2005 Southeastern States Pavement Management and Design Conference

Quantifying the Effects of PMA for Reducing Pavement Distress

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Presentation Overview

1. Introduction
2. Performance Comparisons
3. Summary of Findings & Conclusions

Study Team

ARA Project Team

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- Jagannath Mallela
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Project Monitors

- Mark Buncher
- Tim Glanzman

Study Sponsors

Industry Associations

- The Asphalt Institute
- The Association of Modified Asphalt Producers

Federal Highway Administration

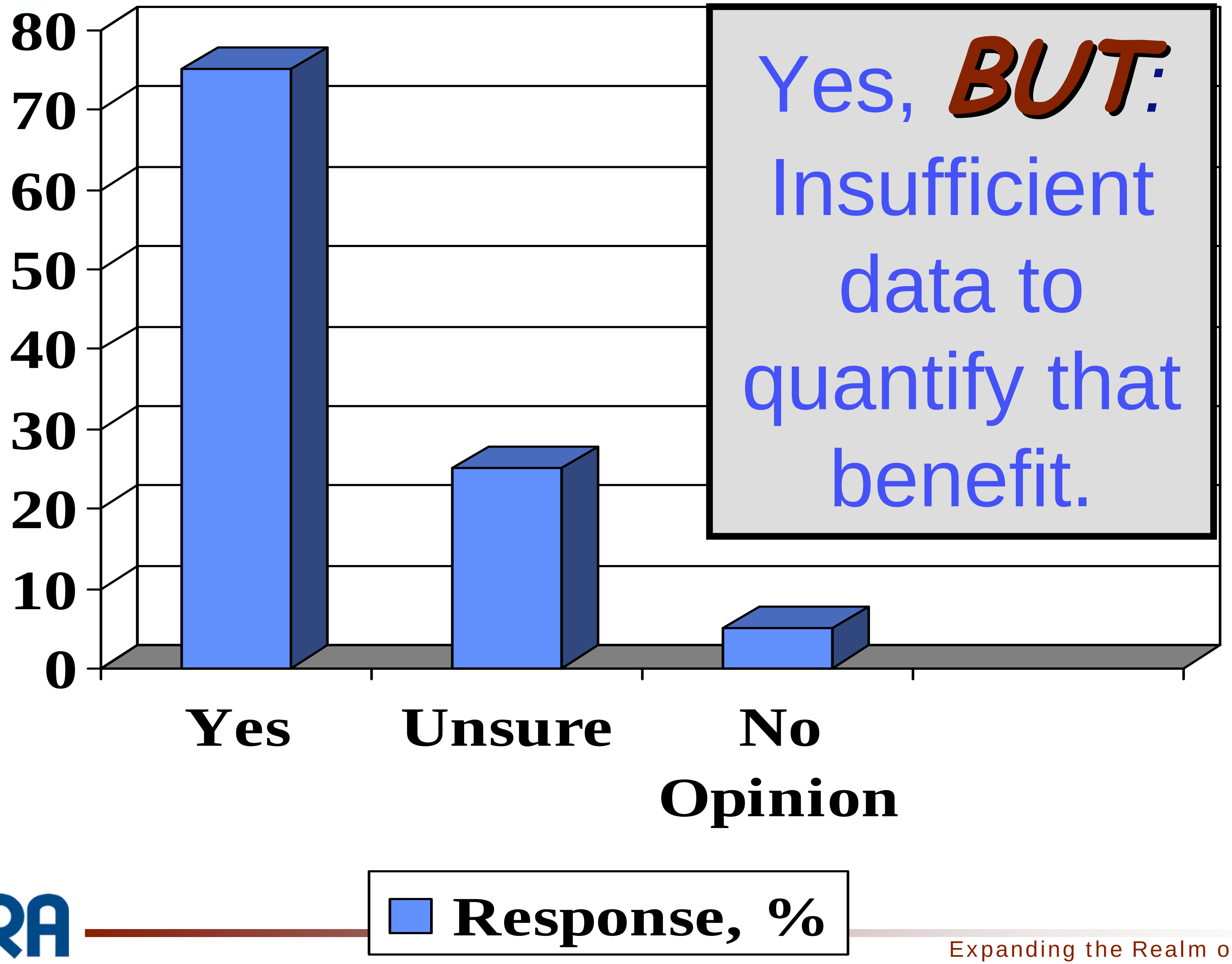
Corporate Sponsors

- Arr-Maz Products
- ATOFINA Petrochemicals, Inc.
- Dexco Polymers LP
- Dynasol LLC
- Goodyear Chemical
- KRATON Polymers
- Polimeri Europas Americas
- Ultrapave

Study Objectives

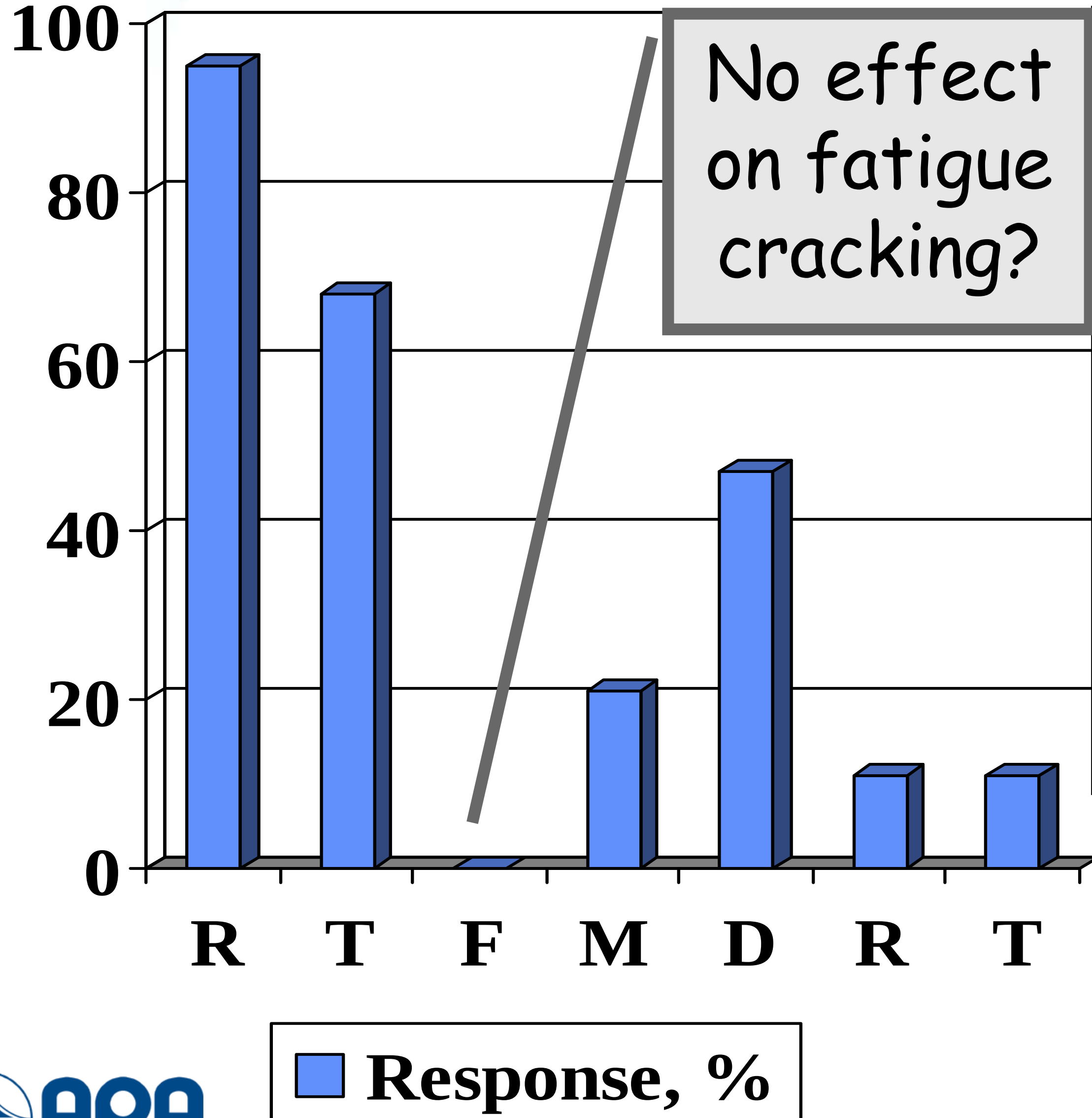
1. Quantify the effect of using PMA as compared to conventional-unmodified HMA mixtures.
2. Identify conditions that maximize effect of PMA to increase HMA pavement & overlay life for use in LCCA.

Is There a Benefit Using PMA?



Yes, ***BUT:*** Insufficient data to quantify that benefit.

Reason for Using PMA?



R = Rutting

T = Thermal Cracking

F = Fatigue Cracking

M = Moisture Damage or Stripping

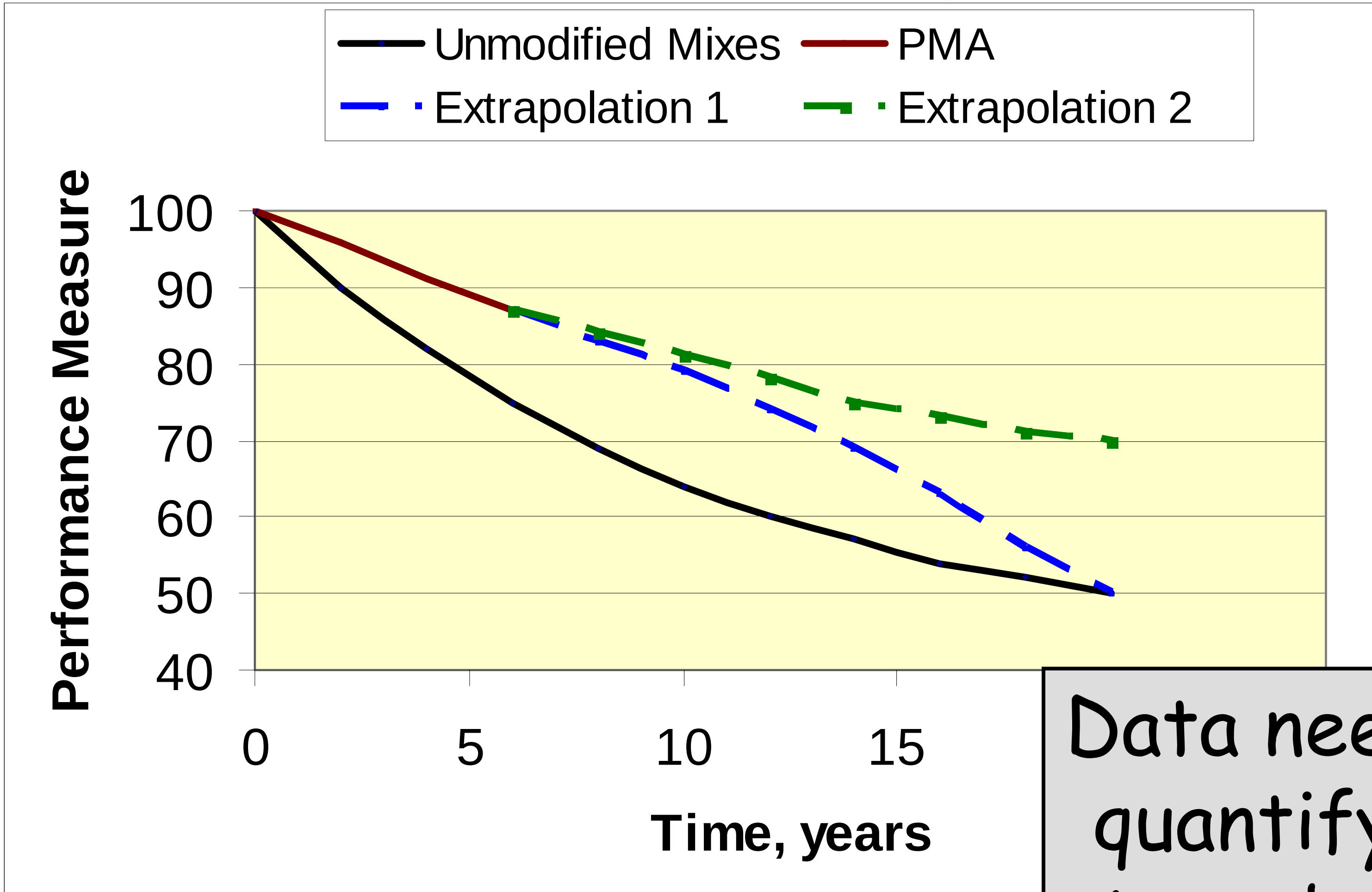
D = Durability

R = Raveling

T = Tenderness

Concern:

Short-Term Versus Long-Term Benefit?



Data needed to quantify long-term benefit.

Performance Comparisons

- Rutting
- Fatigue Cracking
- Thermal Cracking

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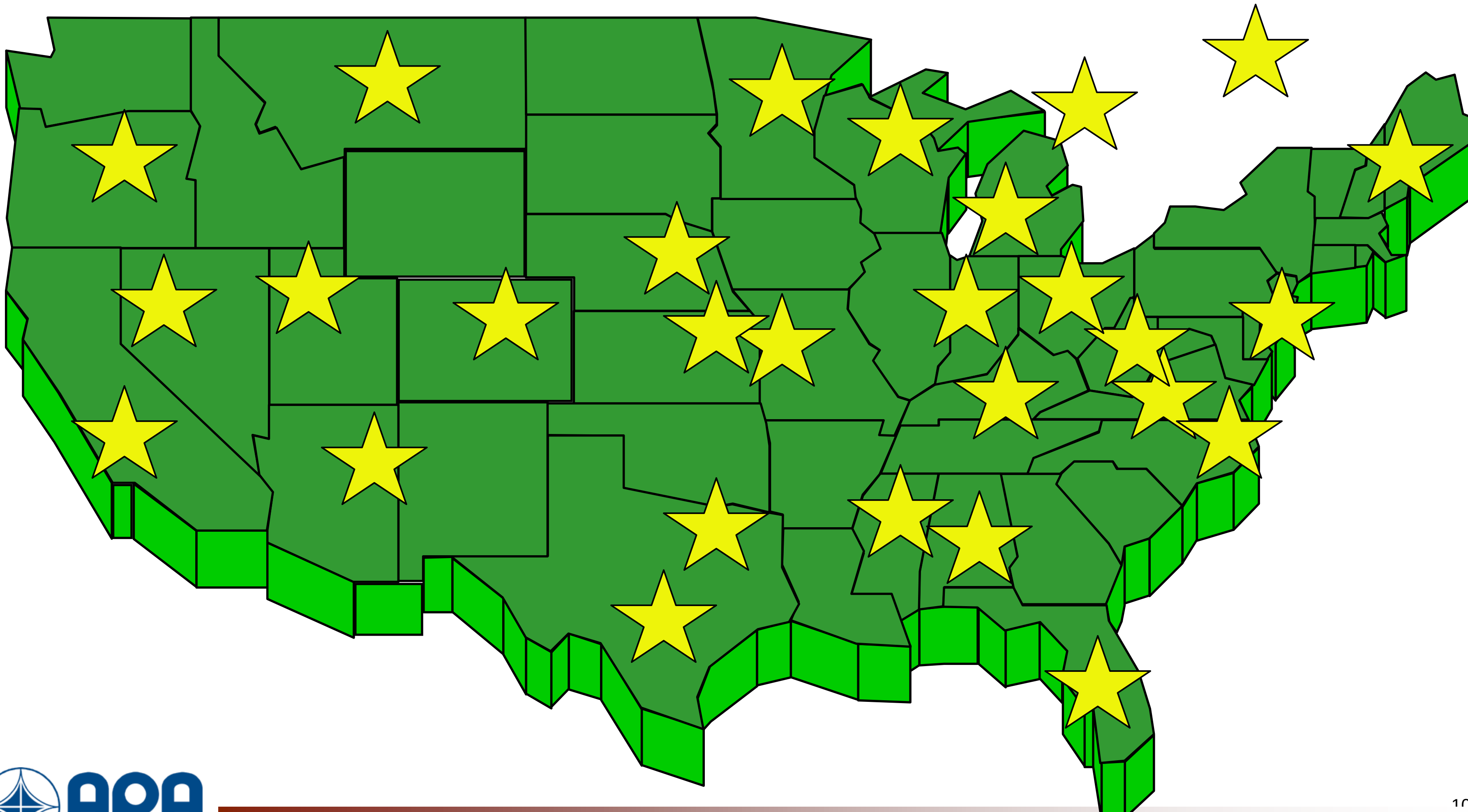
Selected Pavement Locations for Performance Comparisons



Types of Analyses: PMA Versus Companion Sections

- Comparison of Actual Distresses
  - Rutting
  - Fatigue Cracking
  - Transverse Cracking
- M-E Analysis of Performance
  - Distortion, Load Related
  - Fracture, Load Related

Calibration – Agency/Cell Specific

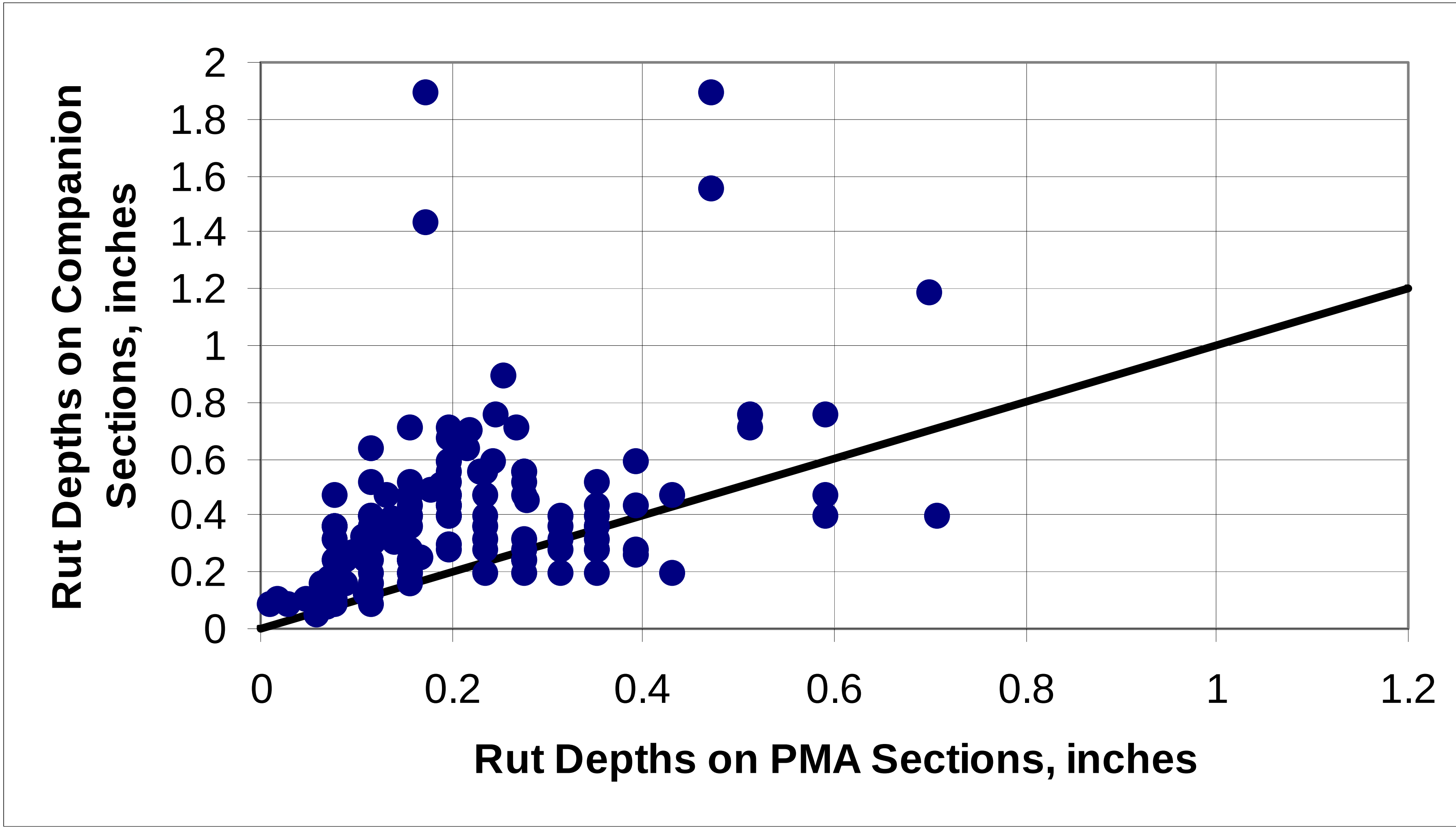
Pavement Cross Section	Foundation	Climate			
		Freeze		Non-Freeze	
		Wet	Dry	Wet	Dry
Thin HMA	Fine-Grained	2	2	4	3
	Coarse-Grained	3	3	3	3
Thick HM[illegible]	[illegible]	2	2	2	3
	[illegible]	2	2	3	2
Full-Depth	[illegible]	0	1	2	2
	Coarse-Grained	0	1	2	2
HMA Overlays	HMA	3	3	6	6
	PCC	4	3	4	4
Total No. PMA Sections		16	17	26	25

Unmodified Sect. used for Calibration

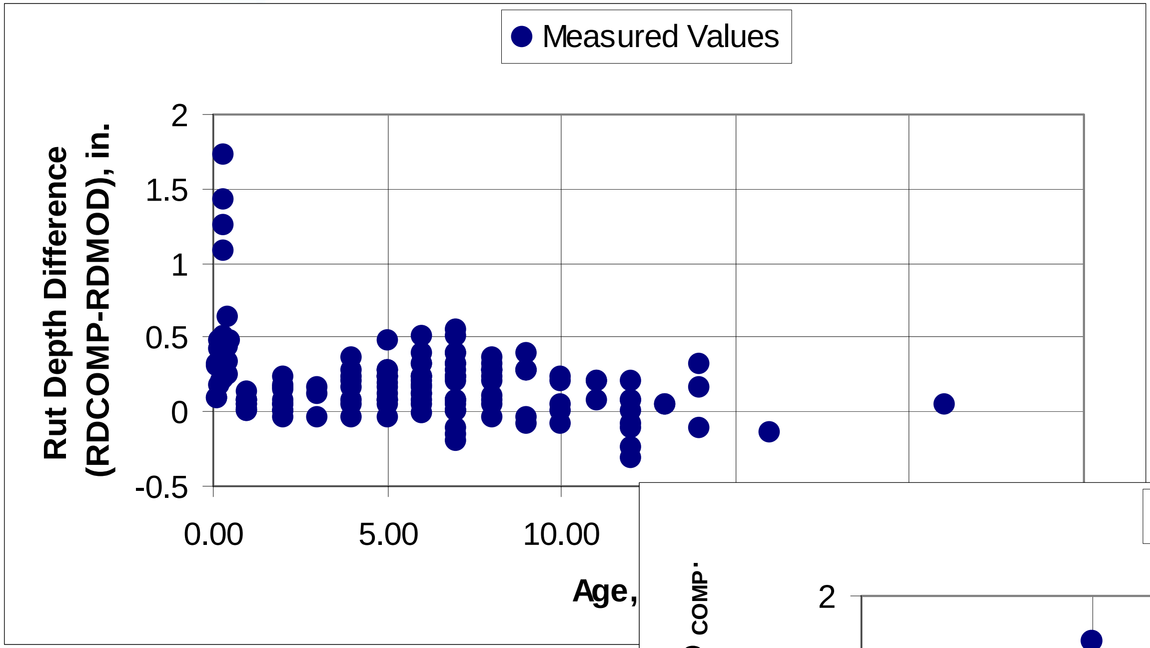
Rutting Analysis

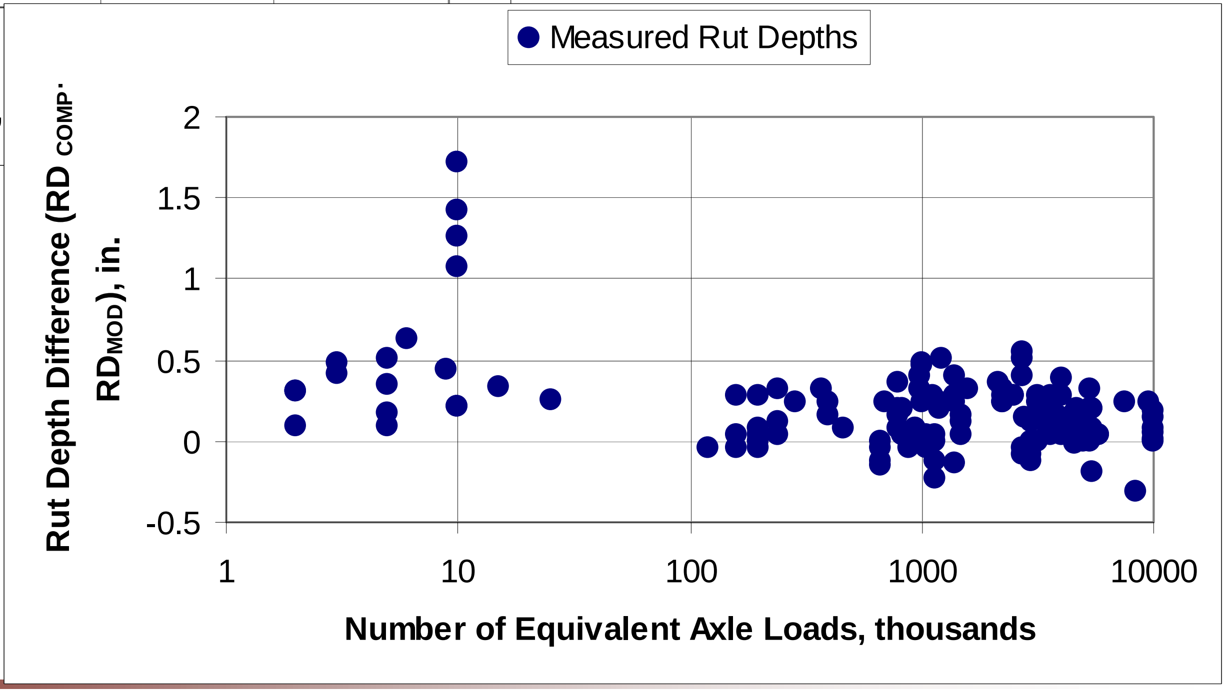
Unmodified Mixes
Versus
PMA Mixes

Distress Comparisons - Rutting

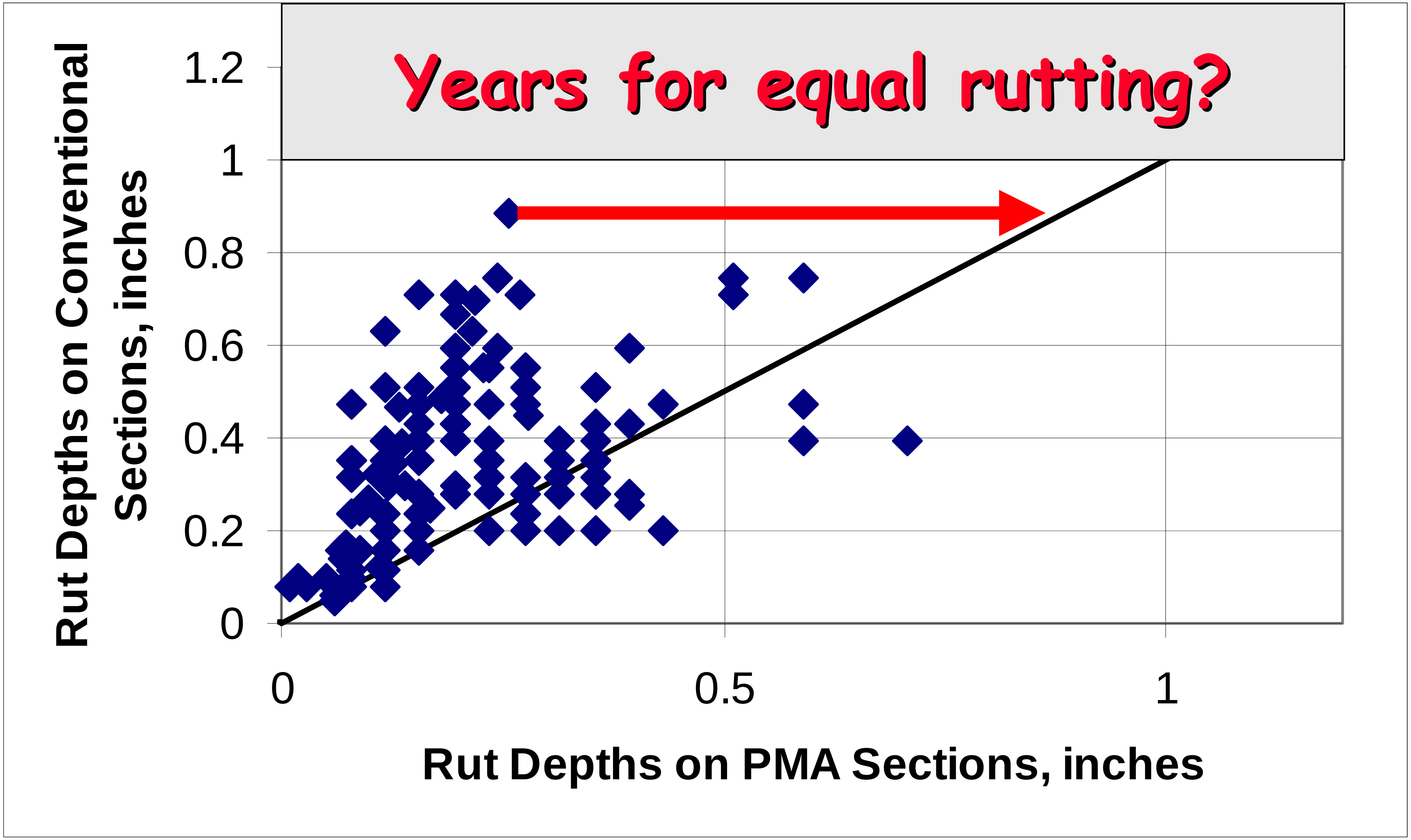


RD Differences: Neat-Modified

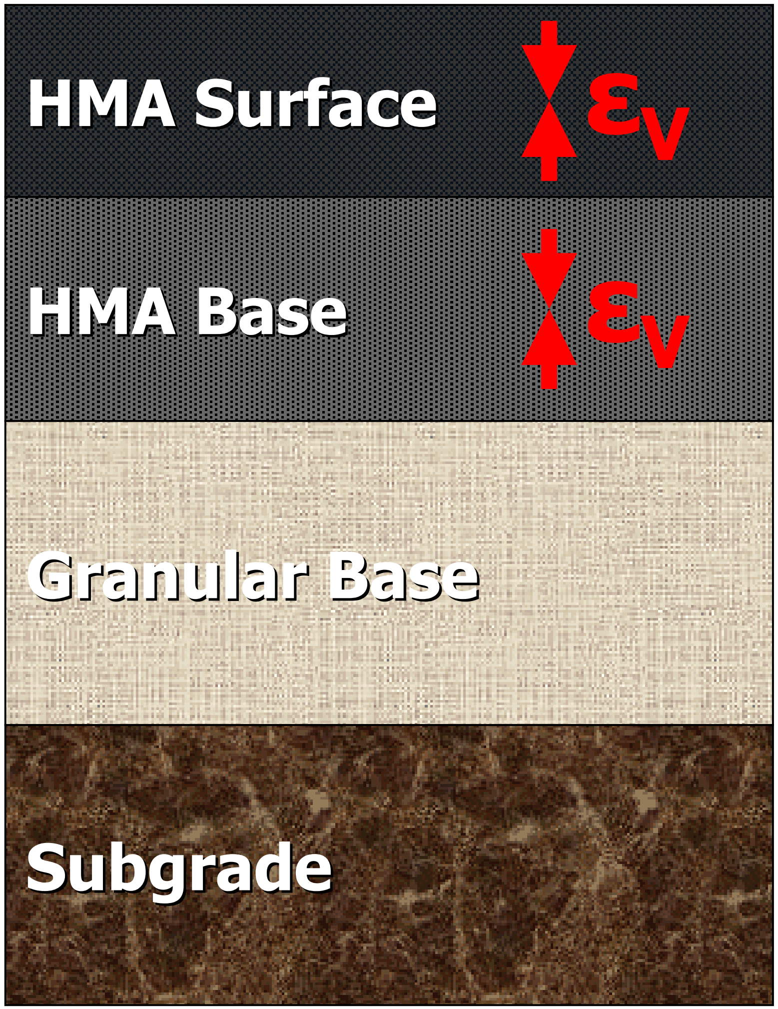




For LCCA, what is the time difference between different rut depths?



Distortion Damage Analysis



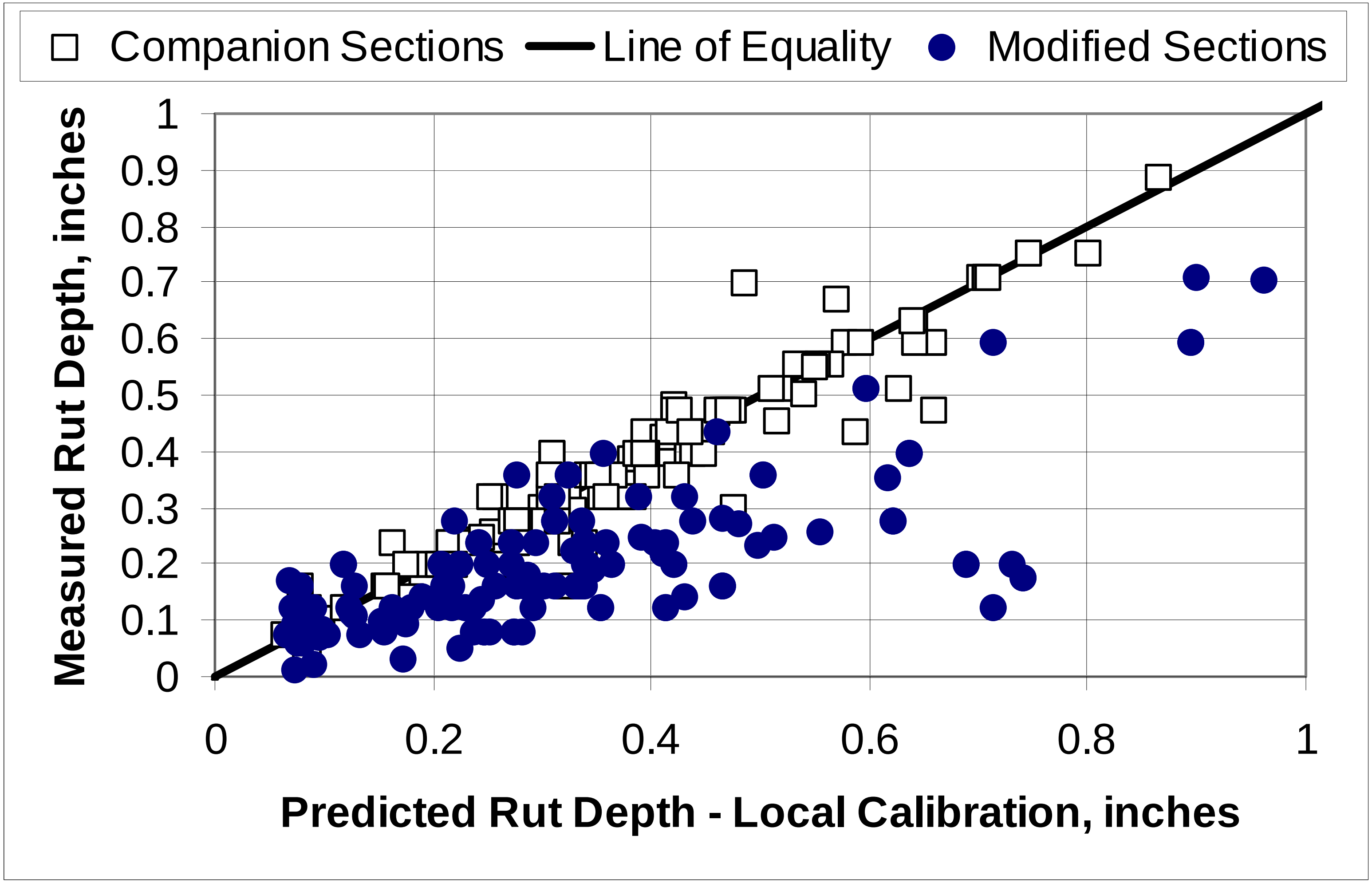
- Use equivalent HMA summer modulus
- Vertical strain at specific depths

$$RD = \sum_{i=1}^{n} \left(\begin{array}{l} 5.37x10^{-7}\left(C_{r1}\right)\left(N\right)^{0.4289\left(C_{r2}\right)} \\ \left(T\right)^{2.5896}\left(V_{beff}\right)^{1.0057}\left(V_{a}\right)^{0.5213} \\ \left(C_{3}\right)\left(\varepsilon_{r}\right)\left(t\right) \end{array} \right)_{i}$$

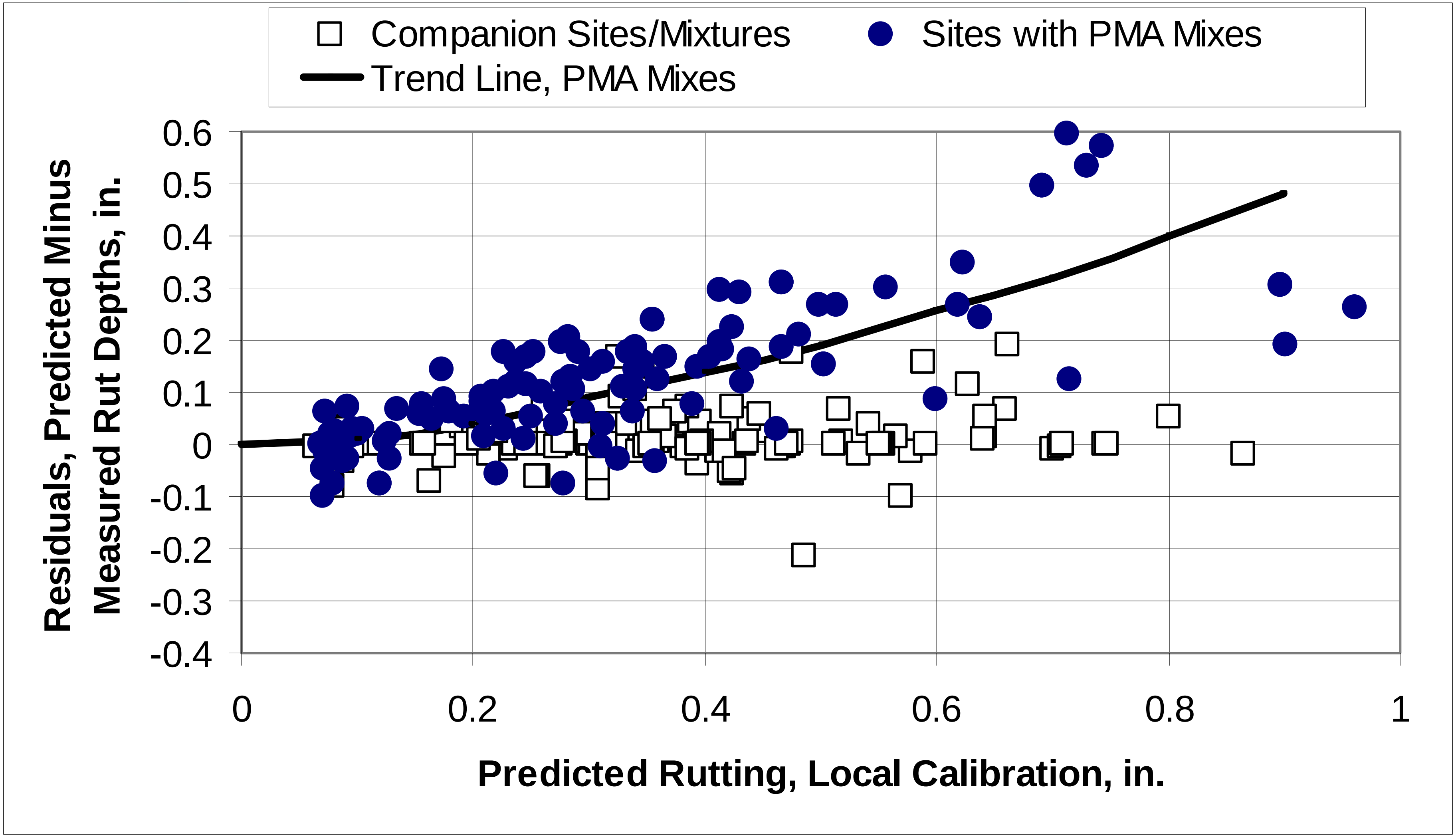
$$DI = \frac{n}{N_R}$$

- Assumption – All rutting occurs in HMA layers

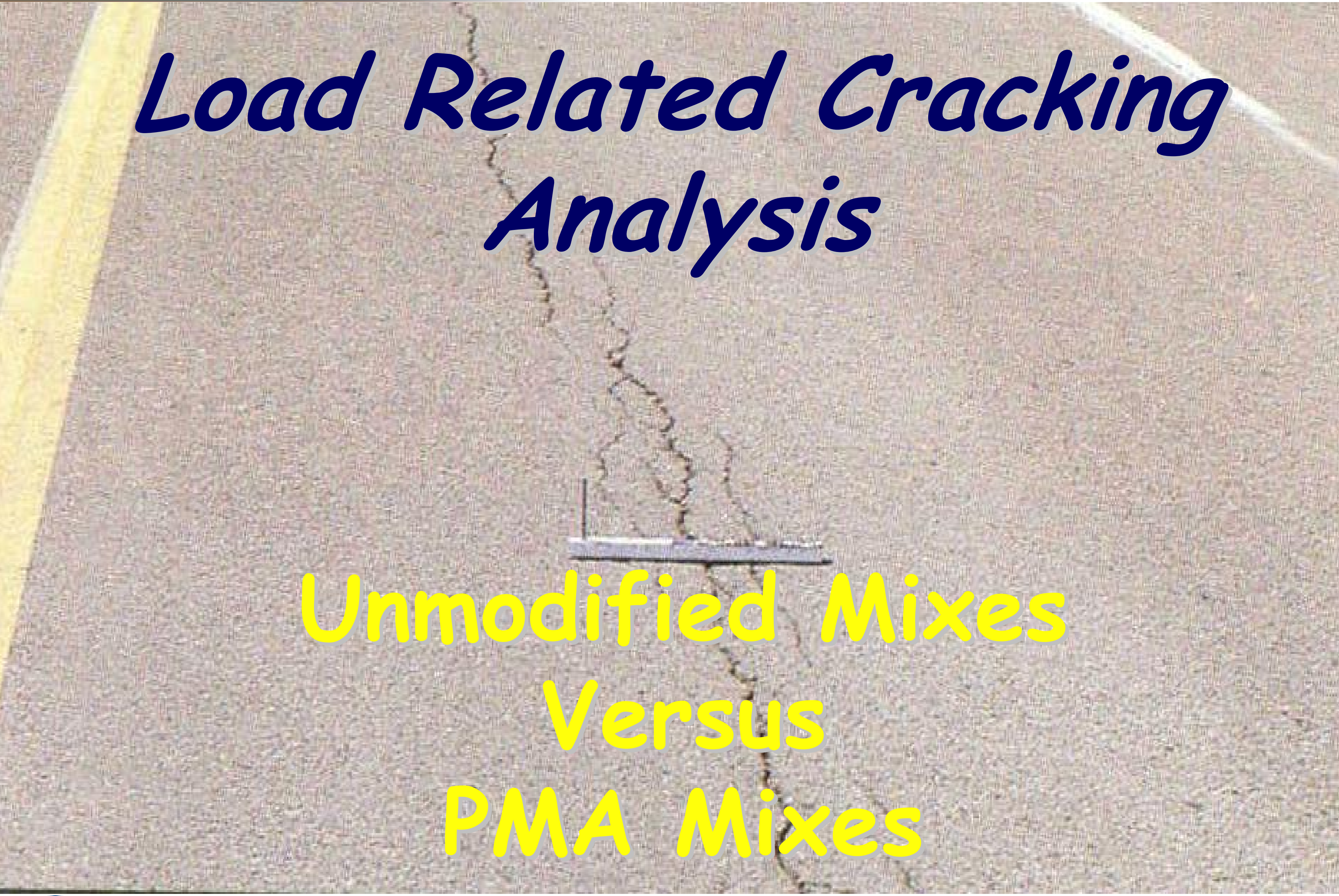
Rutting – Predicted Versus Measured Values



Residual = Predicted – Measured RD

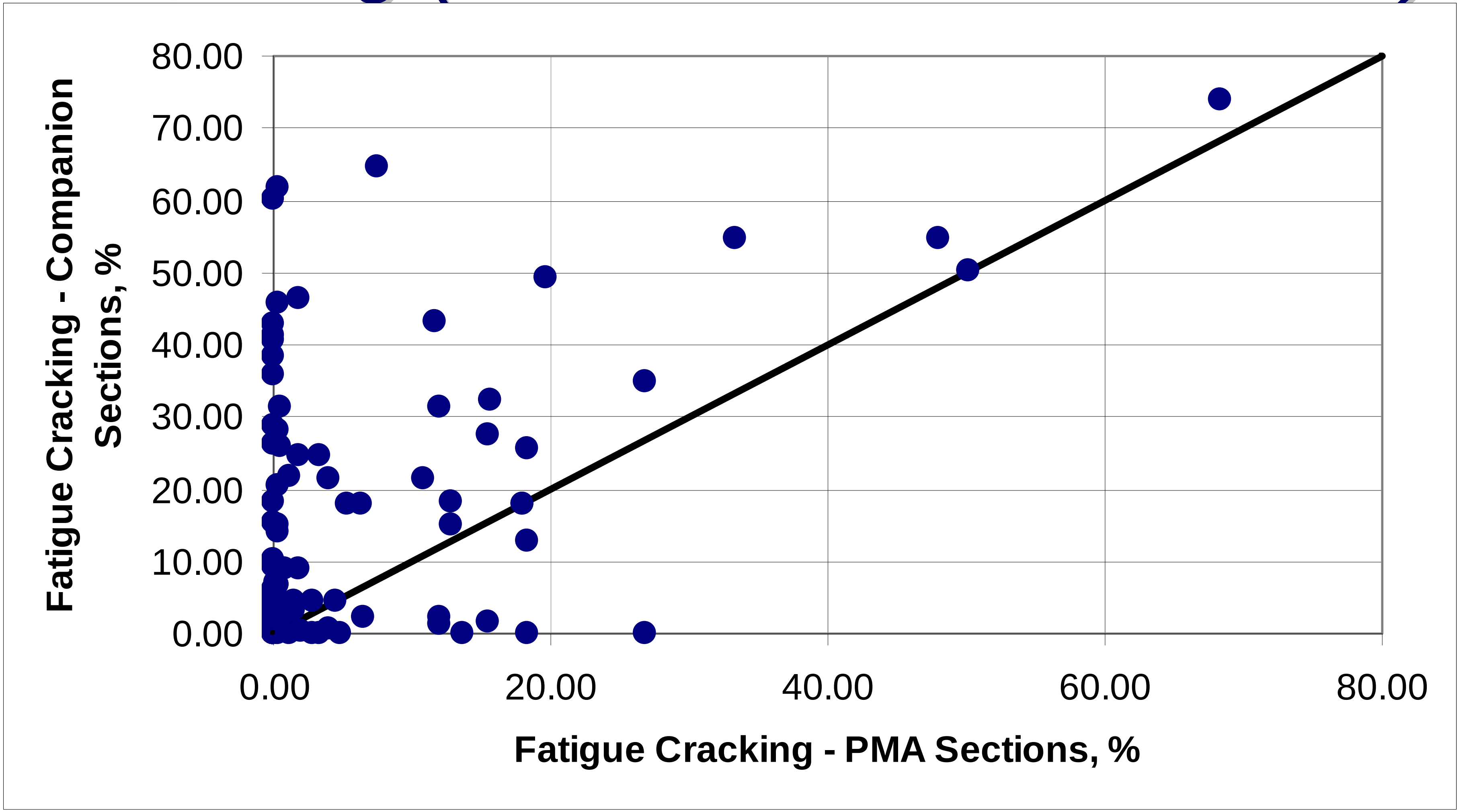


Load Related Cracking Analysis

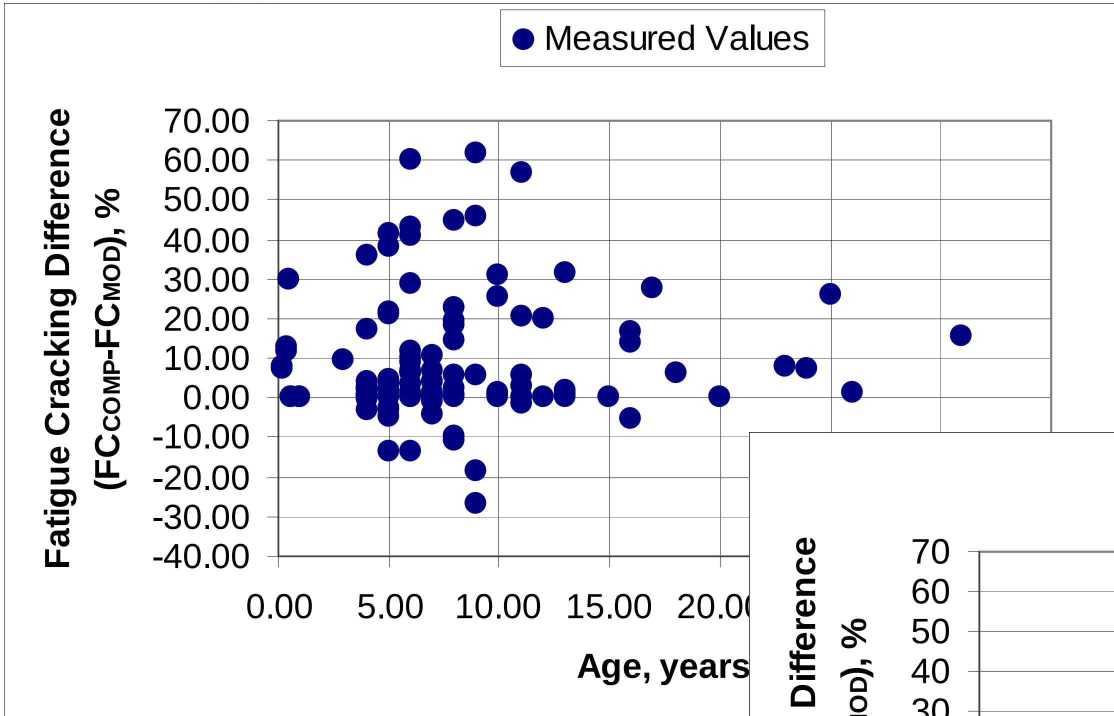


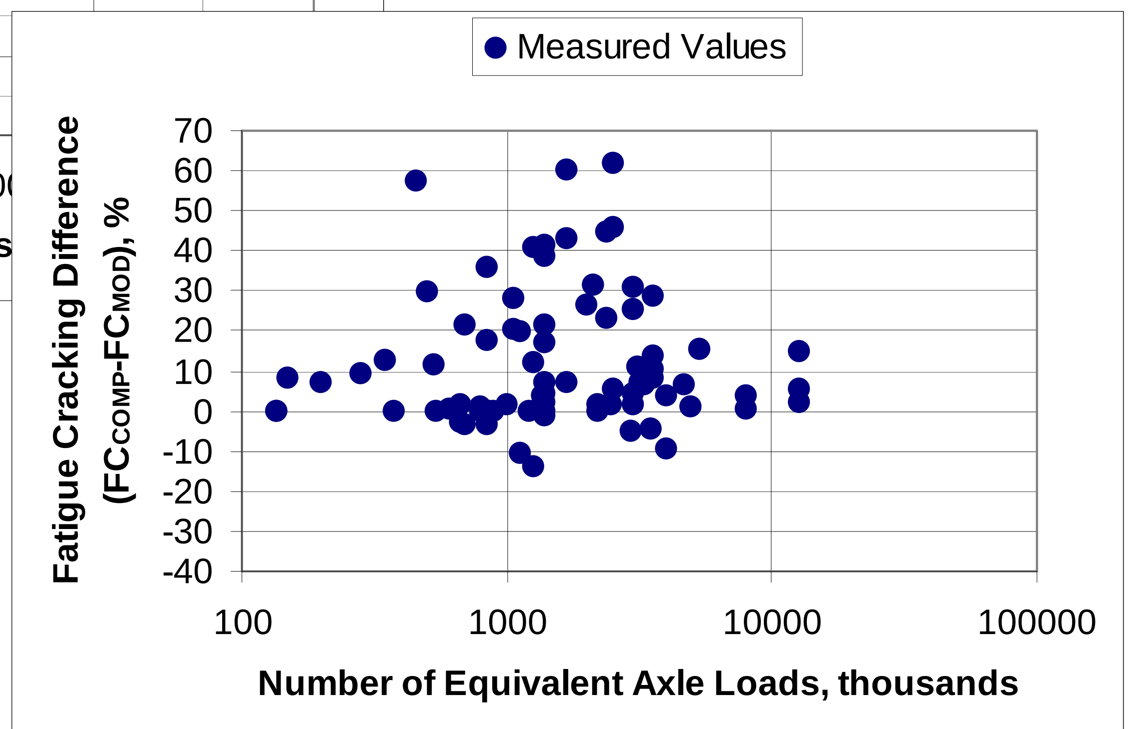
Unmodified Mixes
Versus
PMA Mixes

Distress Comparisons – Fatigue Cracking (Combined Area & LCWP)

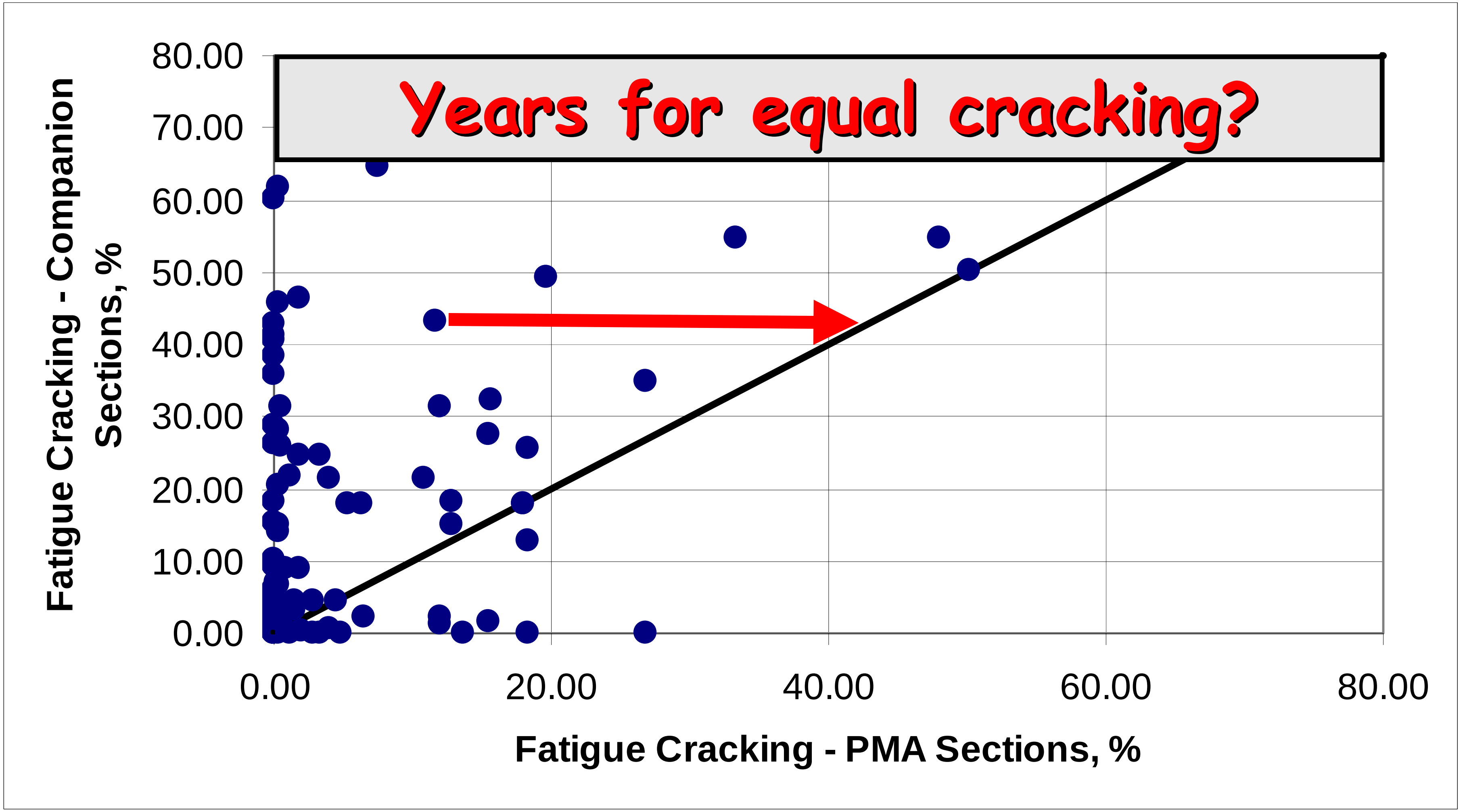


Differences: Neat Minus Modified



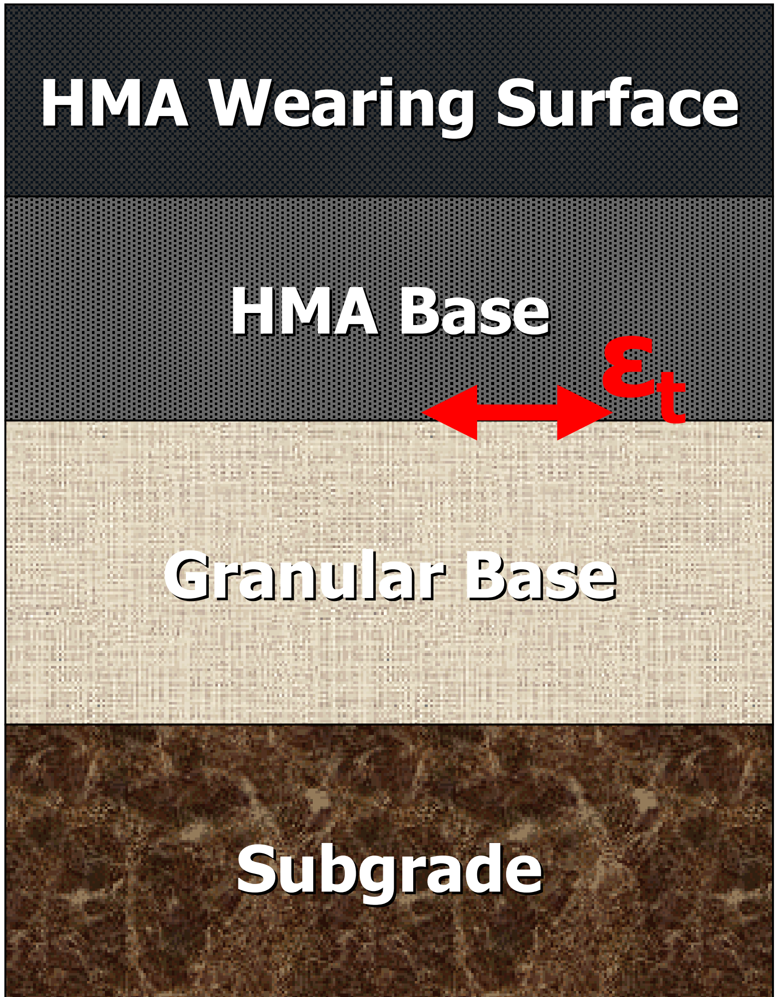


For LCCA, what is the time difference between different amounts of cracking?



Expanding the Realm of Possibility

Fracture Damage Analysis

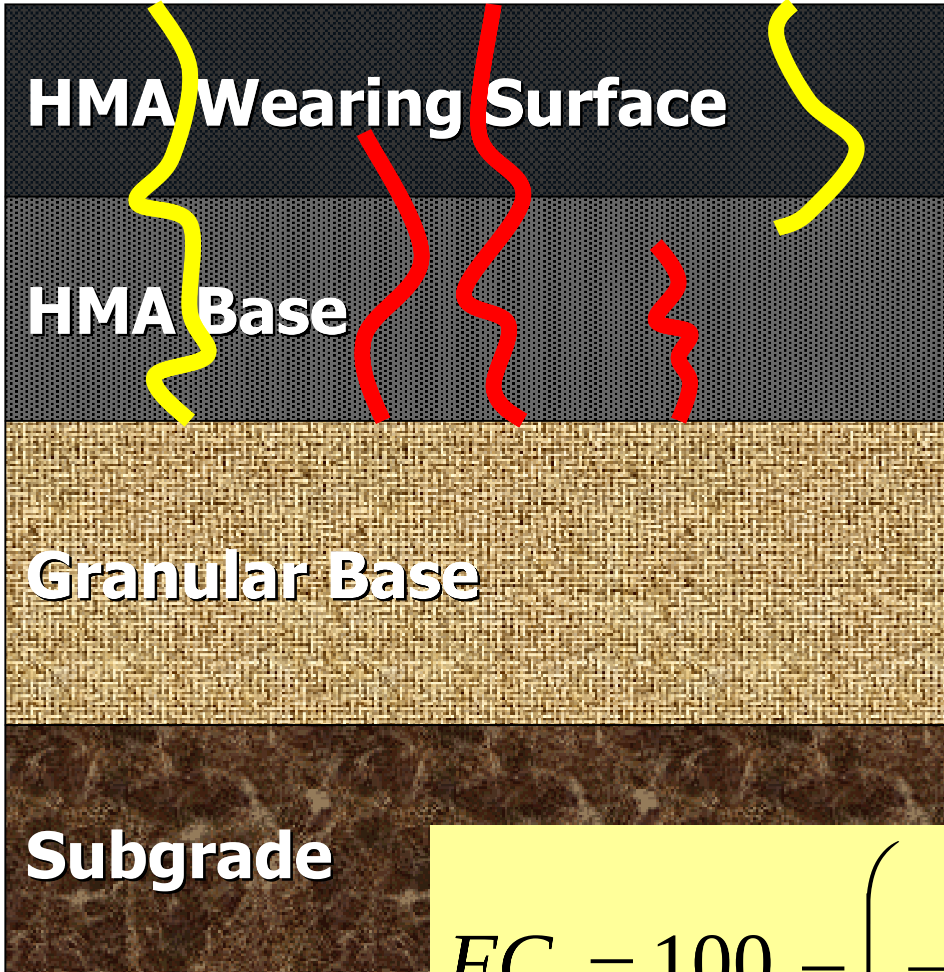


- Use equivalent annual modulus
- Tensile strain at bottom of HMA layer

$$N_f = 0.00432\left(C_{f1}\right)\left(10\right)^M \left(\varepsilon_t\right)^{-3.291}\left(E\right)^{-0.854}$$

$$M = 4.84\left(\frac{V_{beff}}{V_a + V_{beff}} - 0.69\right)$$

Fracture Analysis Assumptions

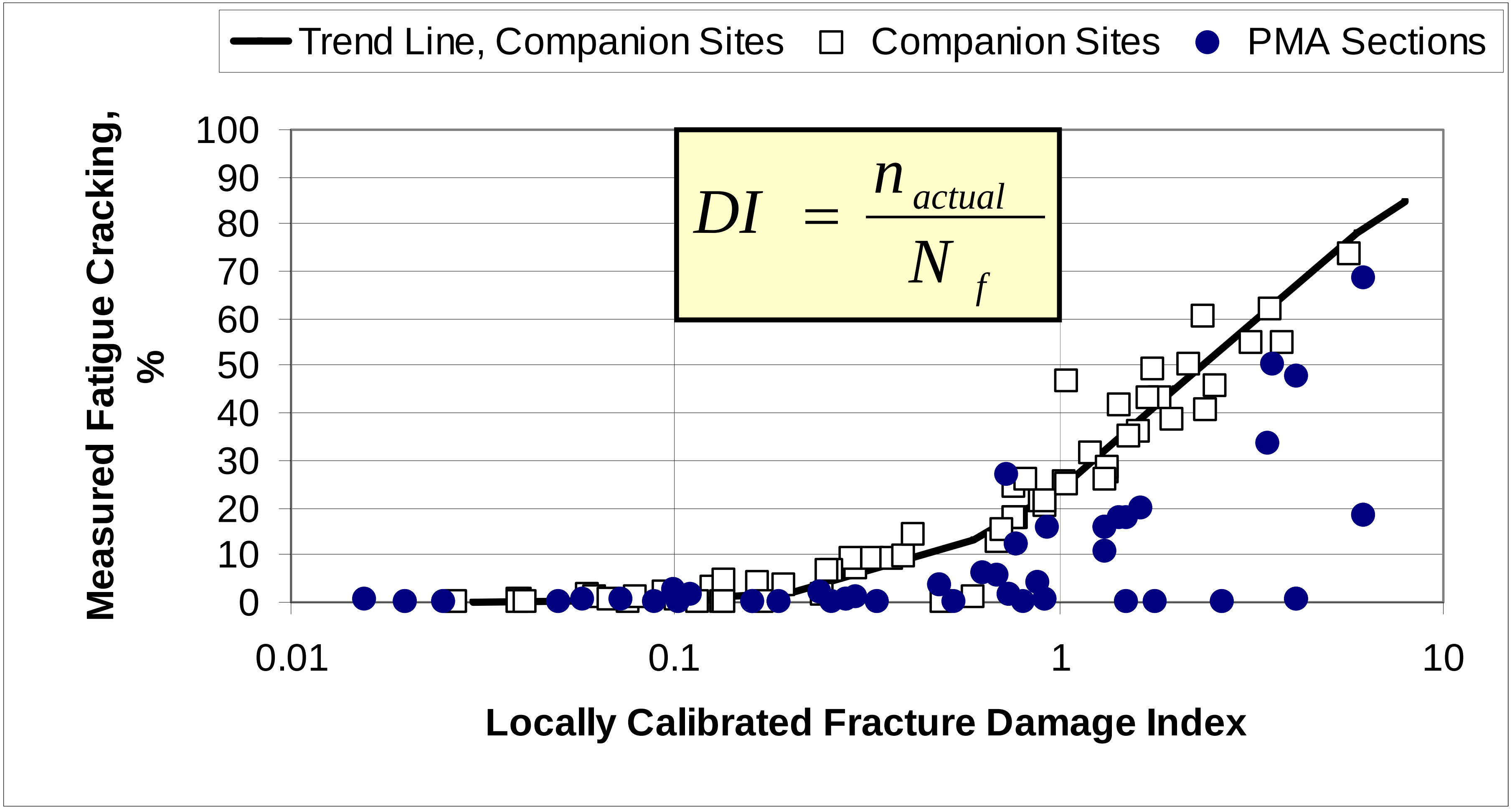


- All load related cracks initiate at the bottom of the HMA.
- Area fatigue cracks combined with longitudinal cracks.

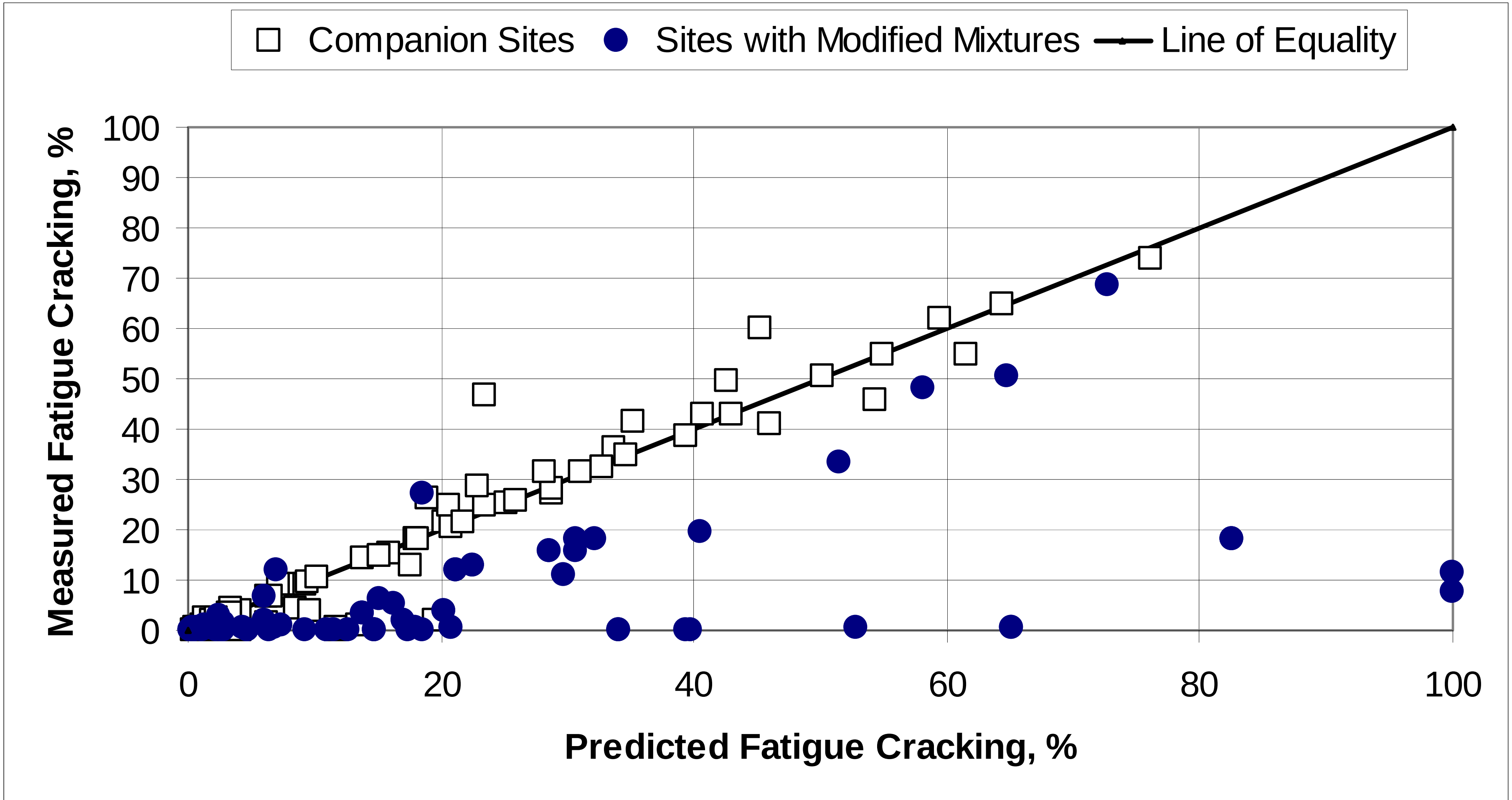
$$DI = \frac{n}{N_f}$$

$$FC = 100 - \left(\frac{100}{5.43656\left(C_{f2}\right)^{0.15\left(C_{f3}\right)\left(DI\right)}} \right)$$

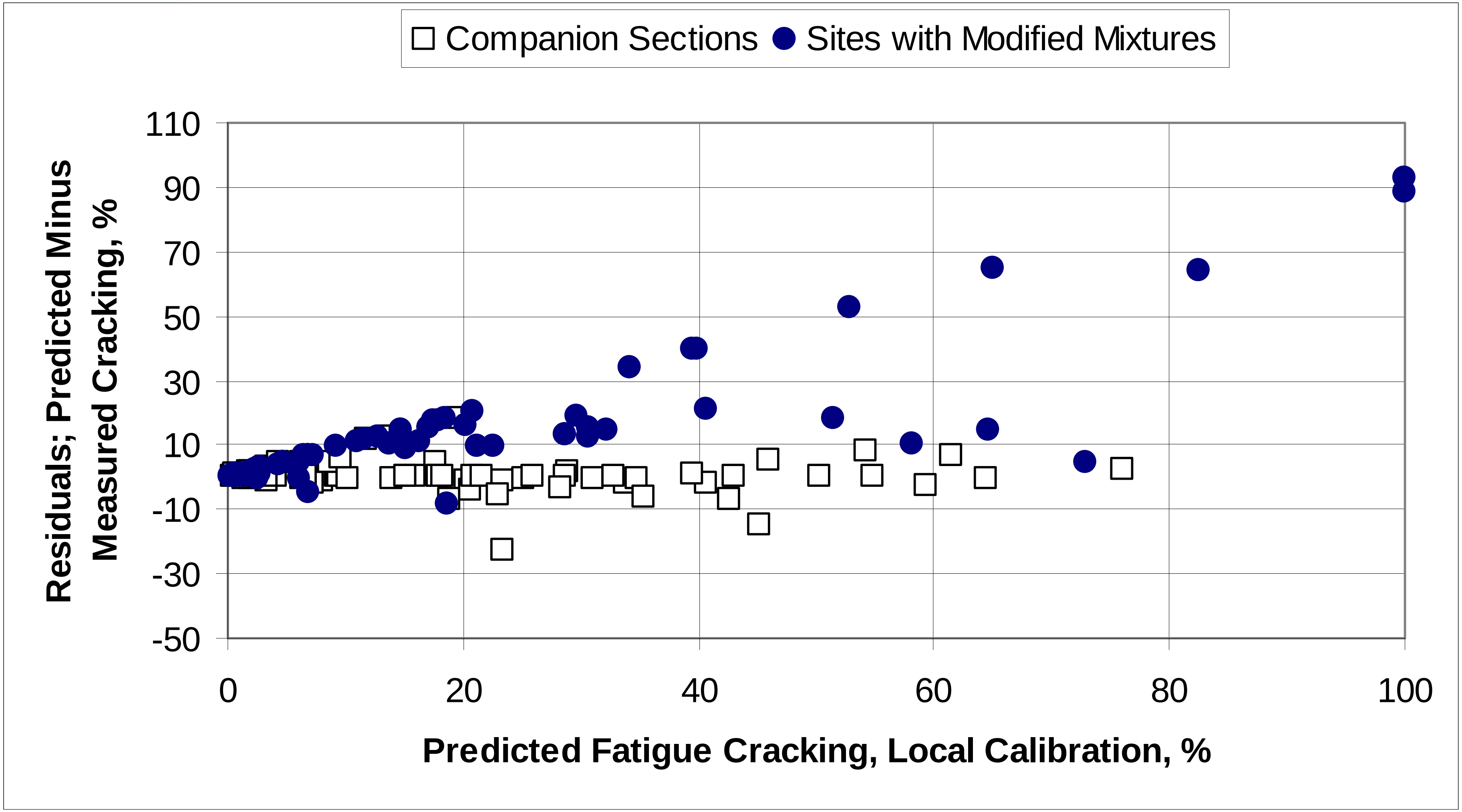
PMA Mixtures: Cracking Versus Damage Index



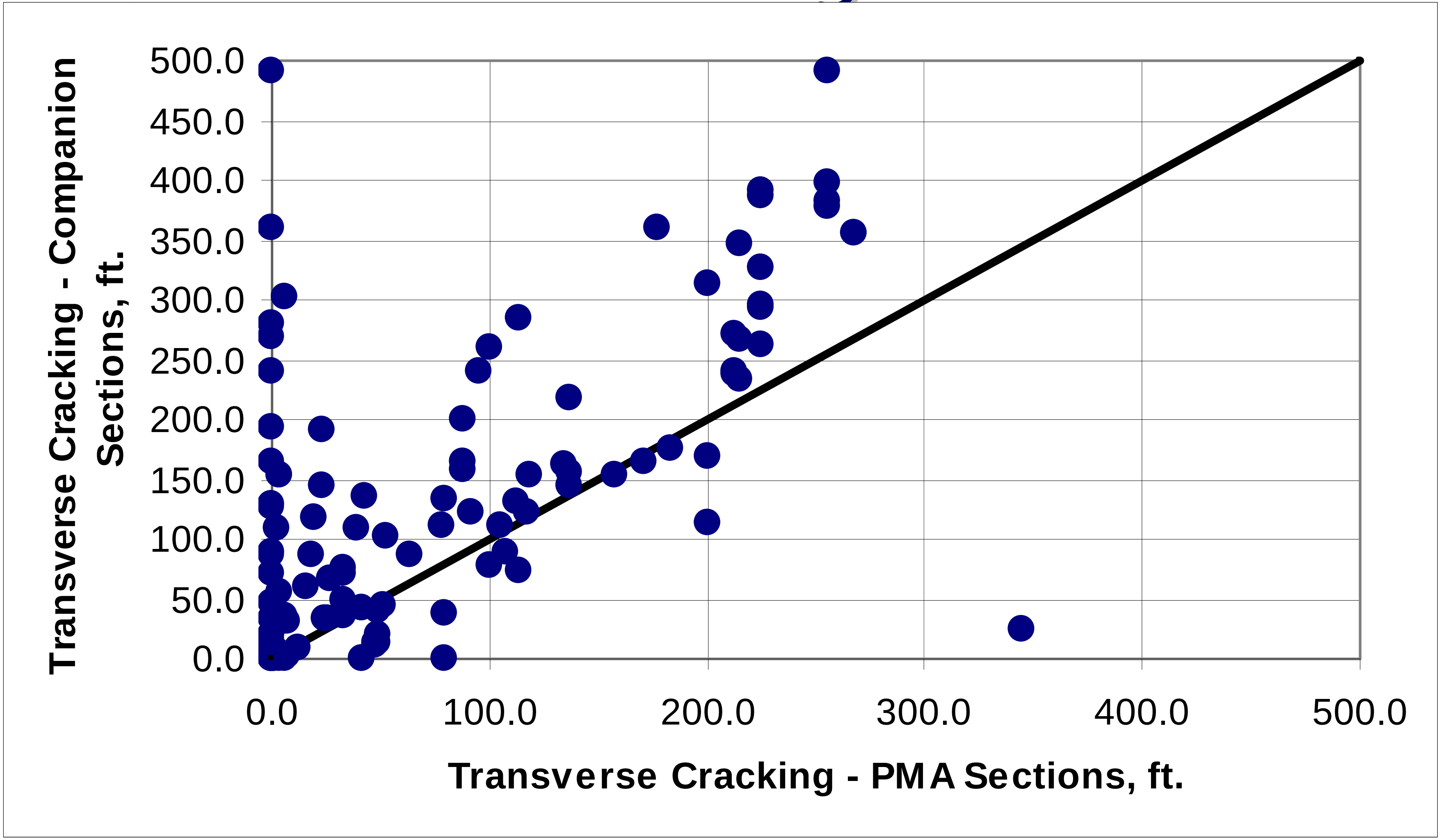
Fatigue Cracking – Predicted Versus Measured Values



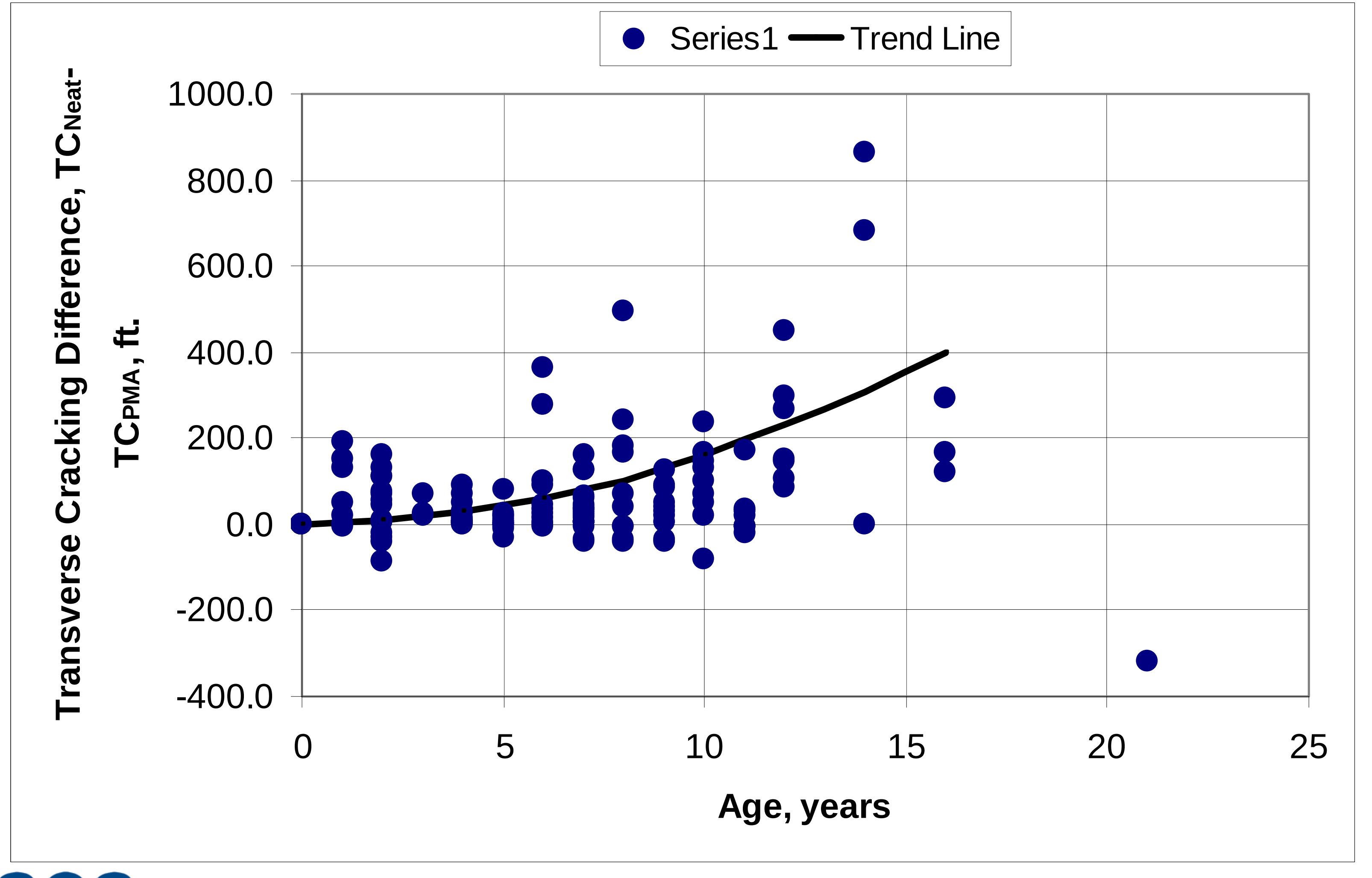
Residual = Predicted - Measured



Distress Comparisons – Transverse Cracking



TC Differences: Neat - Modified Values



Summary of Findings & Conclusions

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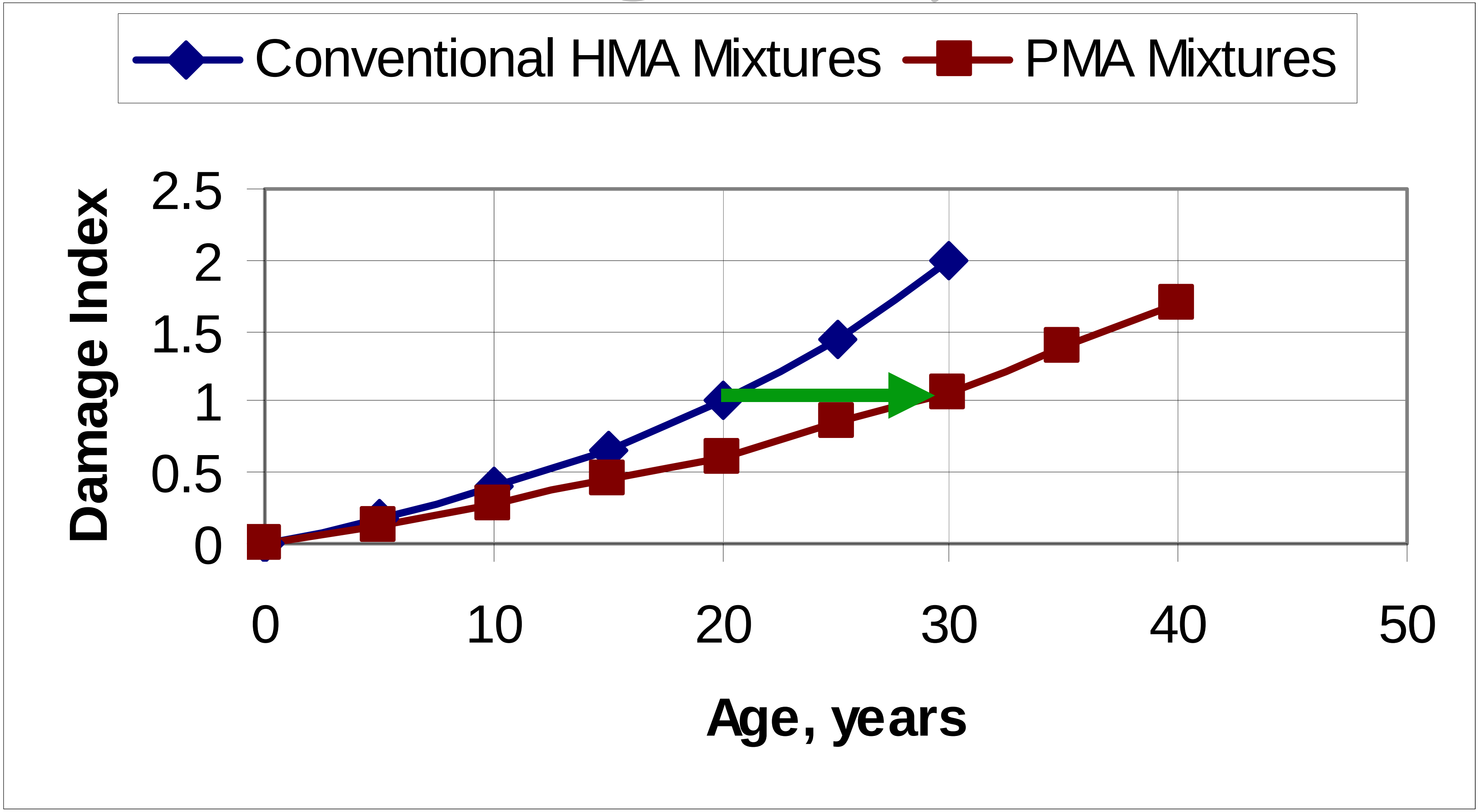
Summary – Enhanced Performance Based on Damage Analysis



Summary – Expected Increase in Service Life, years

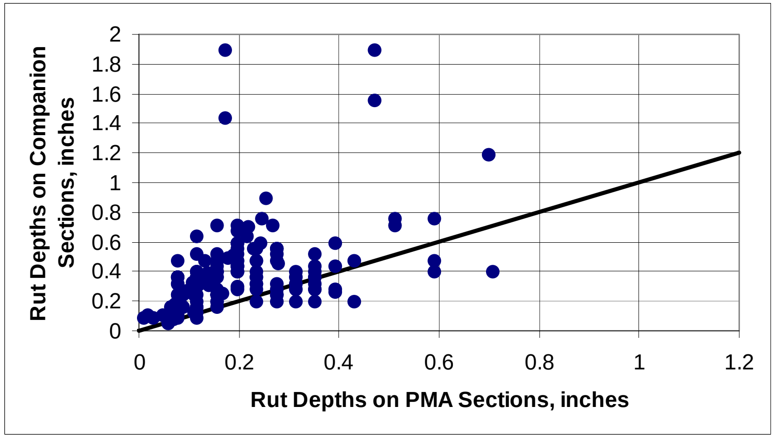
Site Factor	Condition Description		Added Life
Foundation	Non-Expansive/Non-Frost Sus.		5-10
	Expansive		2-5
	Frost Susceptible		2-5
Water Table & Drainage	Deep		5-10
	Shallow; Adequate		5-8
	Shallow; Inadequate		0-2
Existing Pavement Condition	HMA	Good	5-10
		Poor-Extensive Cracking	1-3
	PCC	Good	3-6
		Poor-Faulting & Cracking	0-2

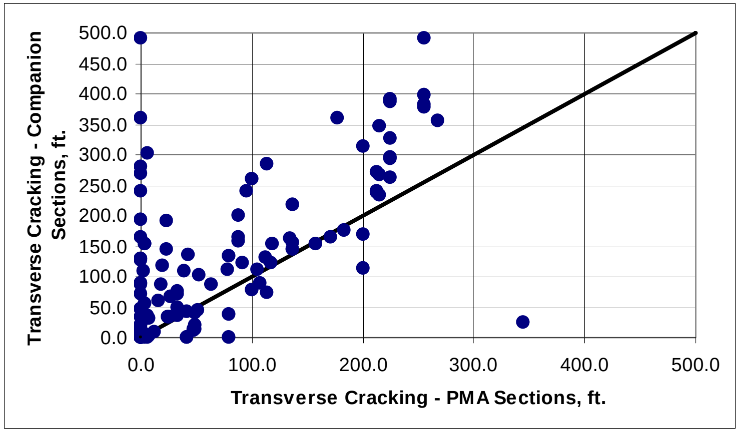
Summary – Expected Increase in Service Life, years

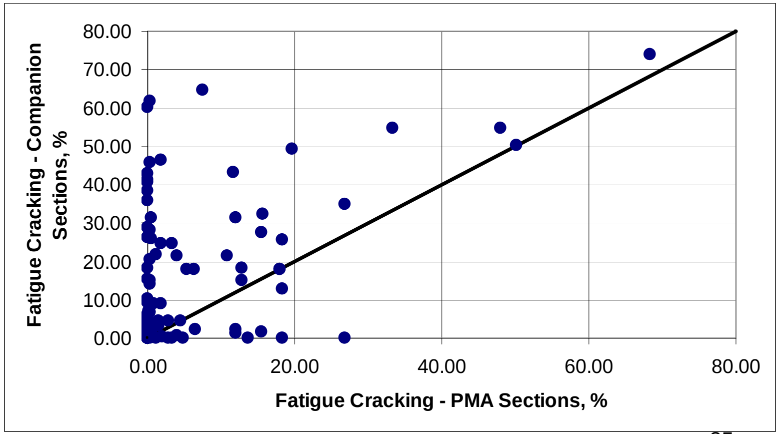
Site Factor	Condition Description		Added Life
Climate; Temp. Fluctuations	Hot	Hot Extremes	5-10
	Mild		2-5
	Cold	Cold Extremes	3-6
Traffic, Truck Volumes	Low	Intersections	5-10
		Thoroughfares	3-6
		Heavy Loads	5-10
	Moderate		5-10
	High		5-10

Findings

- Use of PMA reduces distress in pavements & overlays
  - Less Fatigue Cracking
  - Fewer Transverse Cracks
  - Smaller Ruts



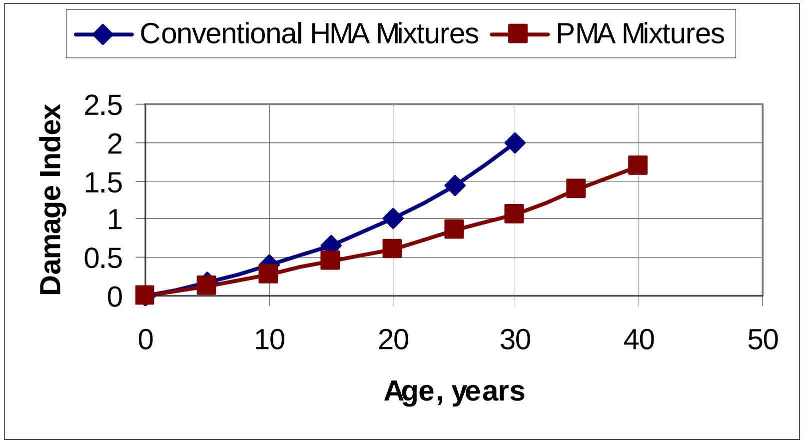




Findings

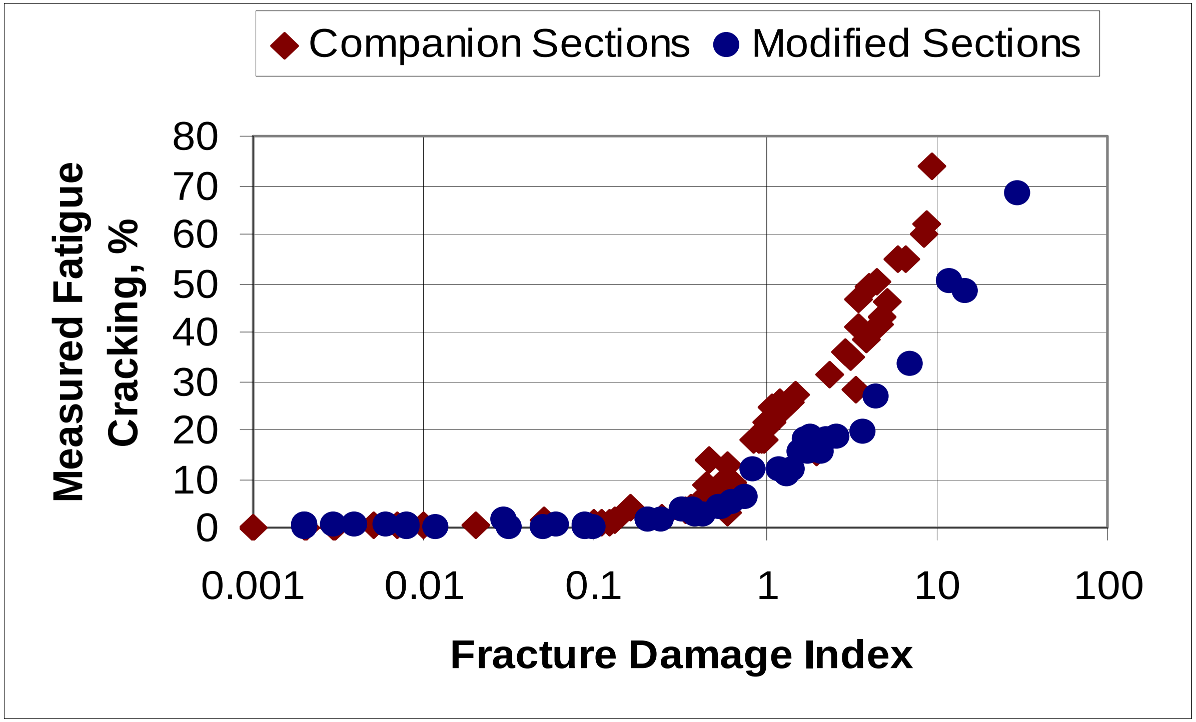
Field & laboratory investigations of PMA mixes suggest:

- **Enhanced Performance**
  - 25 to 100 % increase in service life
  - 3 to 10 years increase in service life
- **Reduced Maintenance Activities**
  - Crew Safety
  - Traffic Delay



Findings

- Mechanistic-empirical analysis confirms need for ***different calibration factors*** for predicting performance of PMA mixtures.



Conclusions

- Use of PMA mixes do extend the service life over unmodified HMA mixes.
- Layer thickness should not be reduced when empirical design methods are used.

Thus, for LCCA:

- ✔ Increase service life
- X Do not reduce thickness

Thank you for your attention - Any questions?

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