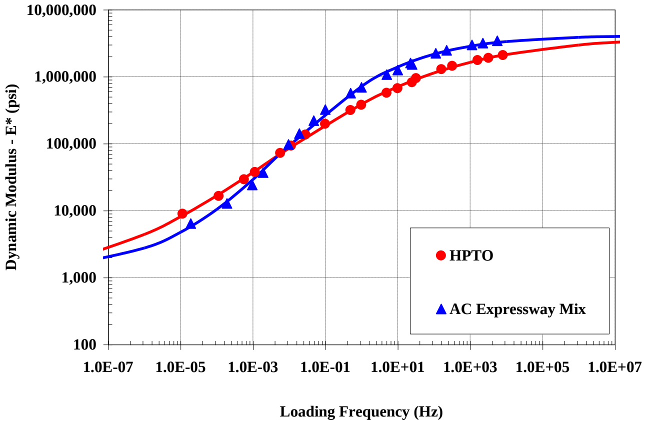
Overlay Tester Results



Dynamic Modulus Testing

- For Mechanistic Design procedures, Dynamic Modulus (E*) is main material input parameter
- Test method determines the modulus of HMA under various temperatures and loading frequencies



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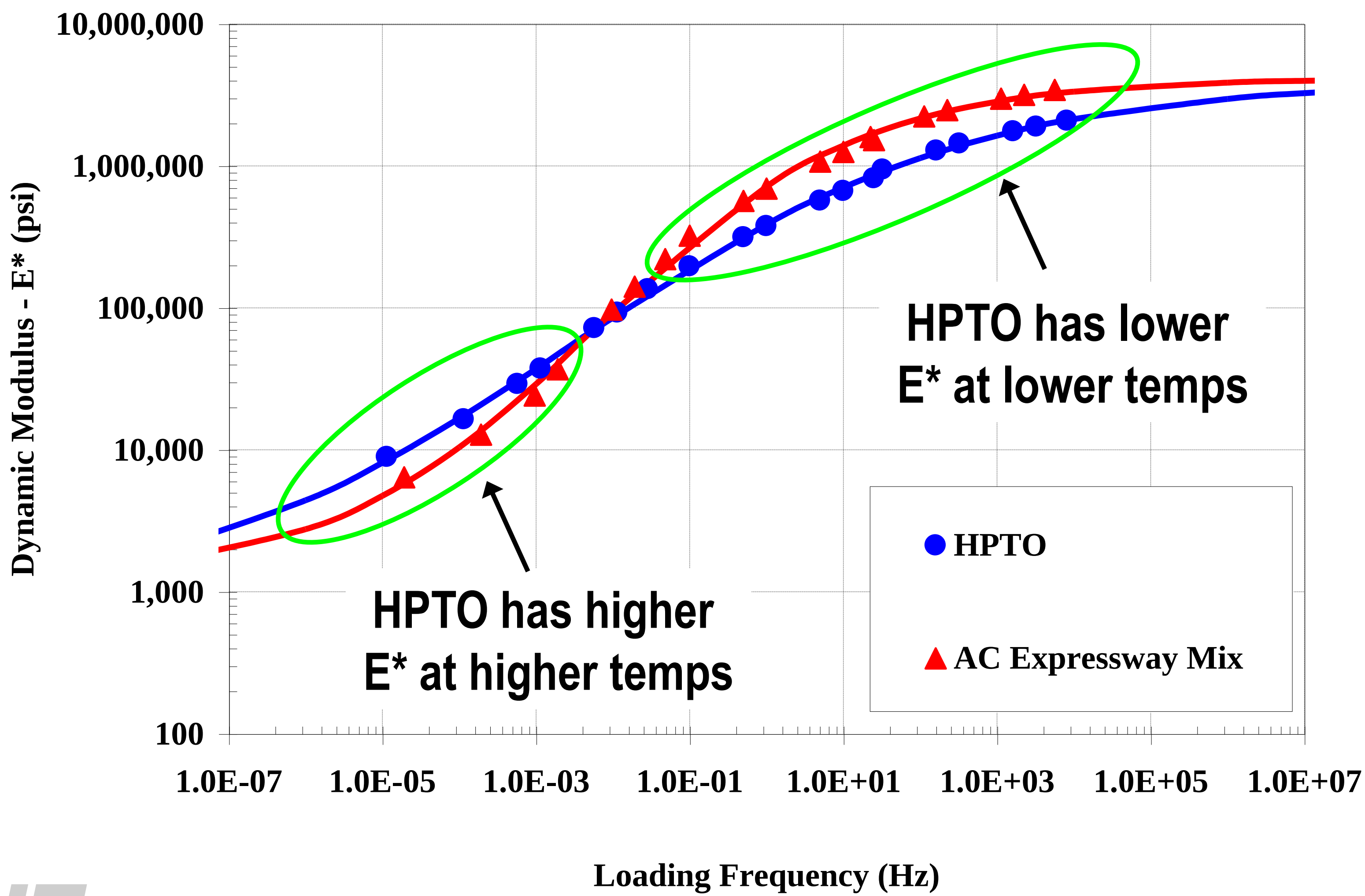
Dynamic Modulus Testing



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Flexible Wall Permeability Testing

- For Pavement Preservation, important to “seal” pavement to limit moisture
- Permeability on order of a silt/clay, required testing in “Flexible Wall” Permeability Set-up

Samples cored from 6-inch diameter gyratory sample

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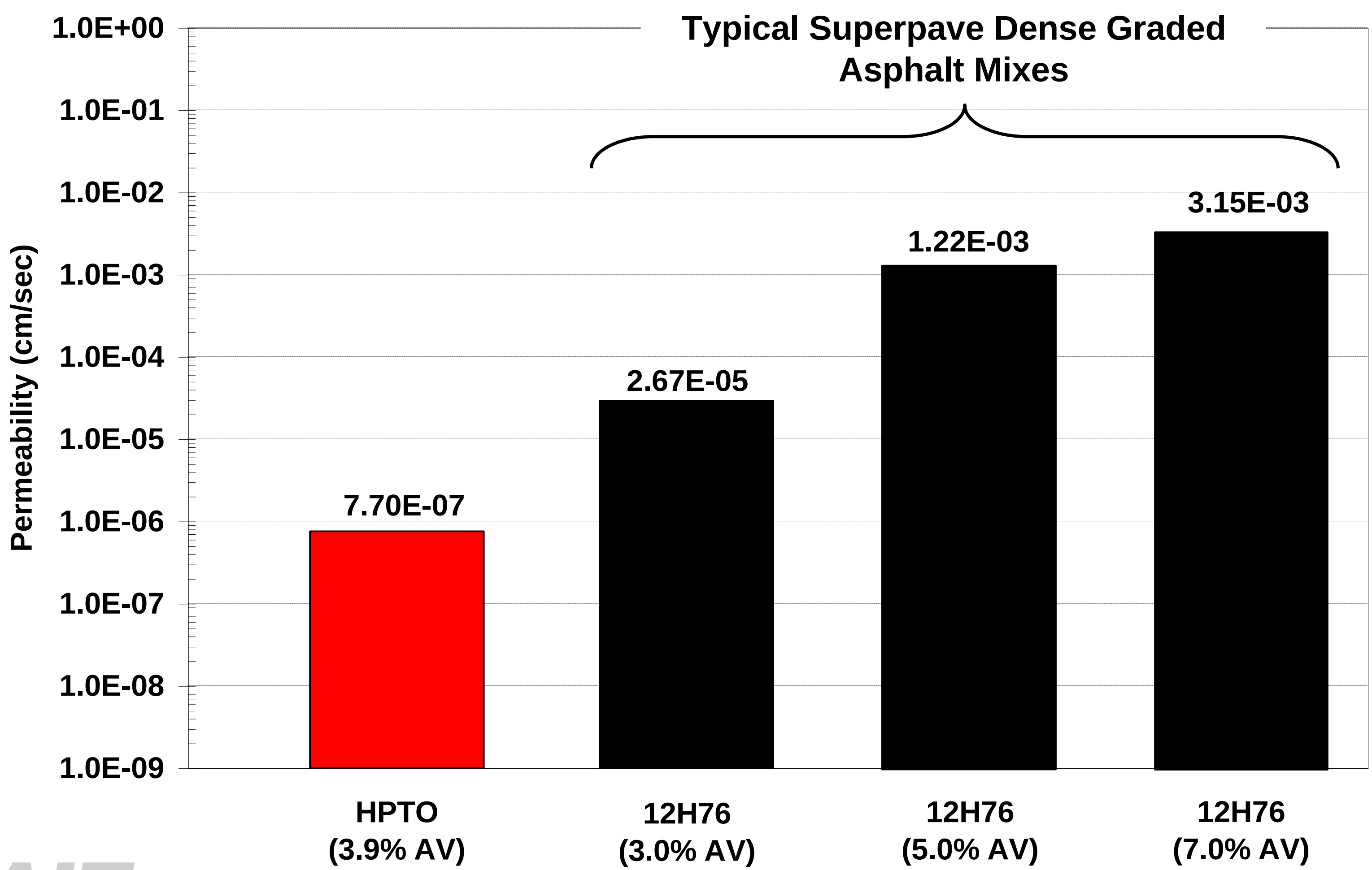
Typical Permeability Values



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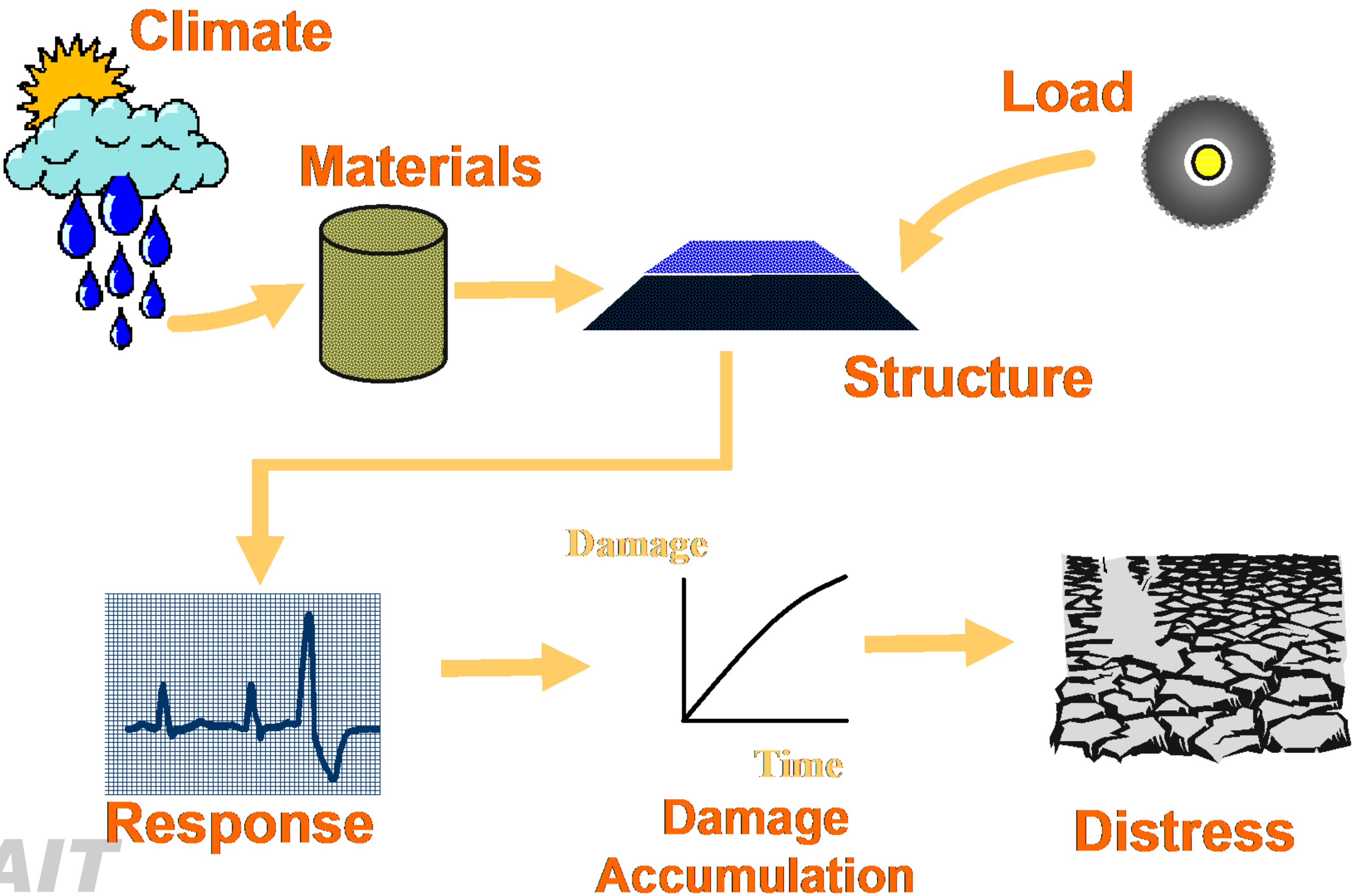
Pavement Distress Simulations Using MEPDG

Mechanistic Empirical Pavement Design



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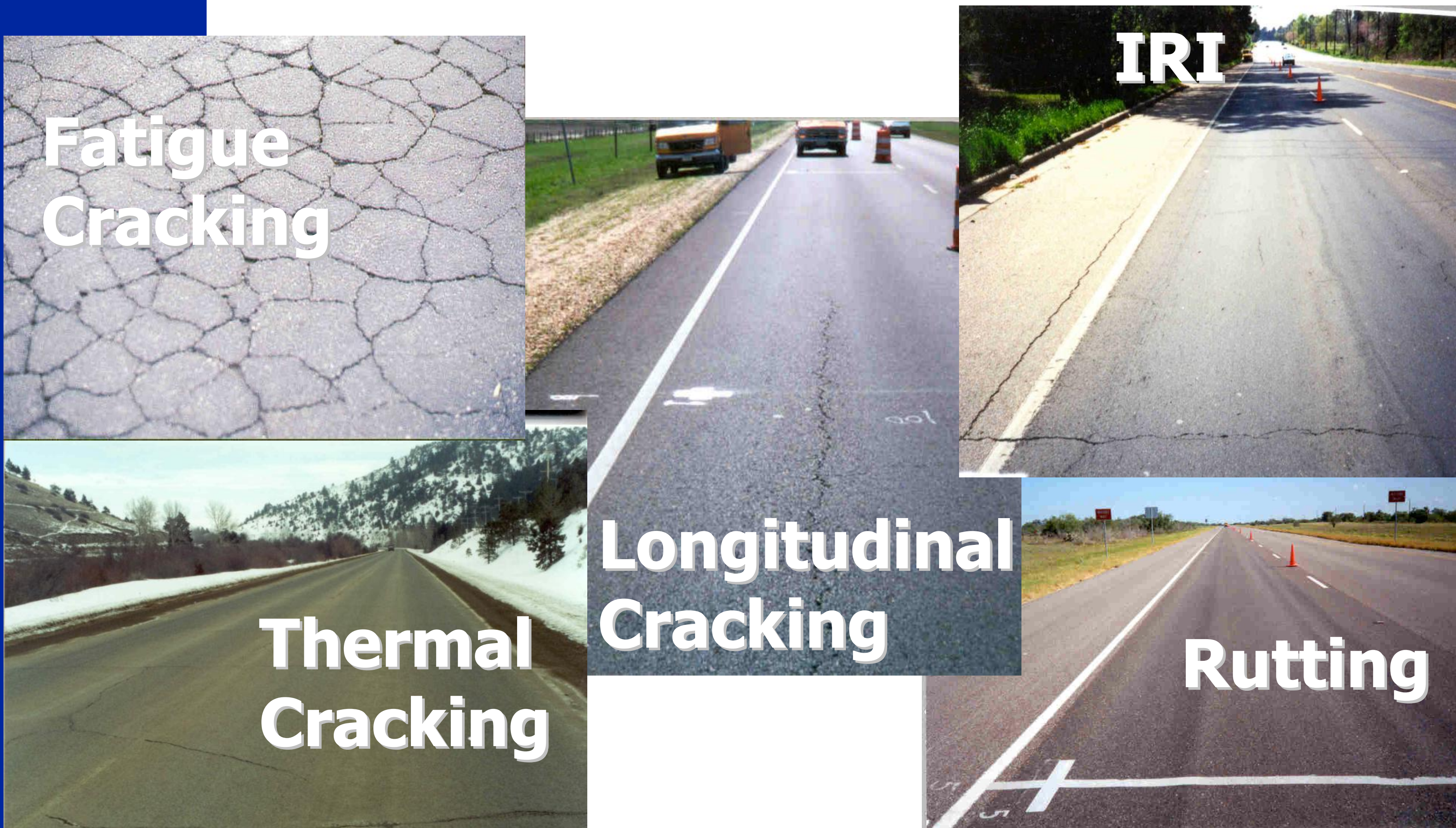
Predicted Distresses (Flexible)



MEPDG Simulation Inputs

- 2 Lane Highway; AADT = 8,840
  - 2.7% Light Trucks (FHWA Class 4 and 5)
  - 5.7% Heavy Trucks (FHWA Class 6+)
- Design: 8" HMA; 8" Unbound Base Agg.
- Materials Used
  - 2" mill and replace using I4-HD (12.5mm Superpave PG64-22) – current surface mix on AC Expressway
  - 1" mill and replace using HPTO
- Evaluating Rutting and Wheelpath Surface Cracking over a 15 year design life
- Surface conditions prior to milling
  - 15% Wheelpath Cracking
  - 0.5" Total Rutting (0.4" in HMA, 0.1" in Unbound Base)

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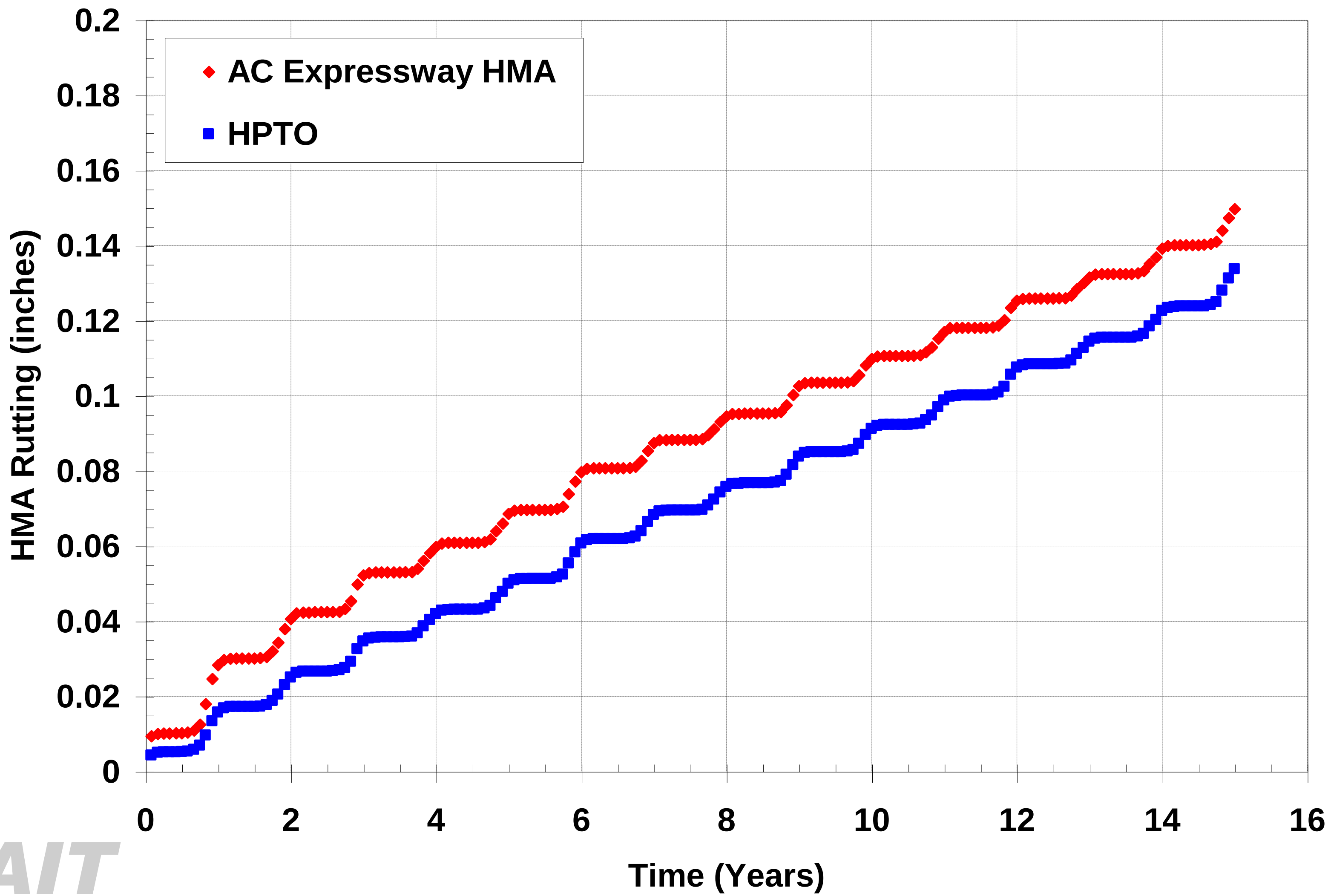
HMA Rutting Evaluation



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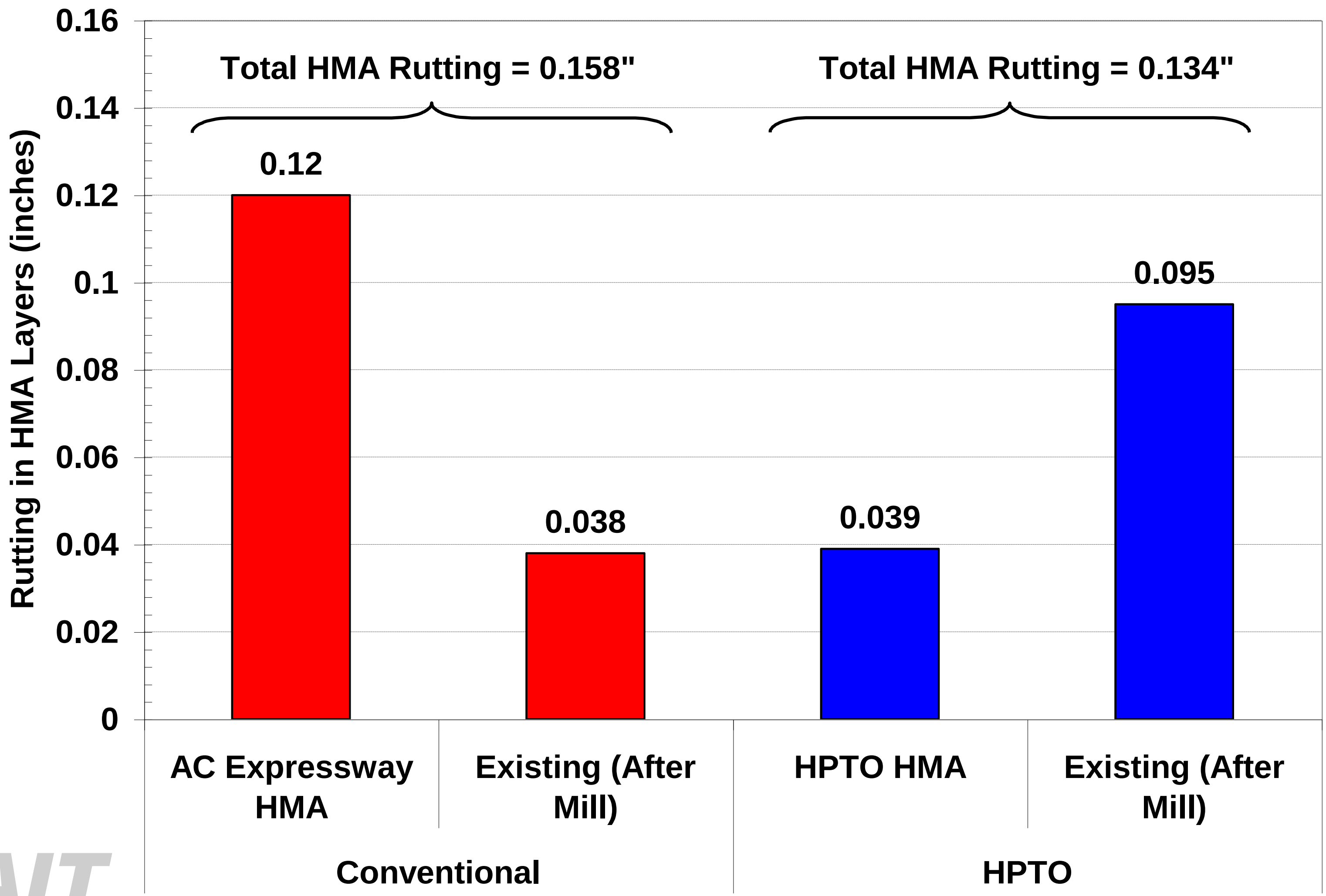
HMA Rutting Evaluation



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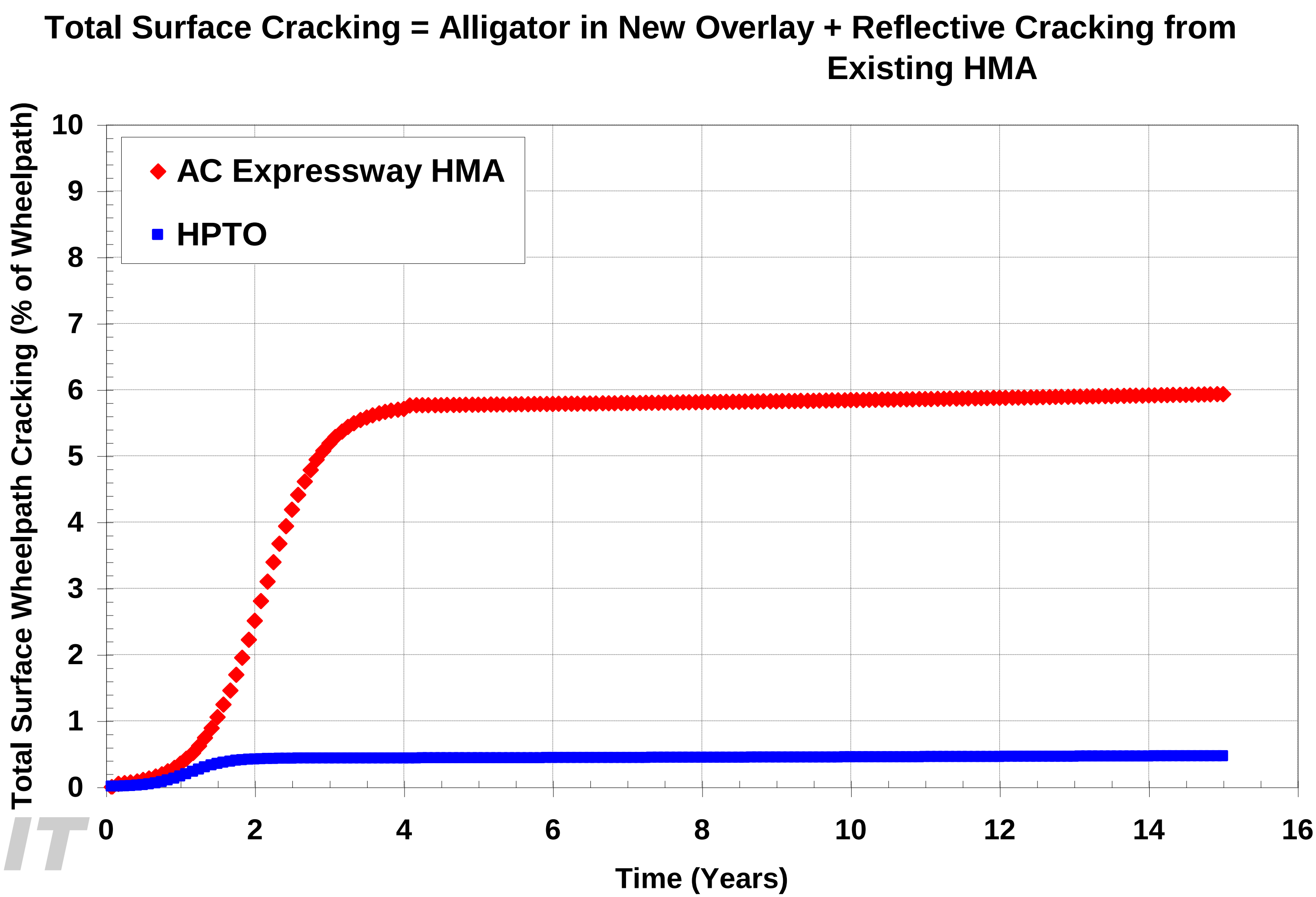
Surface (Wheelpath) Cracking Evaluation



Comparative Costs

- Mill 2”/Pave 2” with 12H64 = $8.80/yd^2$
- Mill 1”/Pave 1” with HPTO = $6.35/yd^2$
- Pave HPTO on Existing = $4.35/yd^2$

* Based on local material cost estimates

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Surface (Skid) Friction, SN_{40}

Material Type	Skid Number
HPTO (New)	53
12.5mm SP (New)	51.6
12.5mm (4 Yrs)	54.3
19mm SP (4 Yrs)	55.7
19mm SP (5 Yrs)	47.7

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Conclusions

- NJDOT investing time and money into Pavement Preservation
  - Preserve infrastructure and improve ride quality
  - "Get in/Get out"
- NJ Municipalities looking for similar preservation/rehabilitation treatments
- Laboratory comparisons show HPTO
  - Rut resistant
  - Durable – flexural fatigue and overlay tester
  - Low permeability to seal existing cracks

Conclusions

- Design simulations using MEPDG verify laboratory test results
- Thin lift provides cost effective alternative
  - Whether mill 1”/replace or direct overlay
- Initial skid resistance shows good resistance and comparable to NJ’s DGA surface mixes
  - “Safe, Durable Highway Materials”

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Thank you for your time!

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