PMA Calibration Factors for the MEPDG

Association of Modified Asphalt Producers

12 February 2008

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Applied Research Associates, Inc.
An Employee-Owned Company

Presentation Overview

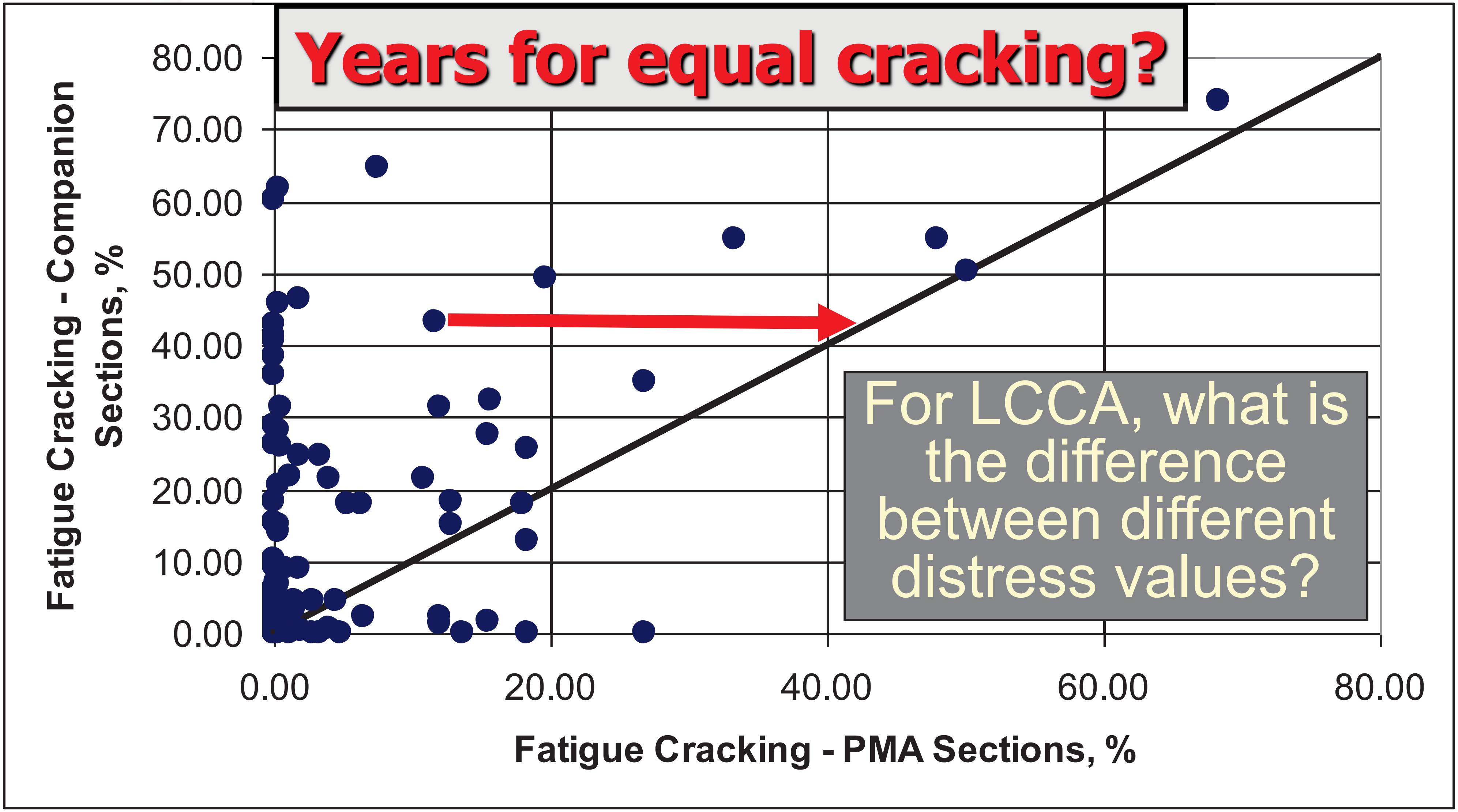
1. Introduction
2. Distress Comparison Update
3. PMA Calibration Factors & the MEPDG
4. Conclusions (Findings & Marketing Issues)

Study Objective

1. Determine the MEPDG calibration factors for PMA mixtures, as compared to neat or unmodified HMA mixtures.

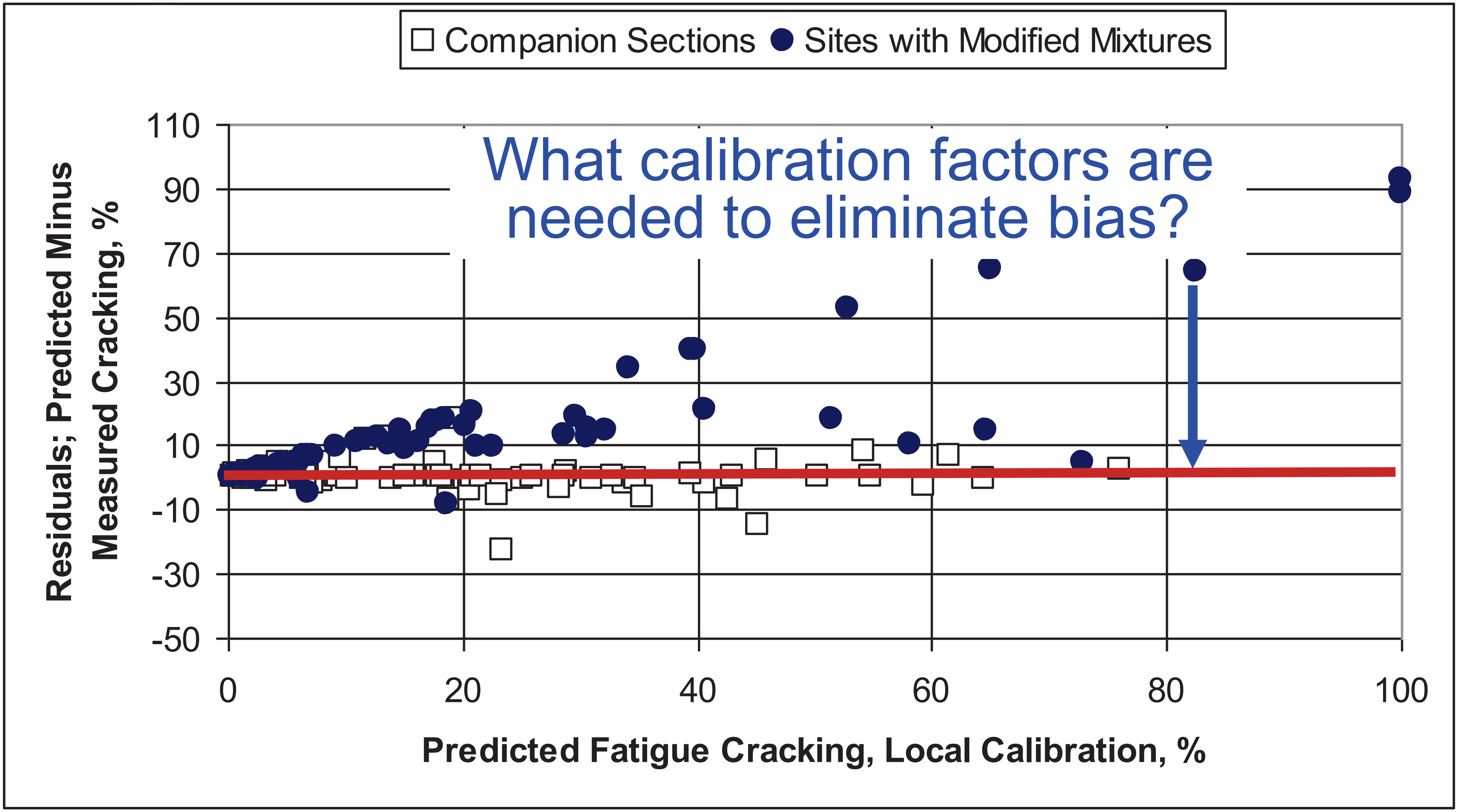
Continuation of: *Quantifying the Effects of PMA for Reducing Pavement Distress*; Report IS-215

Quantifying the Effects of PMA

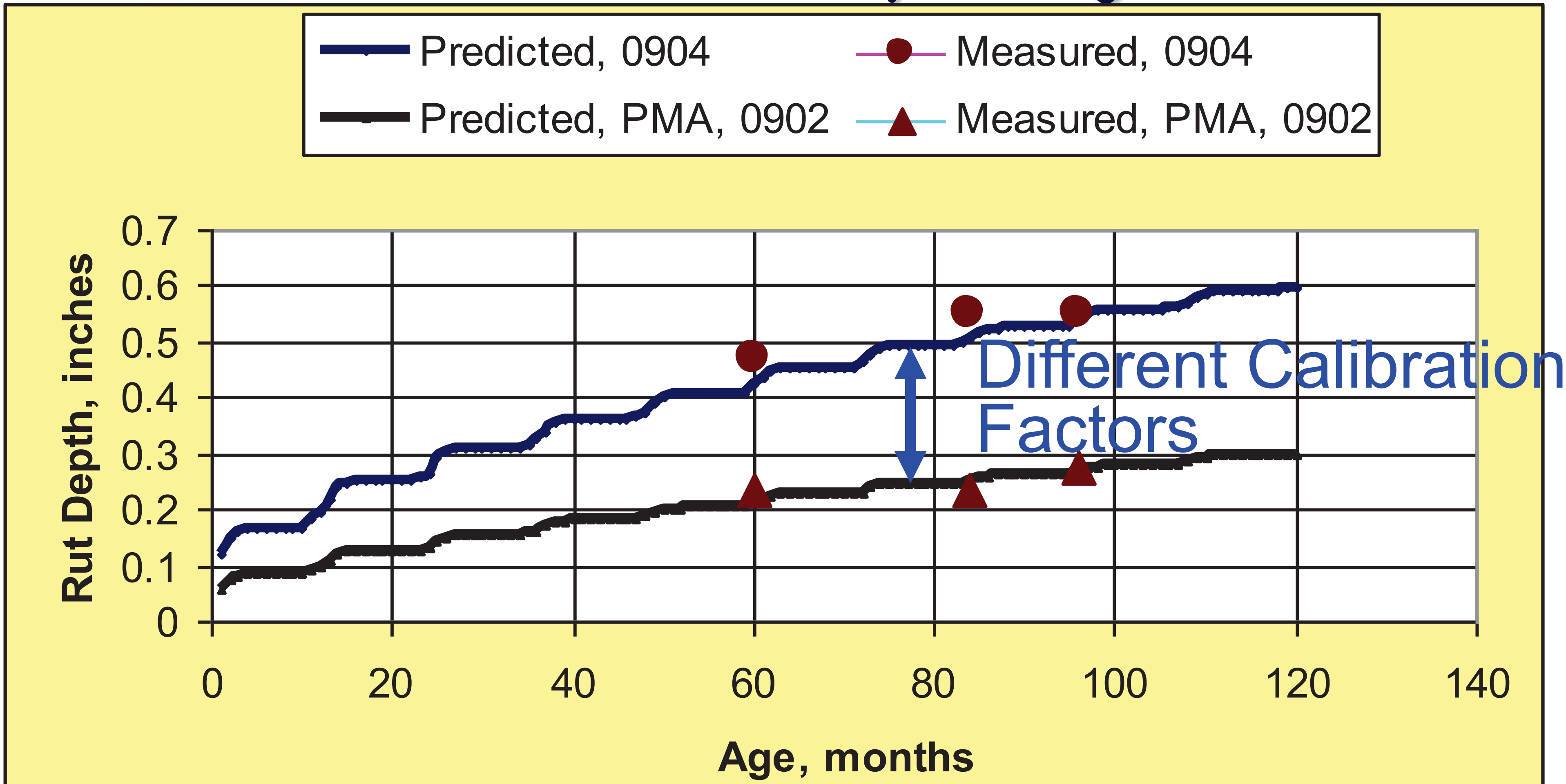


AI Report IS-215

Residuals - Fatigue Cracking



Calibration Study Objective



For Design: What is the calibration factor to eliminate bias between the measured & predicted distress values?

Type of Materials

- Insufficient data to determine material specific effects.
- Most of the test sections included one of the following polymers:
  - Natural latex
  - Synthetic latex
  - Block copolymer
  - Plastics

Cell Specific Calibration

Pavement Cross Section	Foundation	Climate			
		Freeze		Non-Freeze	
		Wet	Dry	Wet	Dry
Thin HMA	Fine-Grained	2	2	4	3
	ined	3	3	3	3
		2	2	2	3
	ed	2	2	3	2
Full-Depth	rained	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

Neat HMA used for calibration to define time difference

Types of Analyses

1. Comparison of measured distress values using more recent data, **2006**.
2. Determine mix calibration factors & compare neat & PMA values using **Version 1.0 of the MEPDG**.

Slight deviation from initial plan.

Presentation Overview

1. Introduction
2. **Distress Comparison Update**
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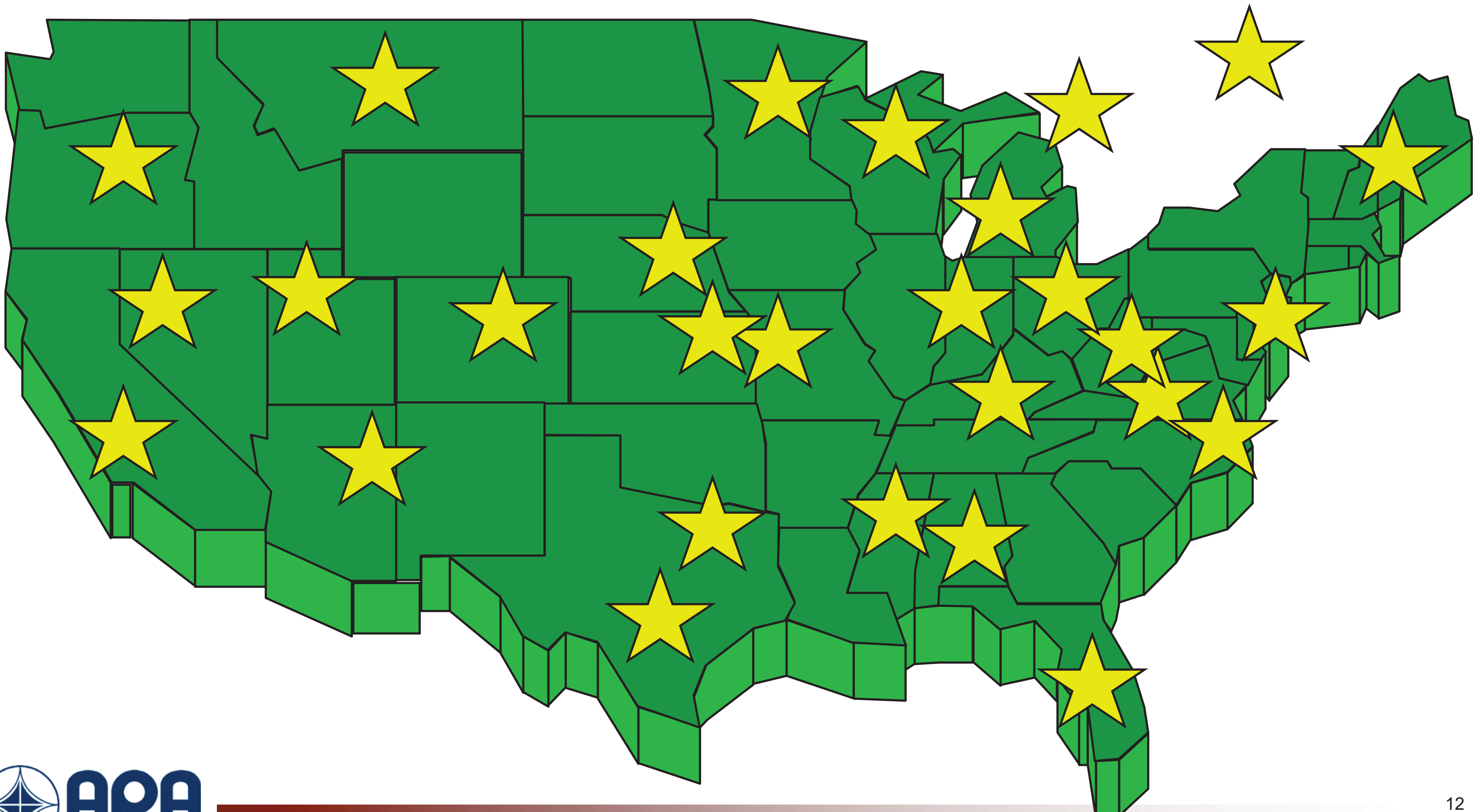
Comparison of Pavement Distress/Performance

- Fatigue Cracking; Area & longitudinal combined
- Rutting
- Thermal Cracking

Selected Pavement Locations for Performance Comparisons



Distress Comparison—Rutting

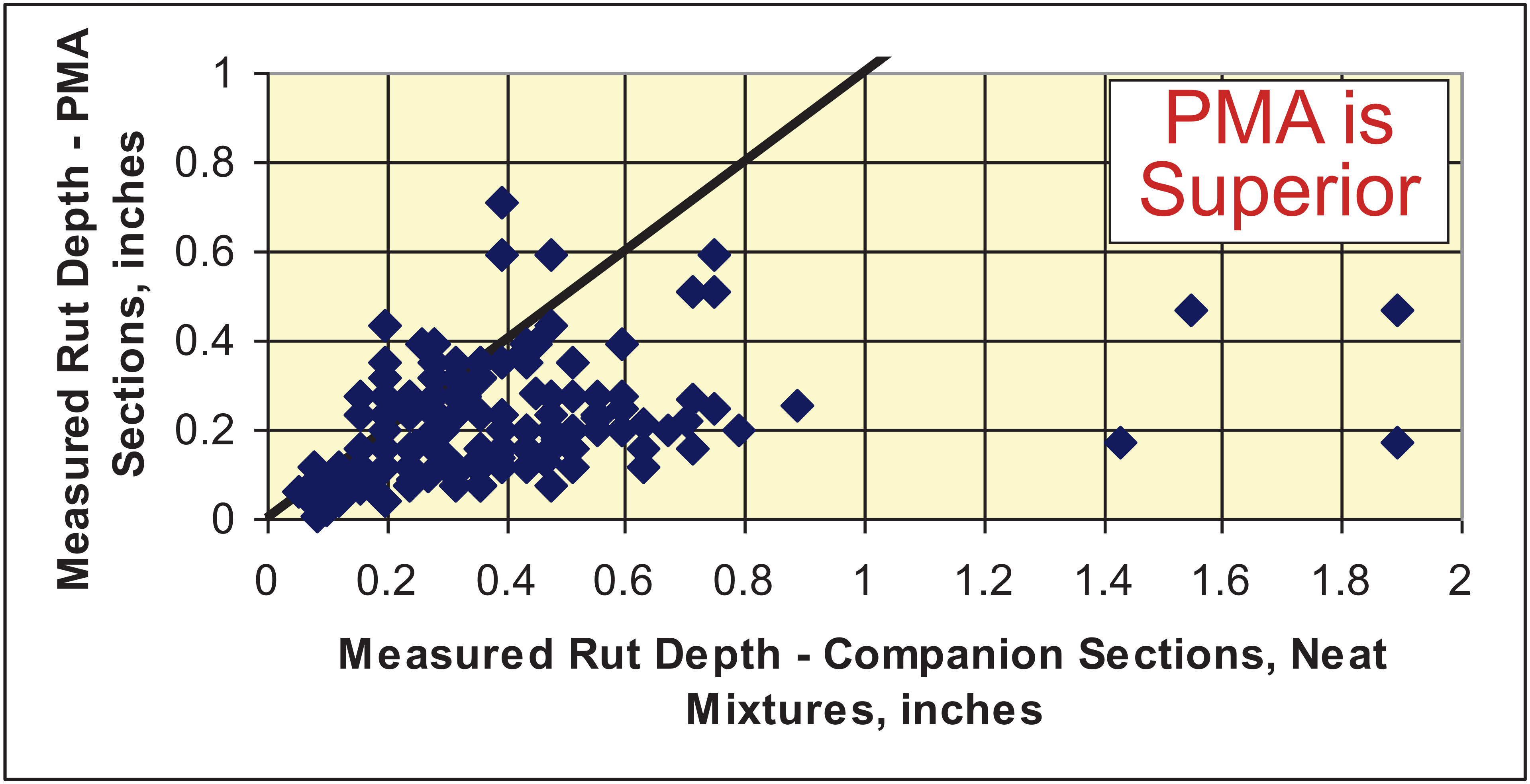


Figure 2 in the report.

Distress Comparison—Fatigue Cracking

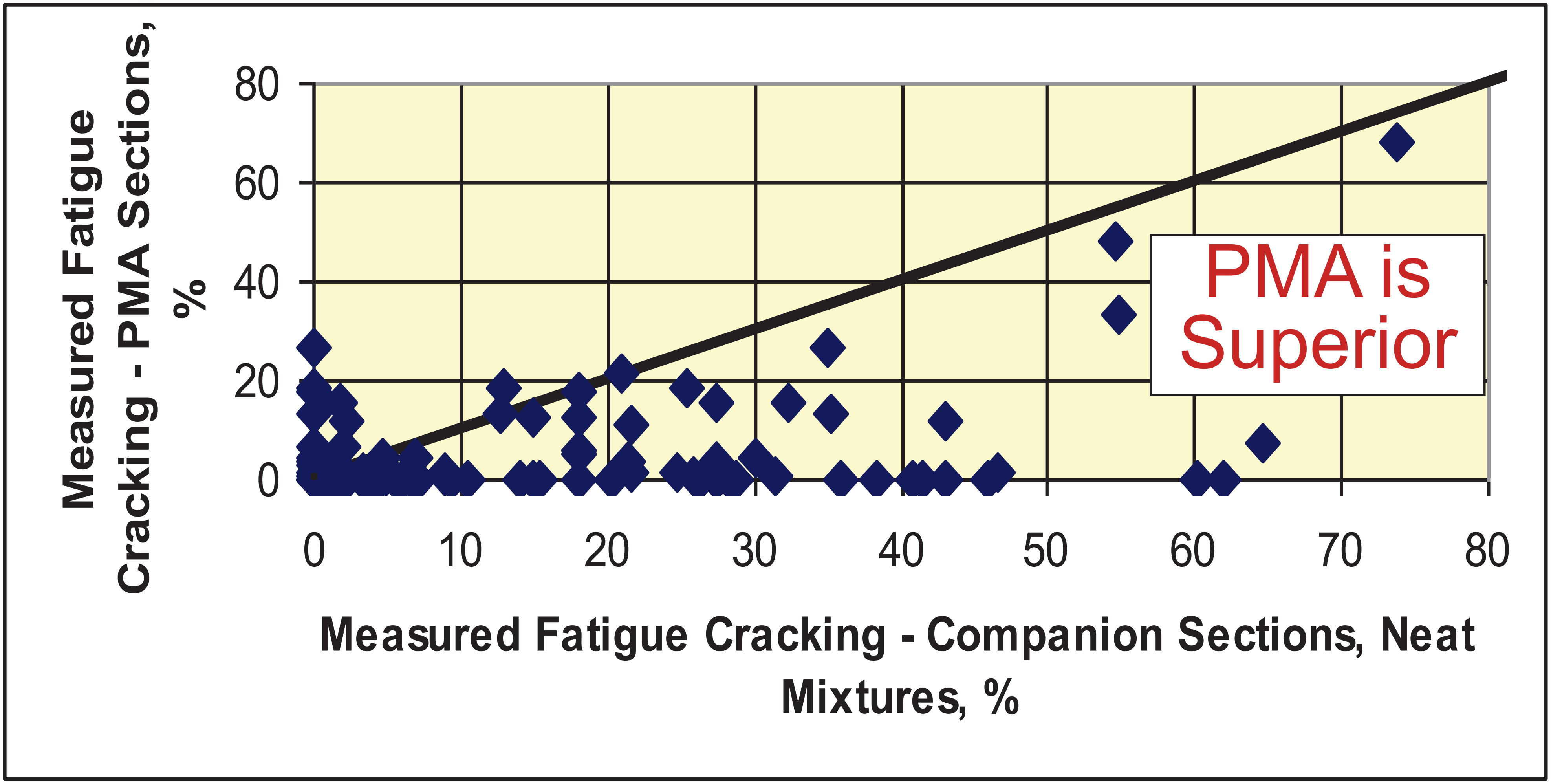


Figure 3 in the report.

Distress Comparison—Transverse Cracking

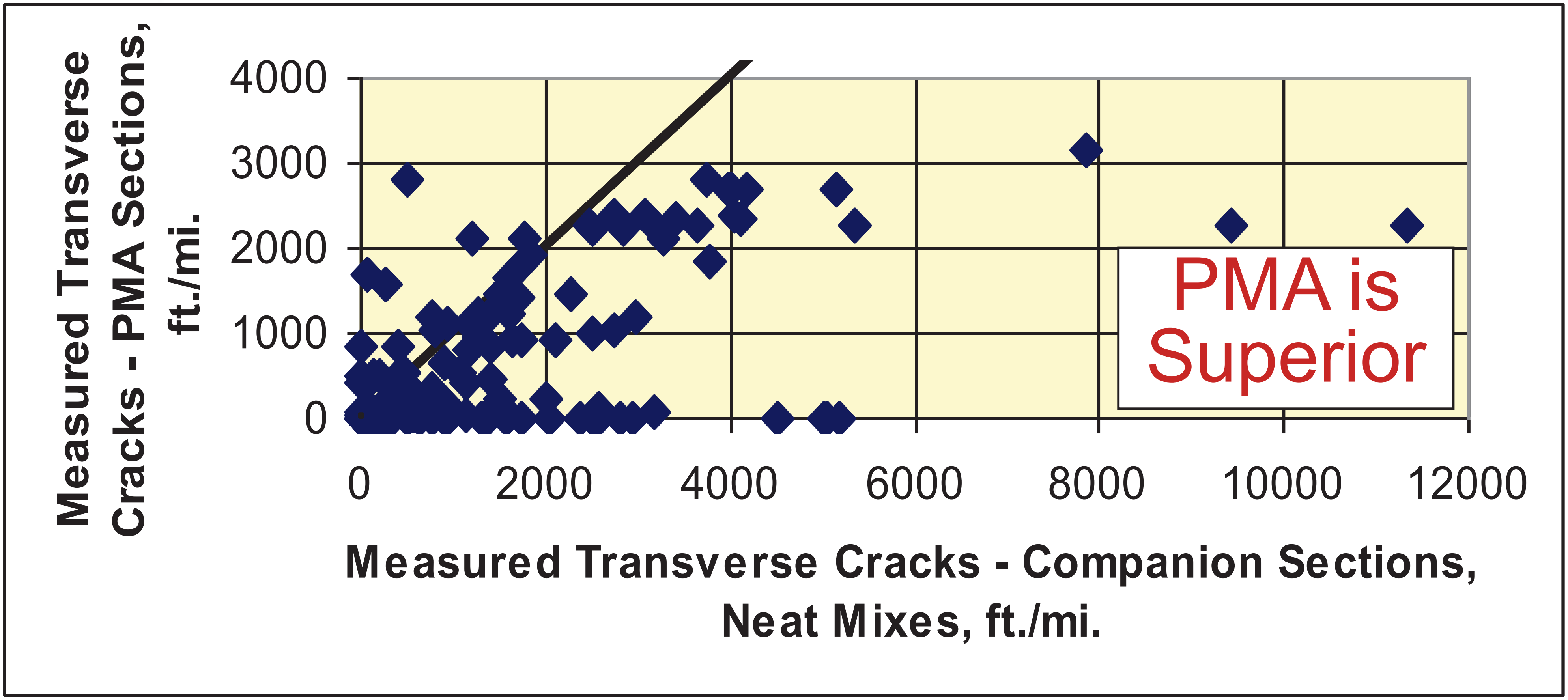


Figure 4 in the report.

Summary of Distress Differences

Distress	Average Difference; Neat Minus PMA Values
Rut Depth, inches	+0.18
Fatigue Cracks, %	+7.1
Transverse Cracks, ft./mi.	+694

Table 1 in the report.

Presentation Overview

1. Introduction
2. Distress Comparison Update
3. **PMA Calibration Factors & the MEPDG; Version 1.0**
4. Conclusions (Findings & Marketing Issues)

PMA Calibration Factors for Rutting

Neat Versus PMA Mixes

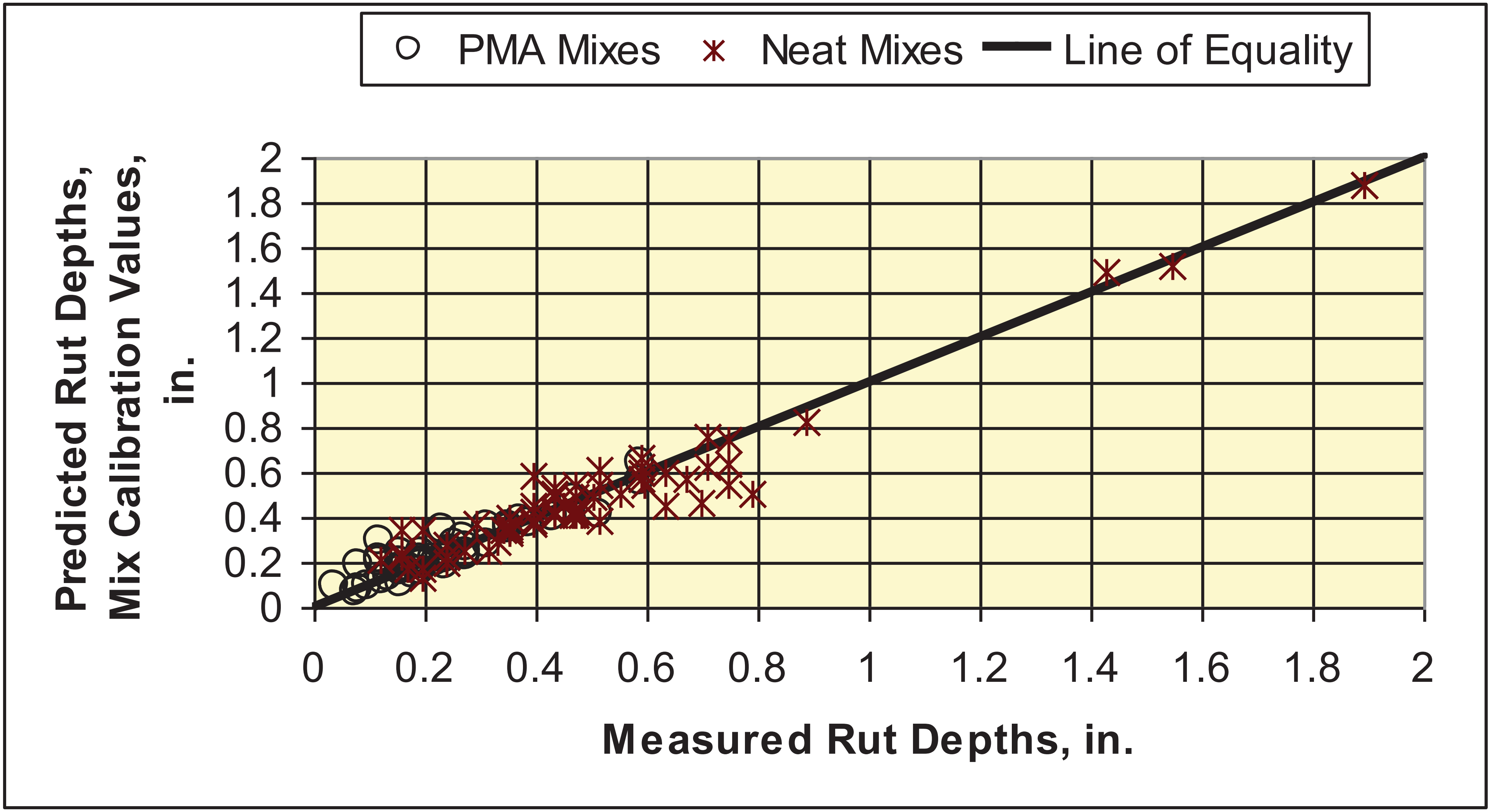
MEPDG Rut Depth Transfer Function

$$\Delta_{p(HMA)} = [h_{HMA}\beta_{1r}k_Z\varepsilon_{r(HMA)}]*$$

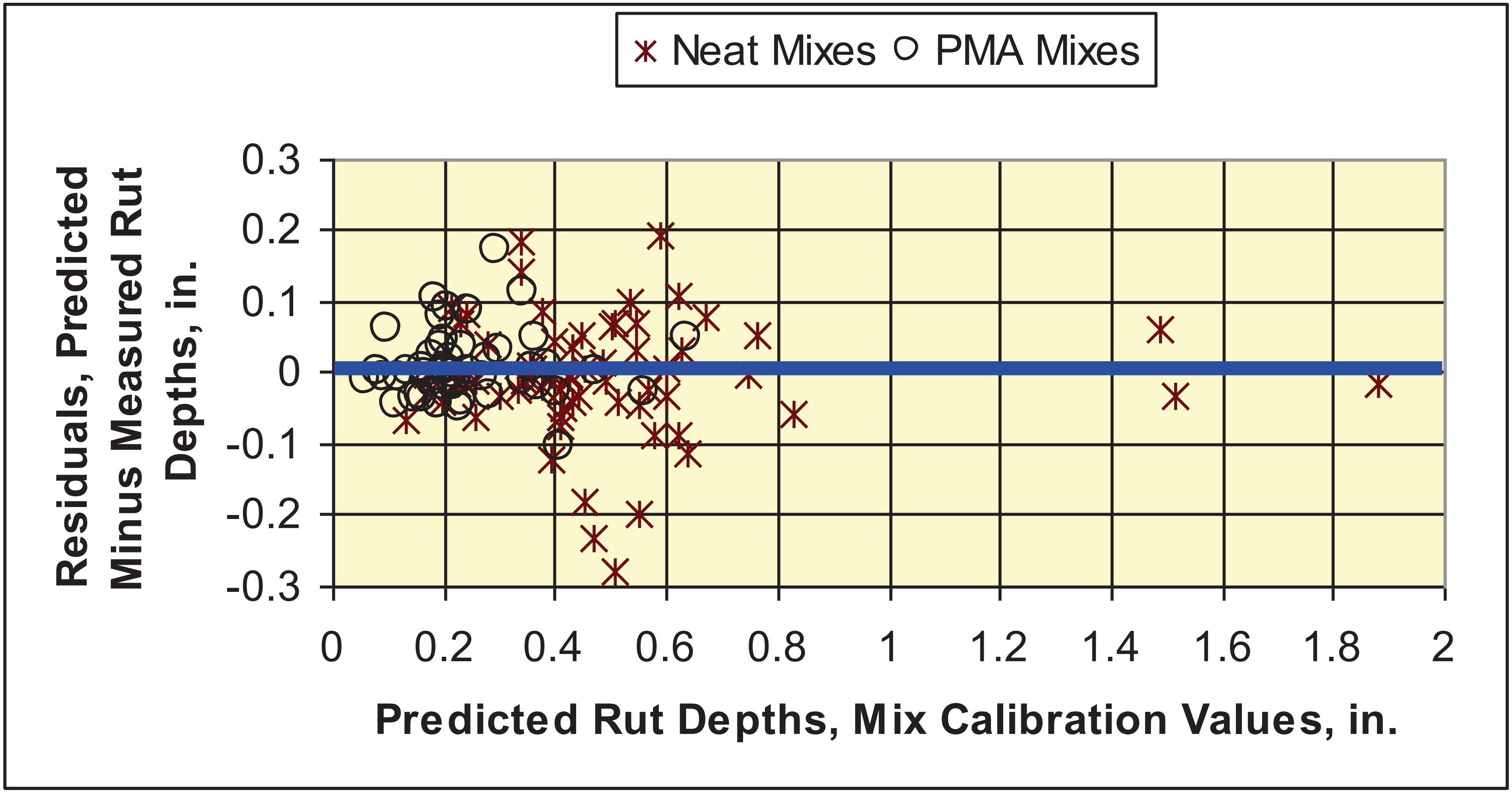
$$[10^{k_{1r}}N^{k_{2r}\beta_{2r}}T^{k_{3r}\beta_{3r}}]$$

The calibration factor varied in study.

Rutting – Neat versus PMA Sections

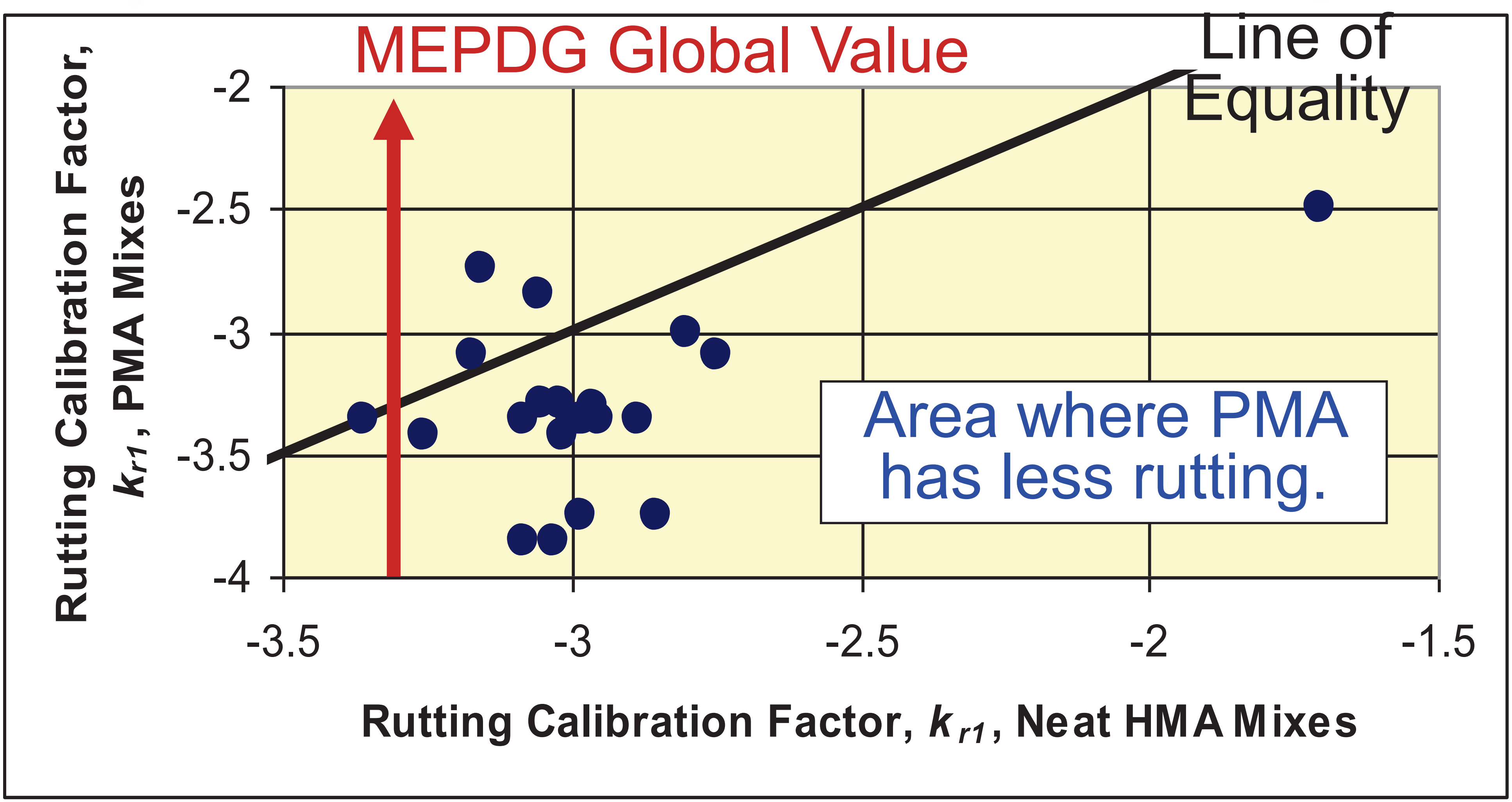


Residuals – Rut Depths

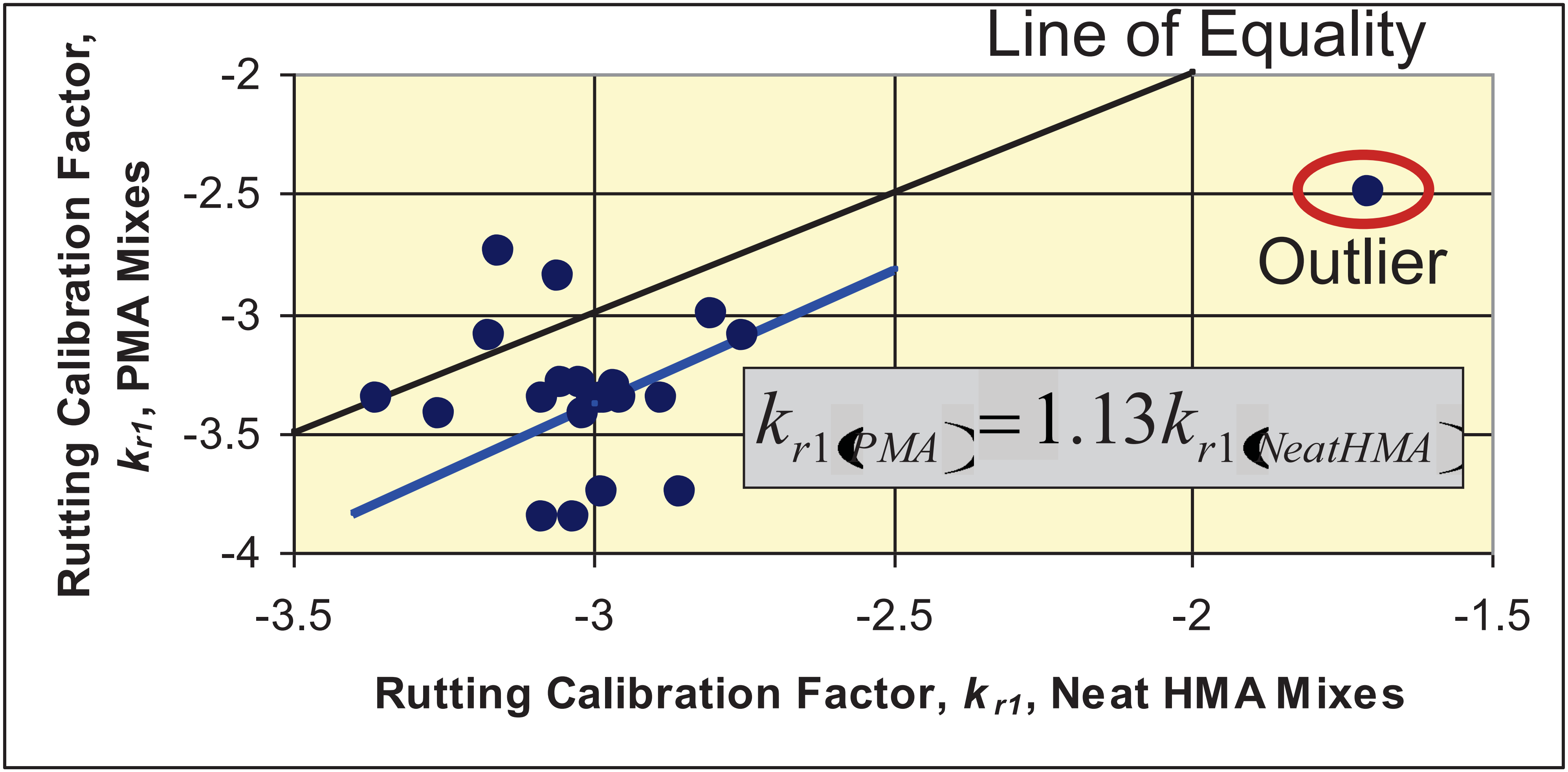


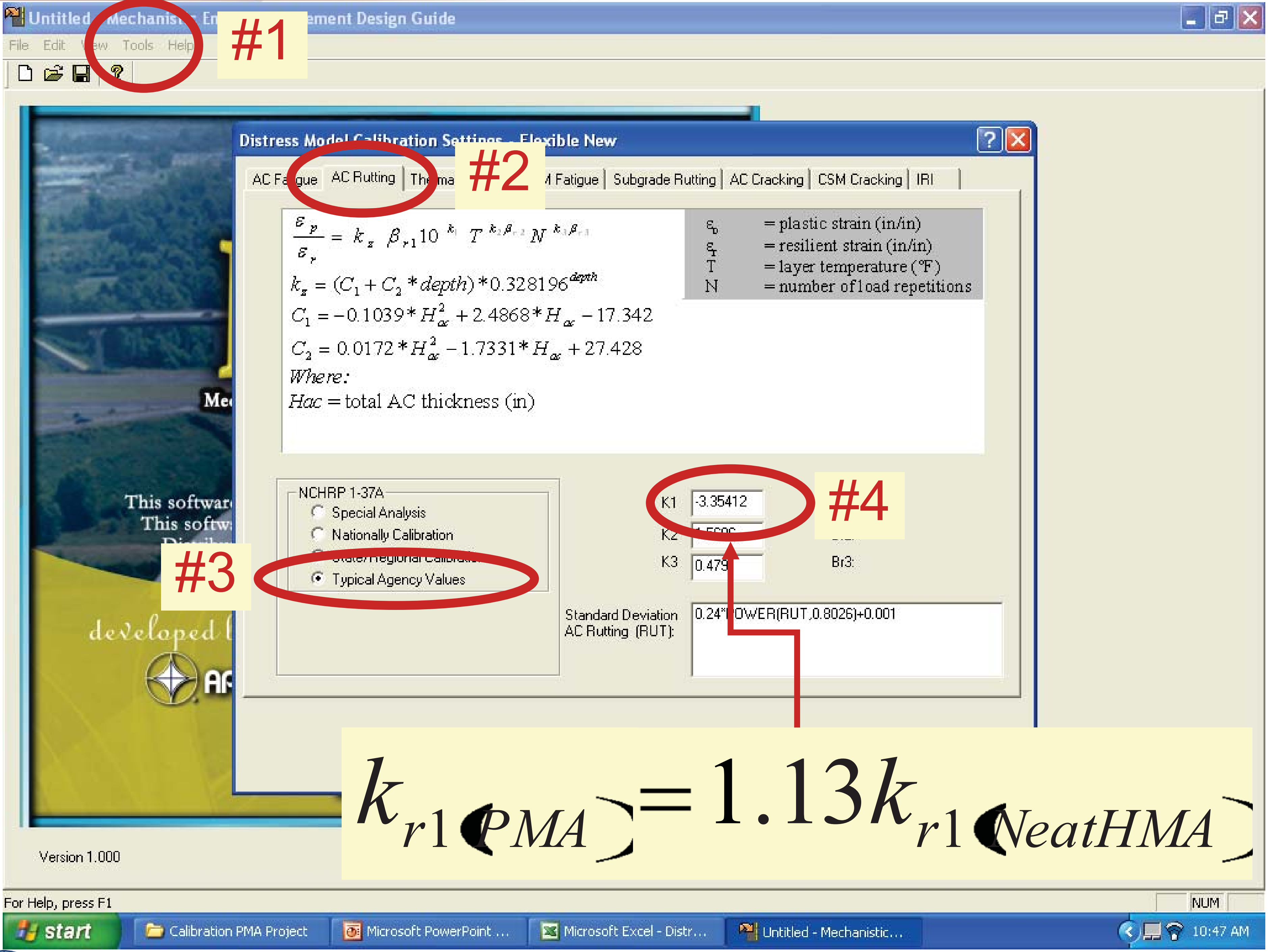
Time does not affect residuals between neat & PMA mixtures.

Comparison of Neat & PMA Calibration Values: Rutting

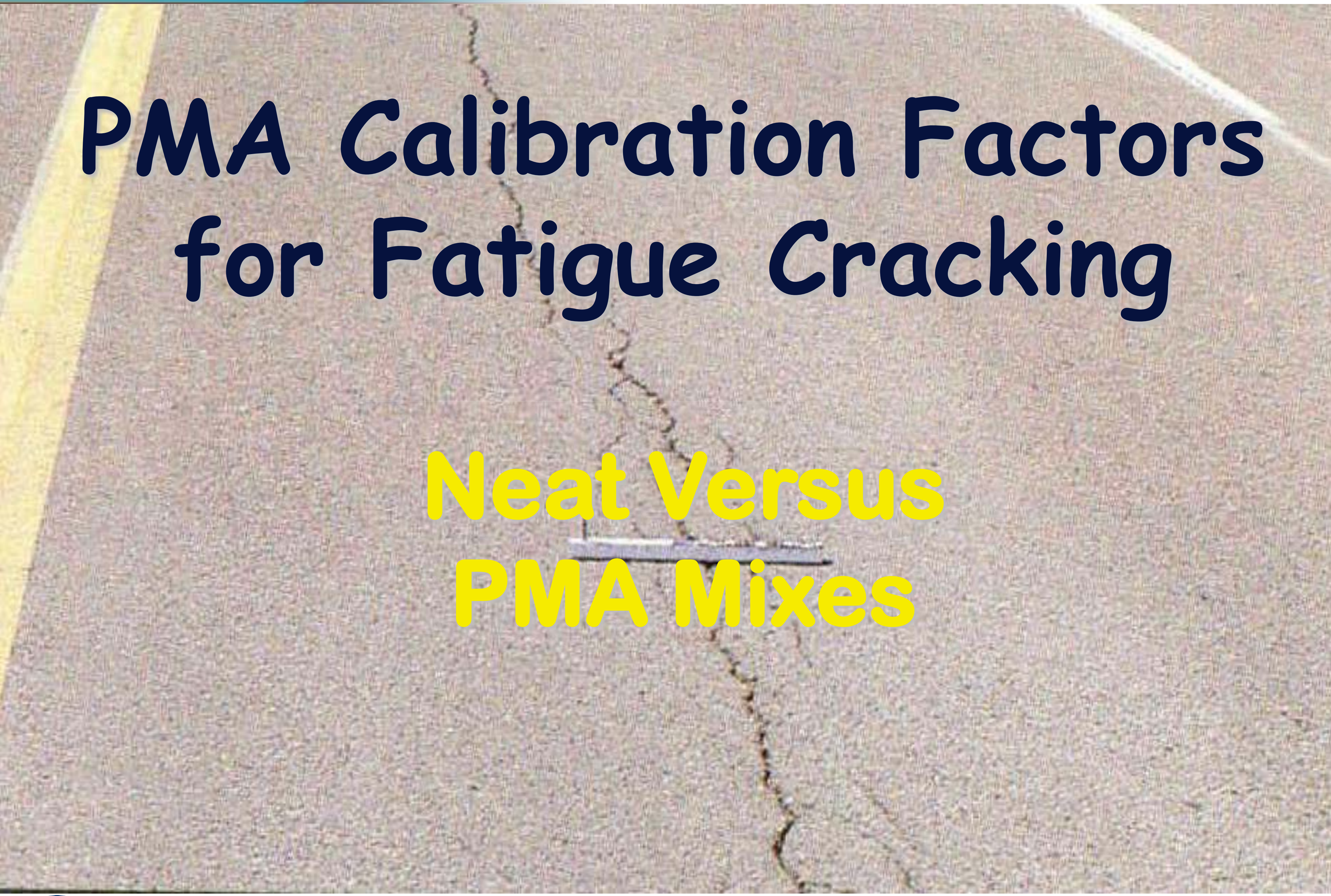


Comparison of Neat & PMA Calibration Values: Rutting





$$k_{r1(PMA)} = 1.13 k_{r1(NeatHMA)}$$



PMA Calibration Factors for Fatigue Cracking

Neat Versus PMA Mixes

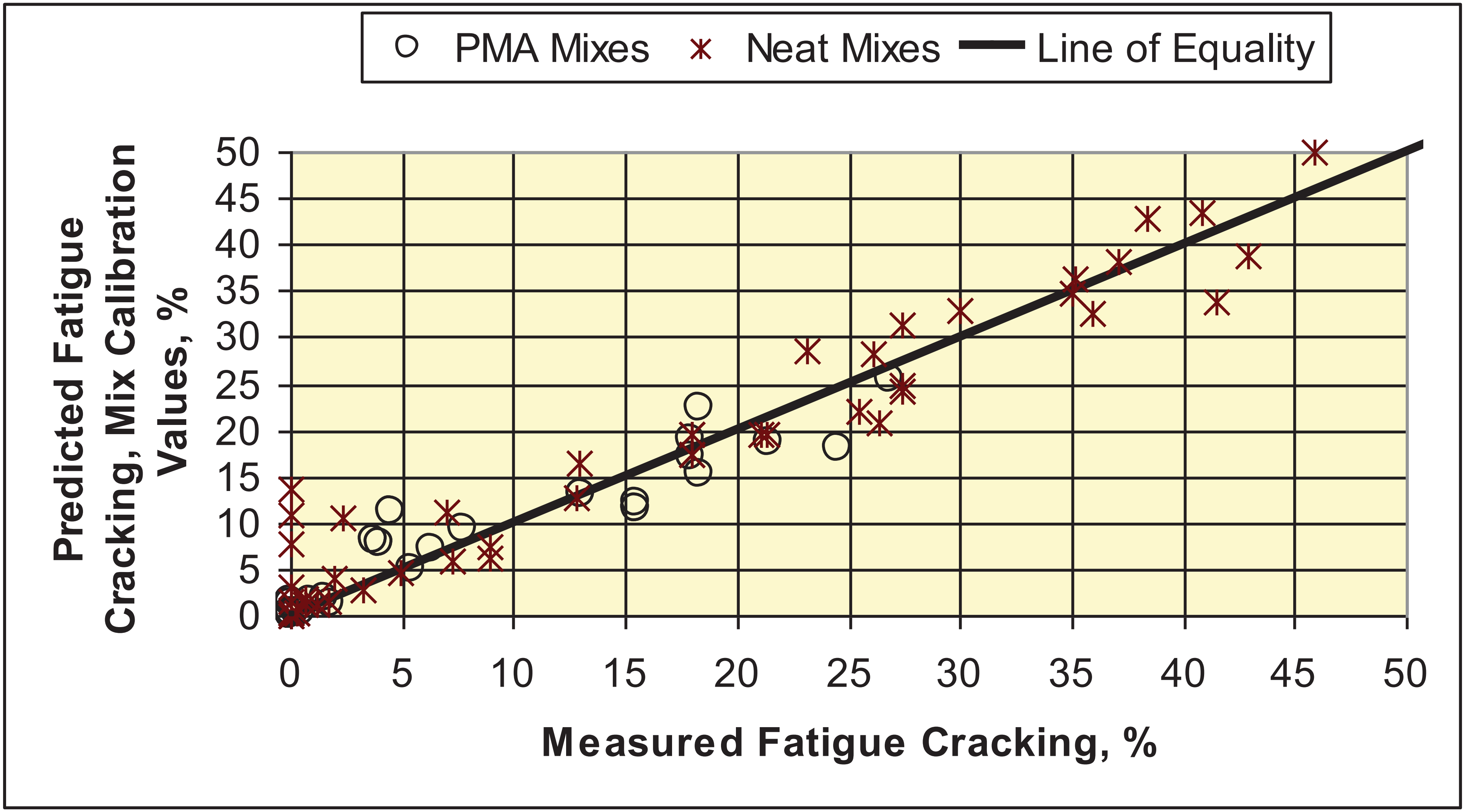
MEPDG Fatigue Cracking Transfer Function

$$N_f = k_{1f} 10^M C_H \beta_{1f} \left(\varepsilon_t\right)^{k_{2f}\beta_{2f}} \left(E_{HMA}\right)^{k_{3f}\beta_{3f}}$$

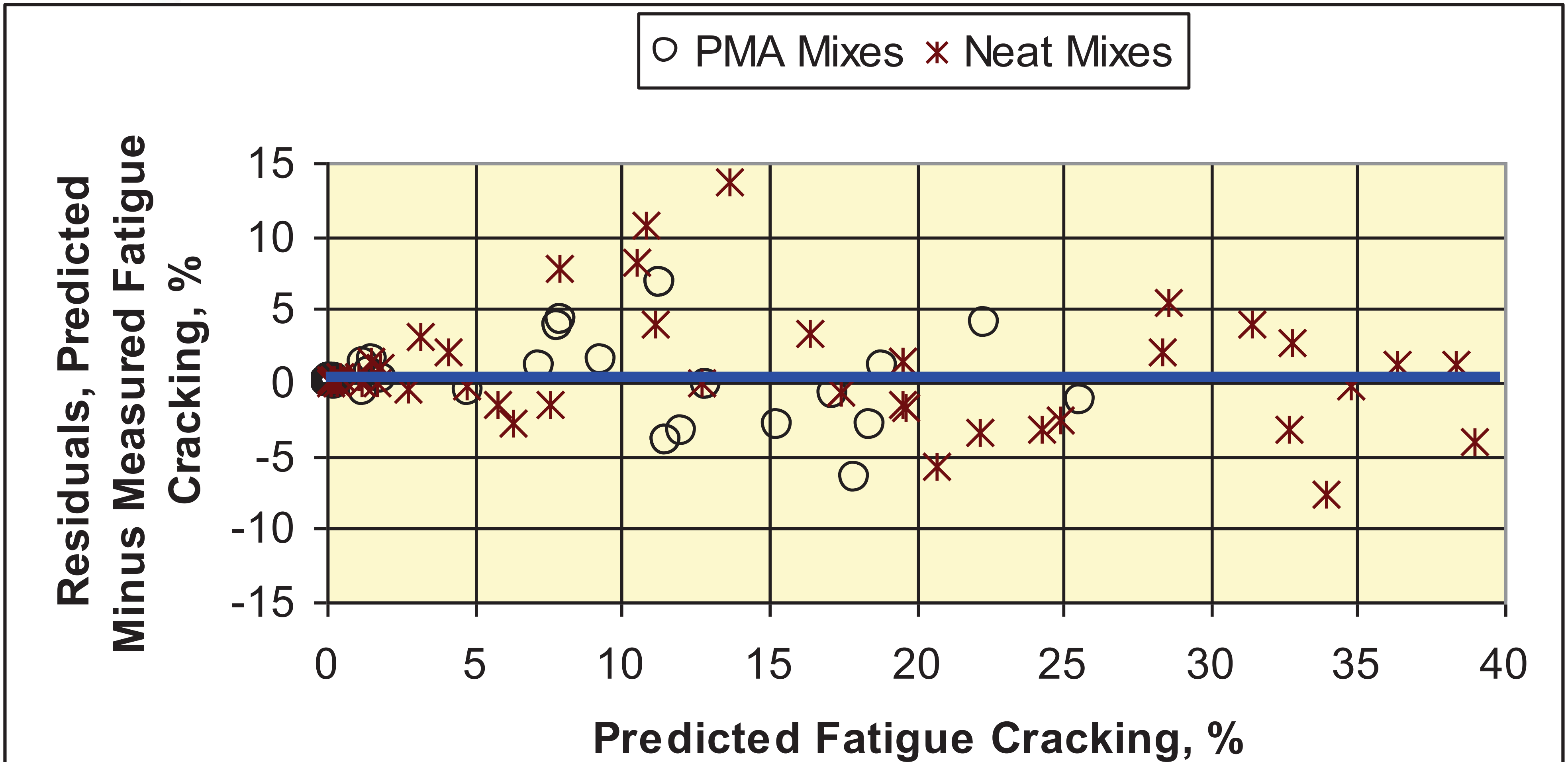
The calibration factor varied in study.

$$FC_{Bottom} = \left(\frac{1}{60}\right)\left(\frac{C_4}{1+e^{\left(C_1C_1^* + C_2C_2^* Log\left(DI_{Bottom} * 100\right)\right)}}\right)$$

Fatigue Cracking – Neat versus PMA Sections

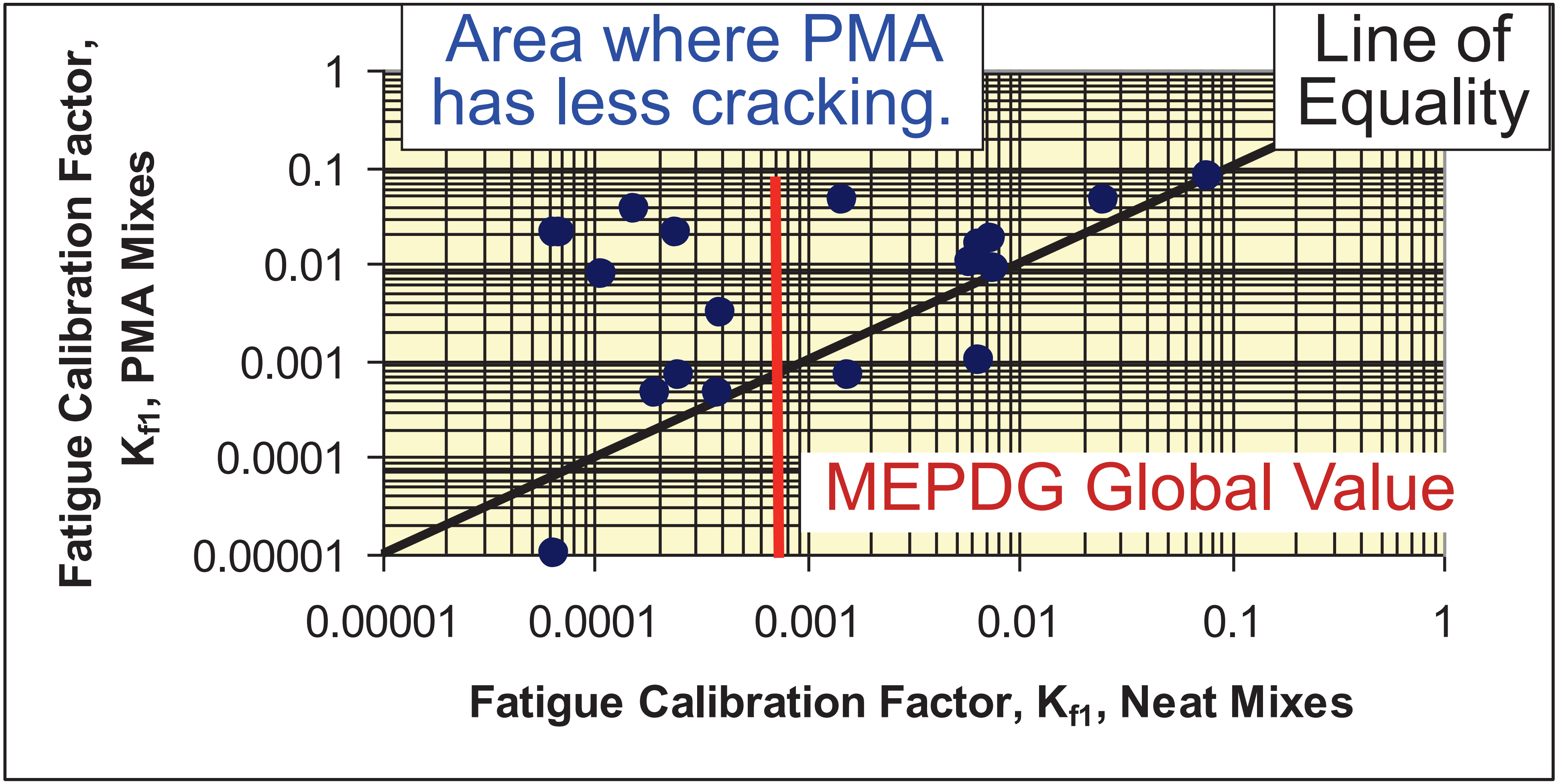


Residuals – Fatigue Cracking



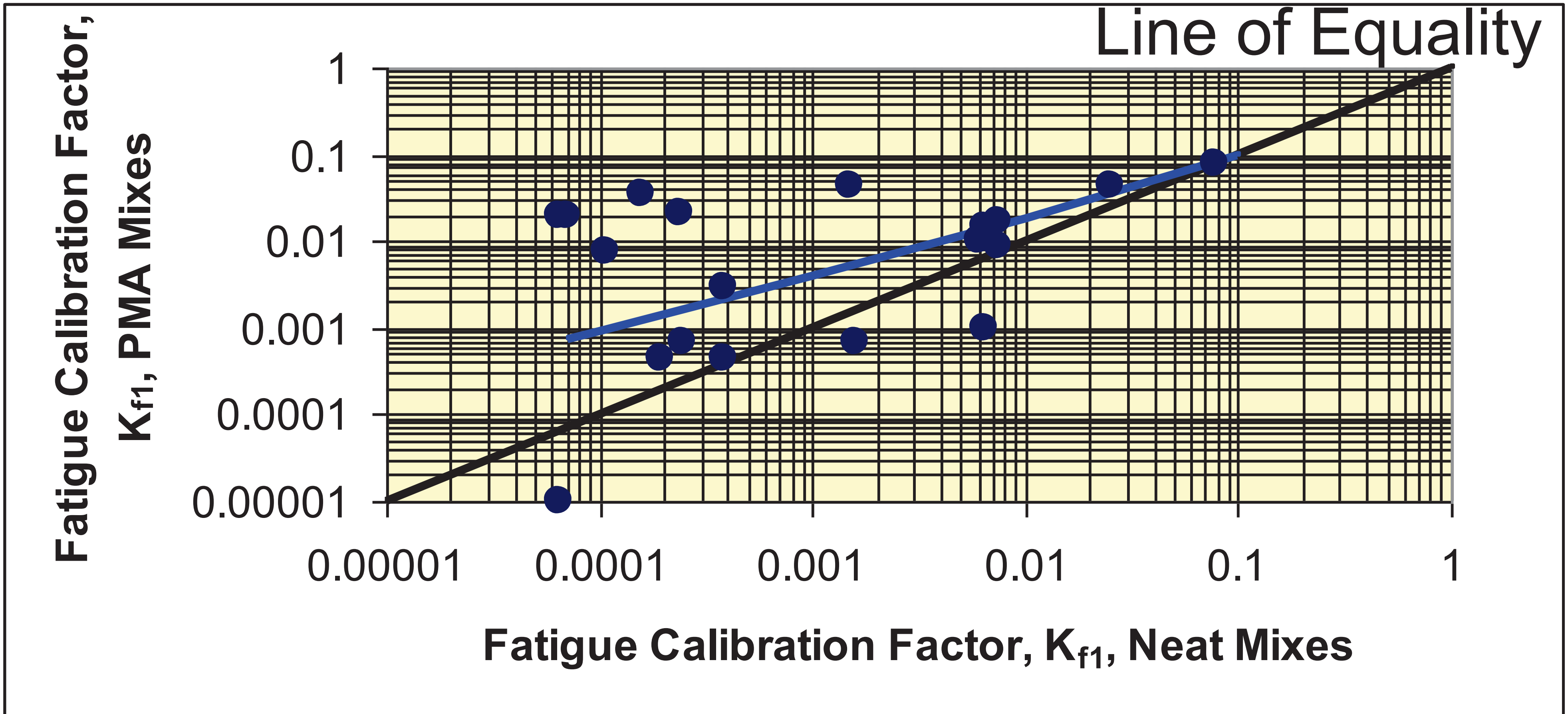
Variability in measured distress causing higher dispersion.

Comparison of Neat & PMA Calibration Values; Fatigue

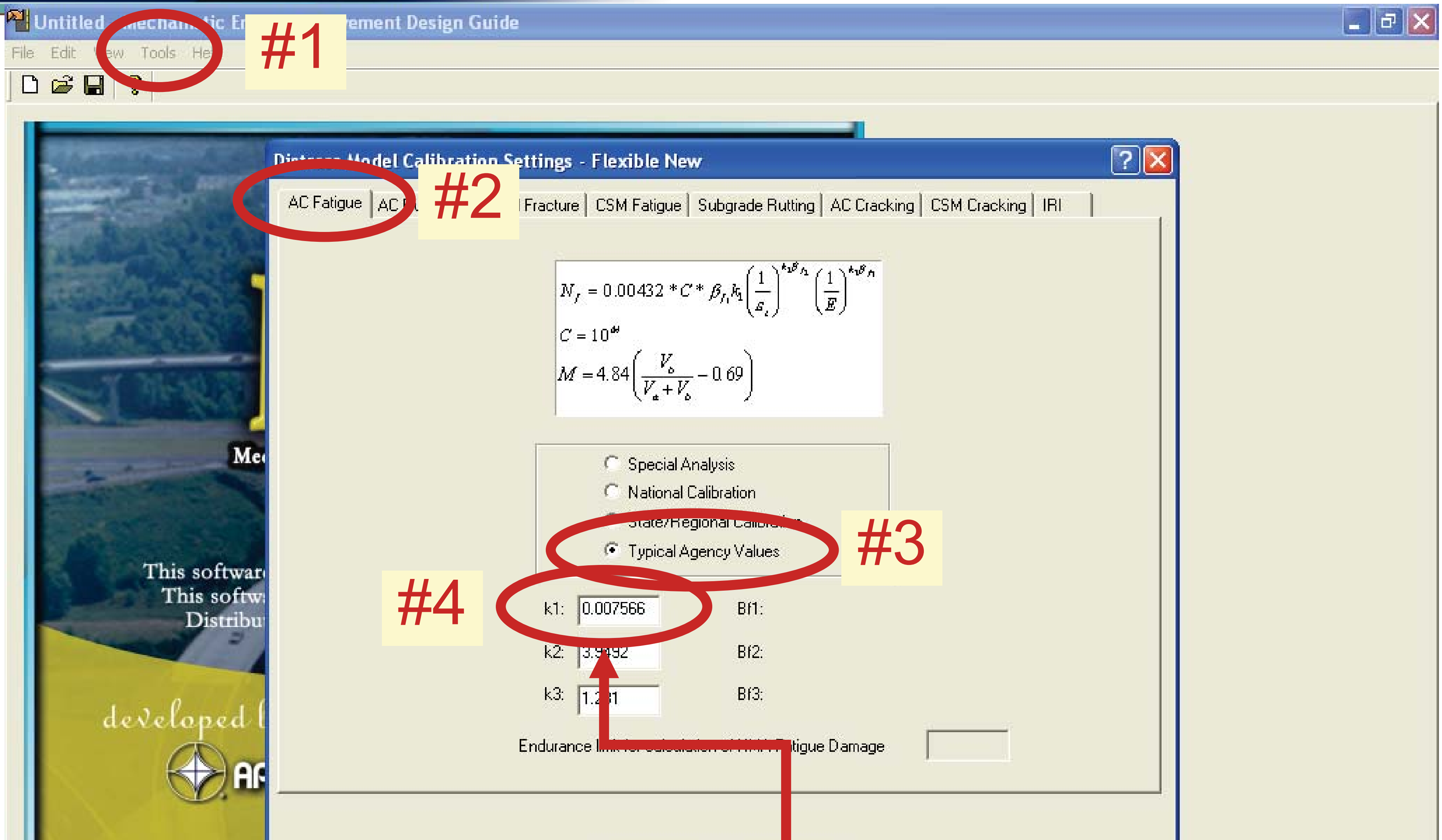


Expanding the Realm of Possibility

Comparison of Neat & PMA Calibration Values: Fatigue



$$k_{f1}(PMA) = 10^{-\left(-Log\left(k_{f1}(NeatHMA)\right)\right)^{0.8}}$$



$$k_{f1}(PMA) = 10^{-\left(Log\left(k_{f1}(NeatHMA)\right)\right)^{0.8}}$$

PMA Calibration Factors for Transverse Cracking

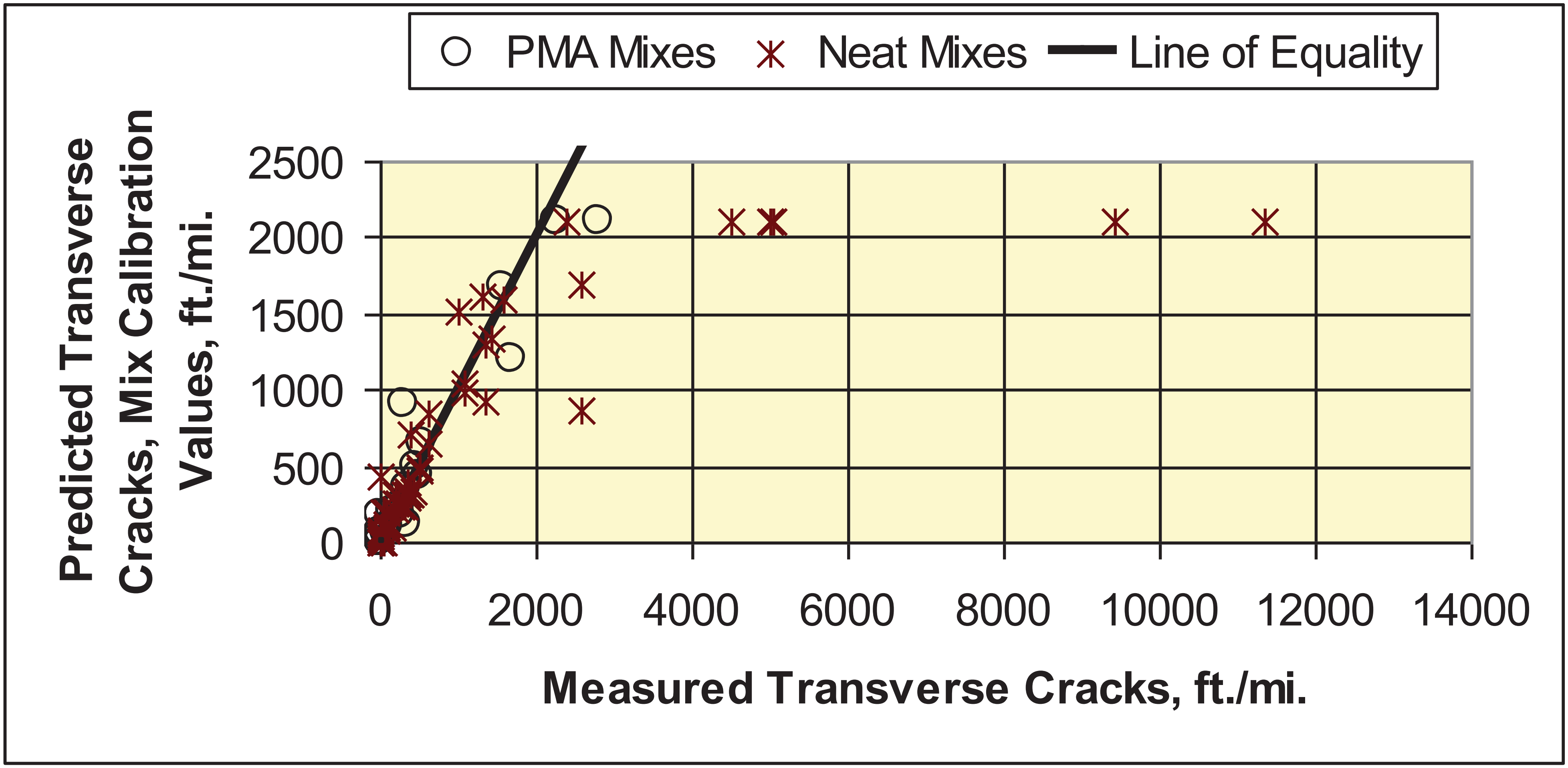
Neat Versus PMA Mixes

MEPDG Transverse Cracking Transfer Function

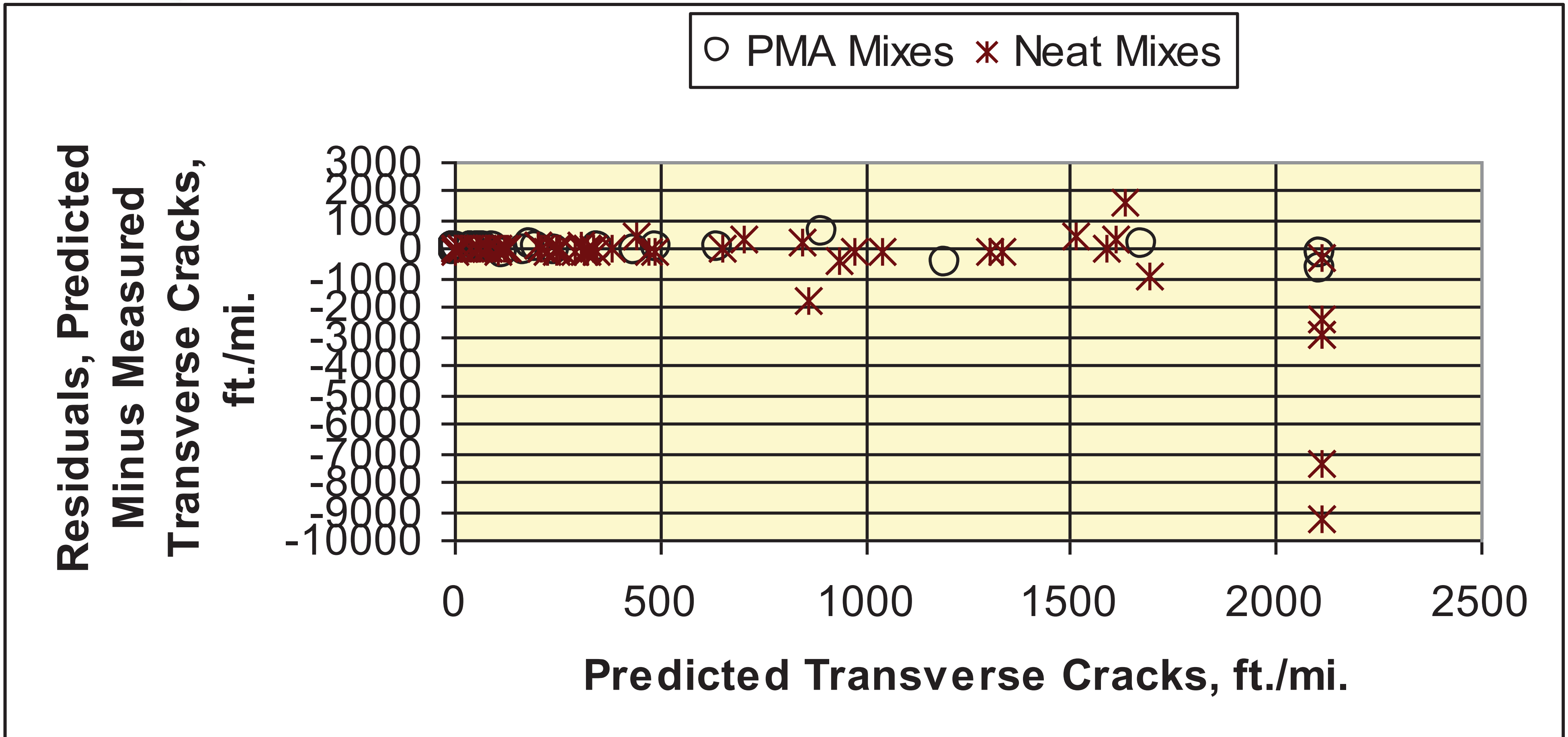
$$TC = \beta_t N\left[\frac{1}{\sigma_d} Log\left(\frac{C_d}{H_{HMA}}\right)\right]$$

The calibration factor varied in study.

Transverse Cracking – Neat versus PMA Sections

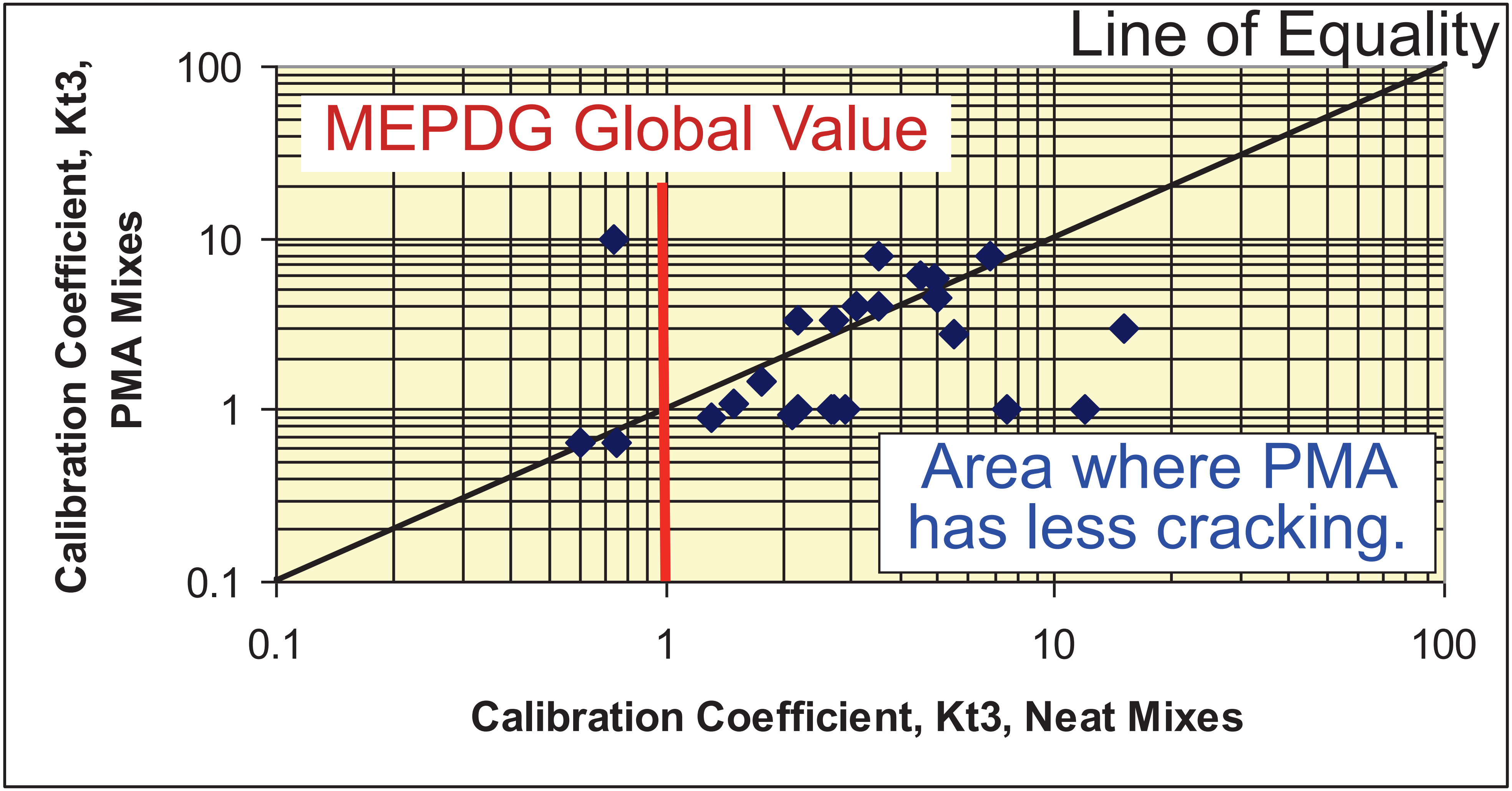


Residuals - Transverse Cracking

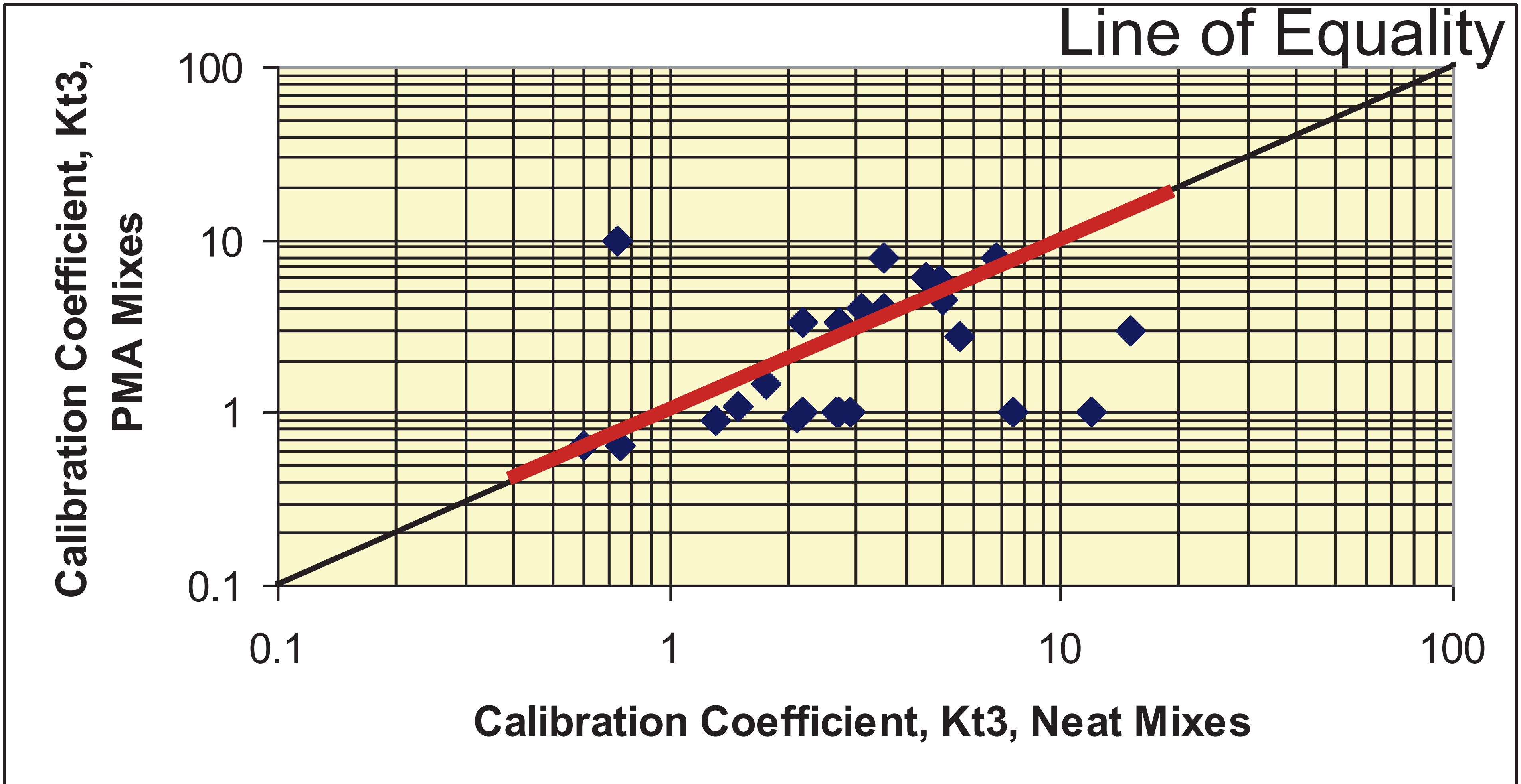


Negative bias caused by limit of predicted transverse cracks, 2110 ft./mi.

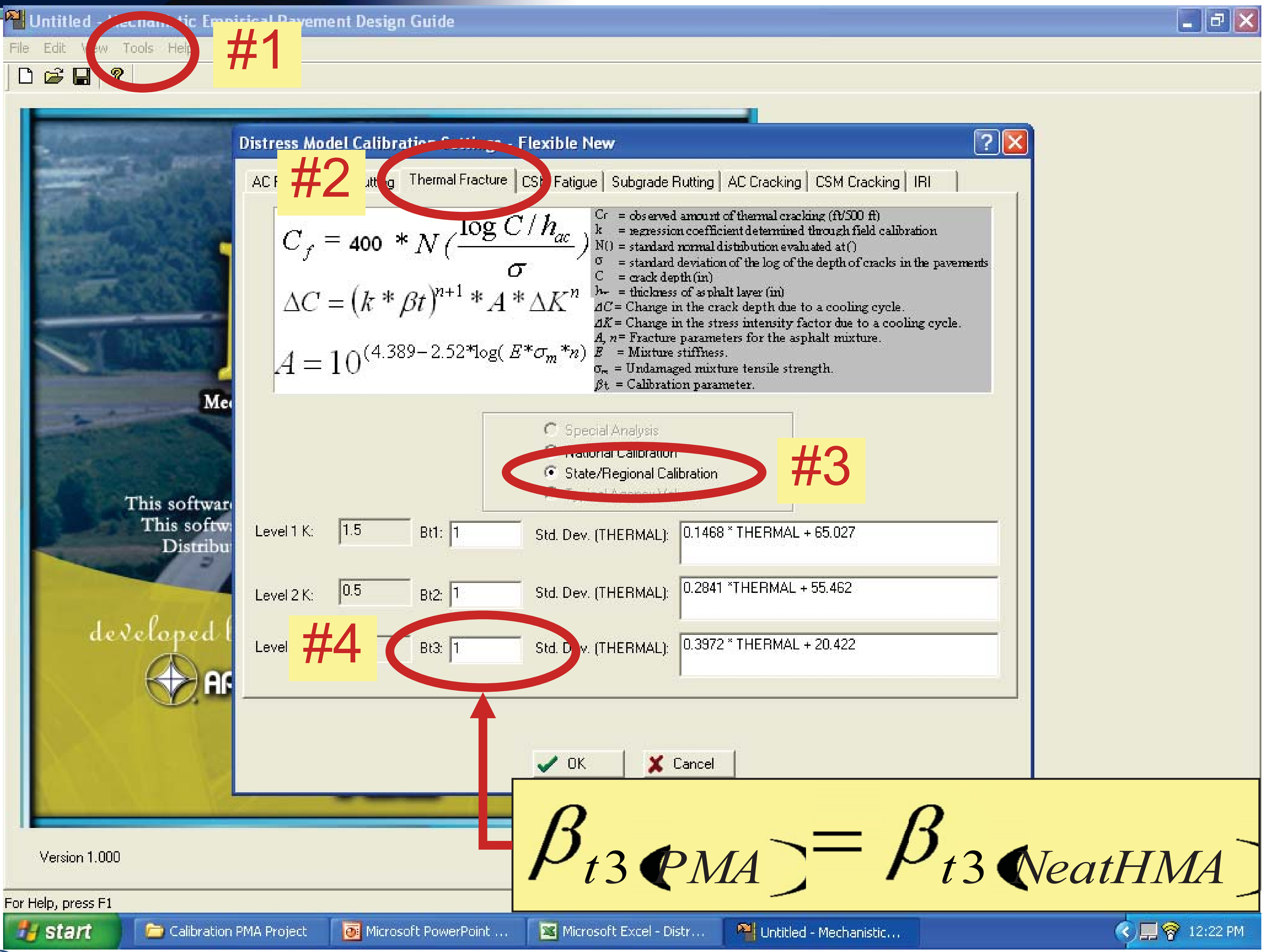
Comparison of Neat & PMA Calibration Values; Transverse Cracking



Comparison of Neat & PMA Calibration Values; Transverse Cracking



$$\beta_{t3}(PMA) = \beta_{t3}(NeatHMA)$$



$$\beta_{t3}(PMA) = \beta_{t3}(NeatHMA)$$

Example Comparison; Rutting

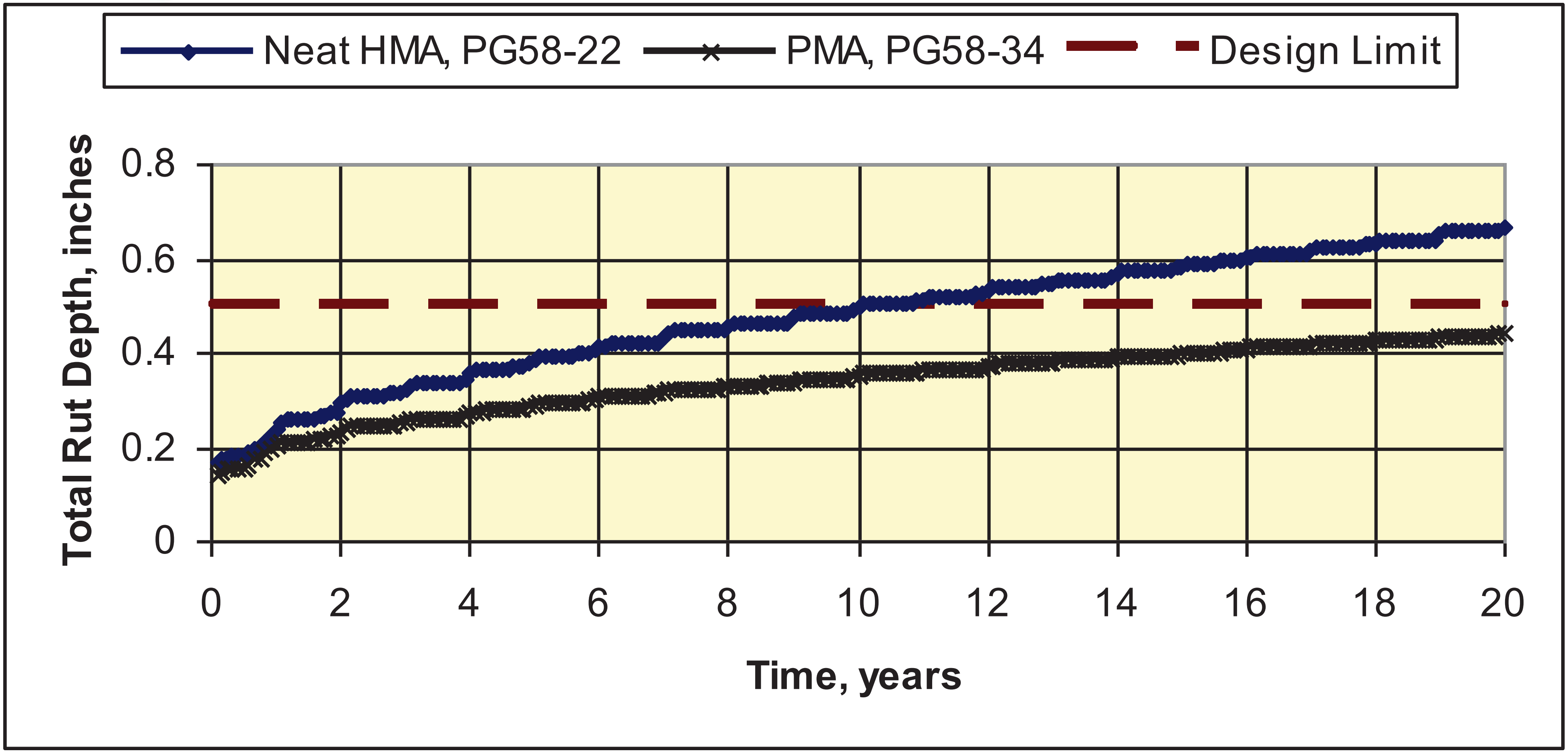


Figure 17 in the report.

Example Comparison; Fatigue Cracking

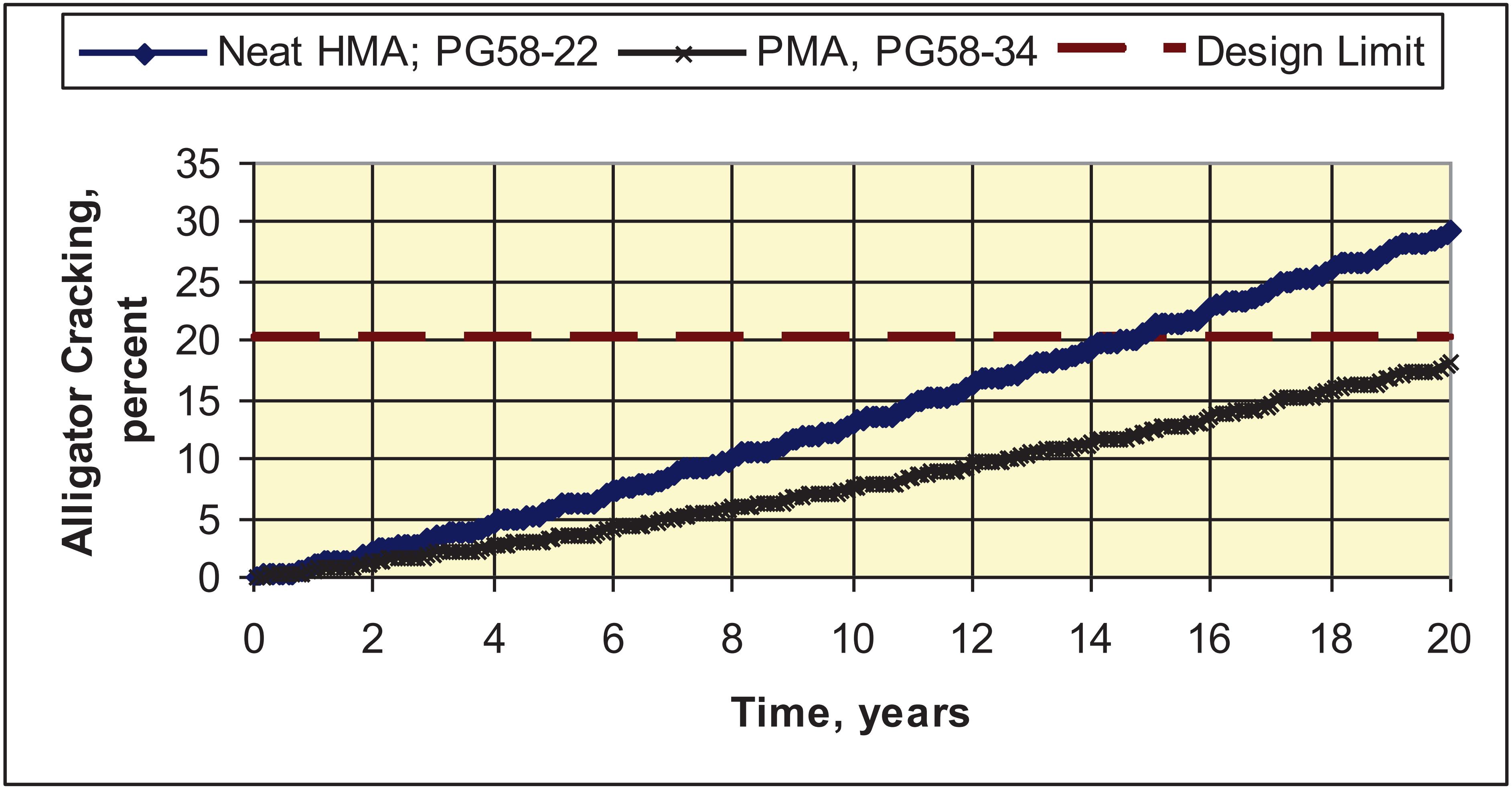


Figure 18 in the report.

Example Comparison; Thermal Cracking

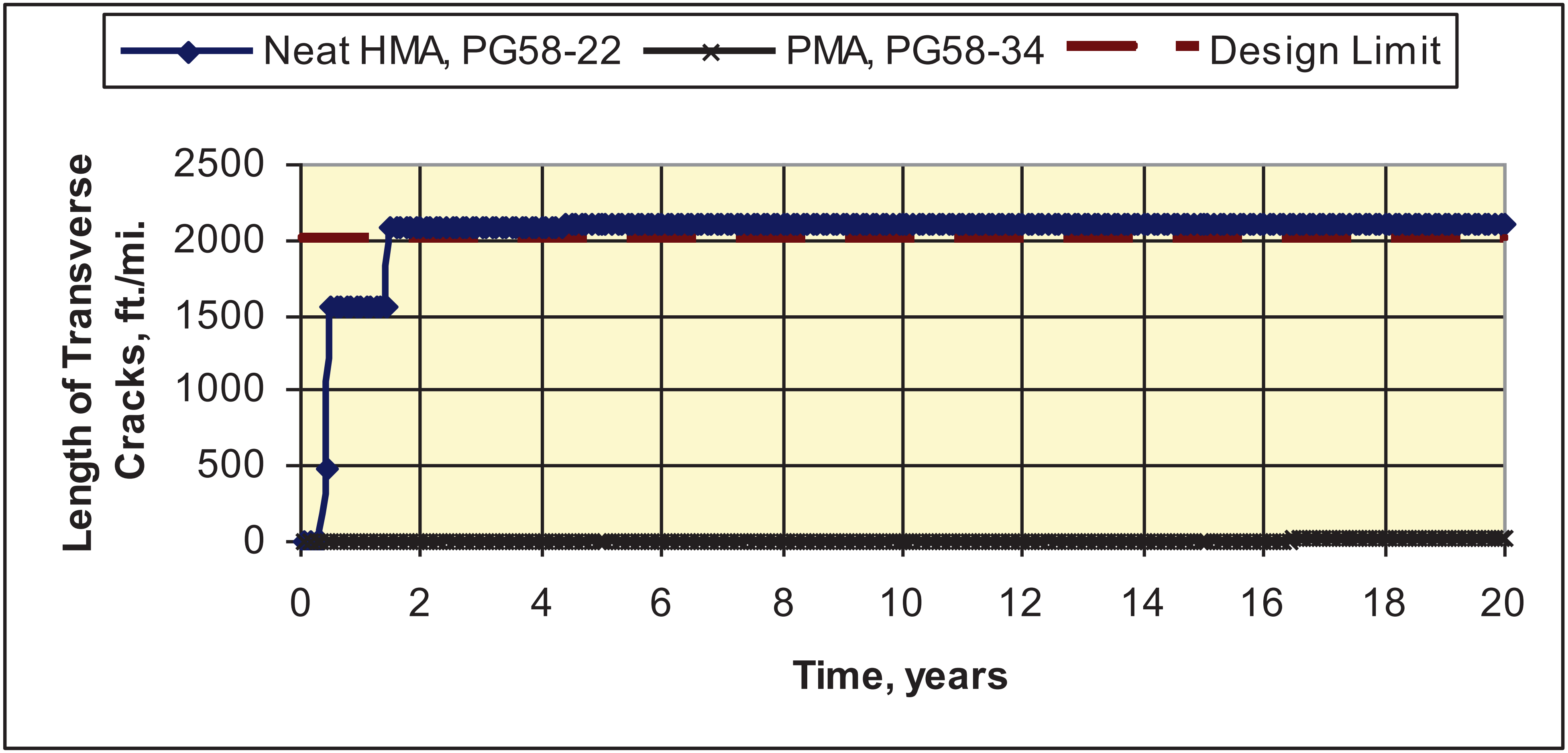


Figure 19 in the report.

Example Comparison: Roughness

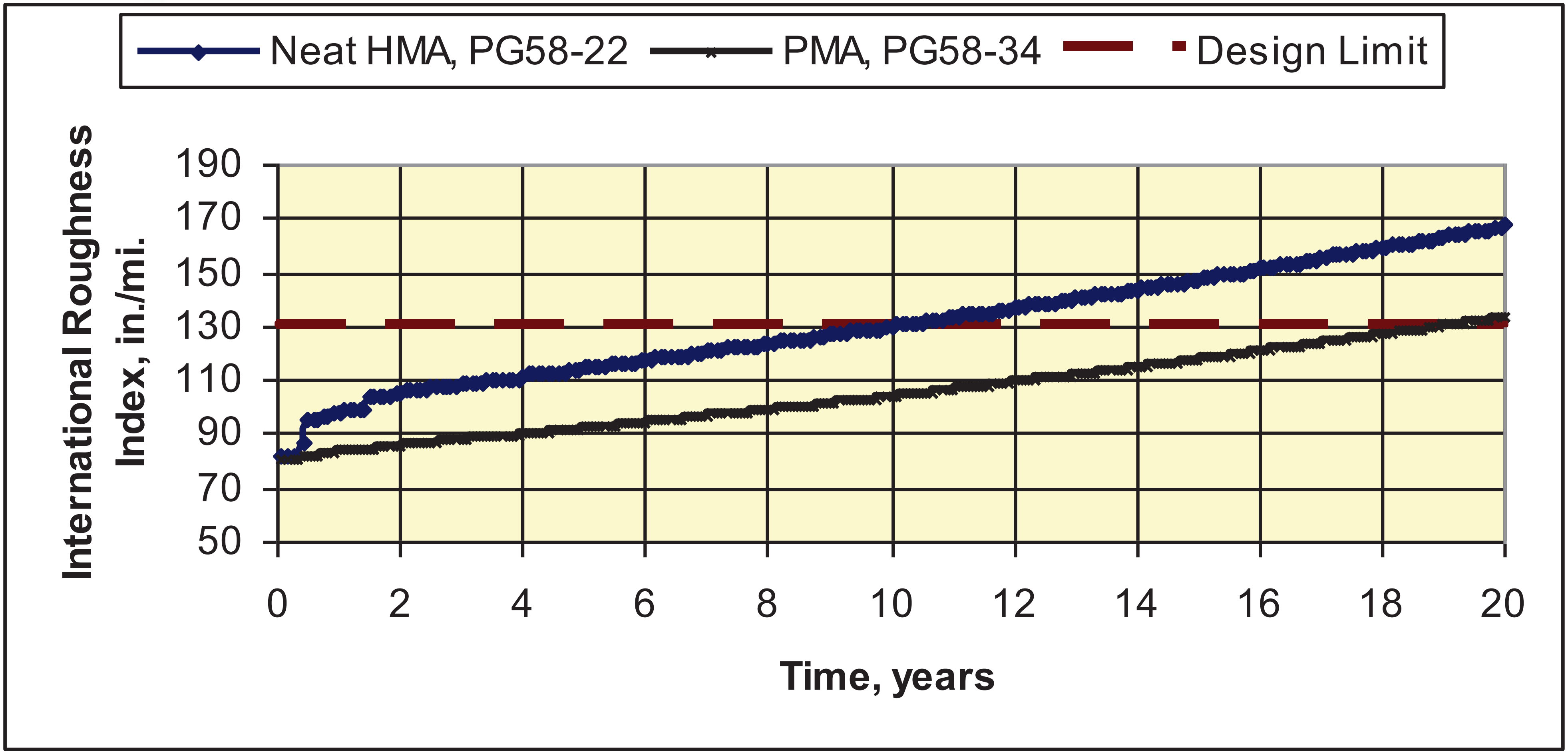


Figure 20 in the report.

Presentation Overview

1. Introduction
2. Distress Comparison Update
3. PMA Calibration Factors & the MEPDG
4. **Conclusions (Findings & Marketing Issues)**

Findings

- **Rutting** – **K_{1r}** for PMA mixtures **is lower** than for neat HMA mixtures.
- **Fatigue Cracking** – **K_{1f}** for PMA mixtures **is greater** than for neat HMA mixtures.
- **Transverse Cracking** – **B_{t3}** for PMA mixtures **is the same** as for neat HMA mixtures.

Marketing Issue

- Rutting & Transverse Cracks:
  - Controls HMA properties
  - Does not control HMA thickness
- Fatigue Cracks:
  - Controls HMA thickness
  - Less control over HMA properties

Marketing Issue

- PMA mixes—Less distress over neat HMA mixes.
- High volume roadways—Thinner PMA layers can be used.
- Low volume roadways—Pavement over weak foundations, overlays of severely distressed pavements – DO NOT DECREASE HMA THICHNESS.

Marketing Issue

- **For LCCA** – increase service life for PMA mixtures (rutting, transverse cracks, & fatigue cracks)
- **For design** – reduce HMA layer thickness for PMA mixtures (fatigue cracks)
- **BUT, inappropriate to apply both findings.**

Recommendation

- DECREASING THE PAVEMENT THICKNESS IS A SHORT TERM BENEFIT!
- DO ***NOT*** DECREASE THICKNESS OF PMA LAYERS AND PAVEMENT STRUCTURE.
- TAKE THE INCREASE IN SERVICE LIFE FOR LCC ANALYSES.


Thank you for your attention -
Any questions?

Study Sponsors

Industry Associations

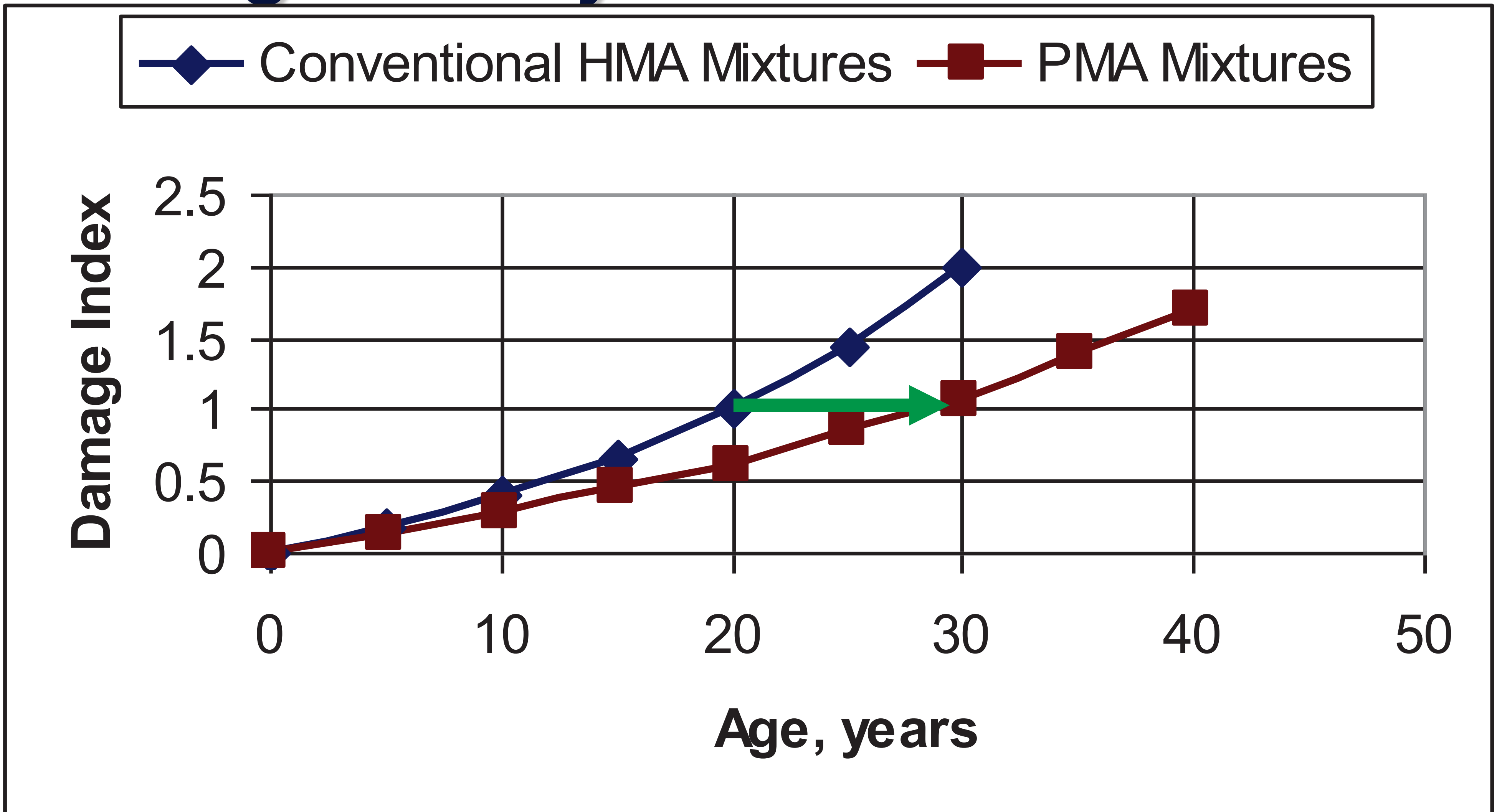
- The Asphalt Institute
- The Association of Modified Asphalt Producers

Federal Highway Administration

Corporate Sponsors

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

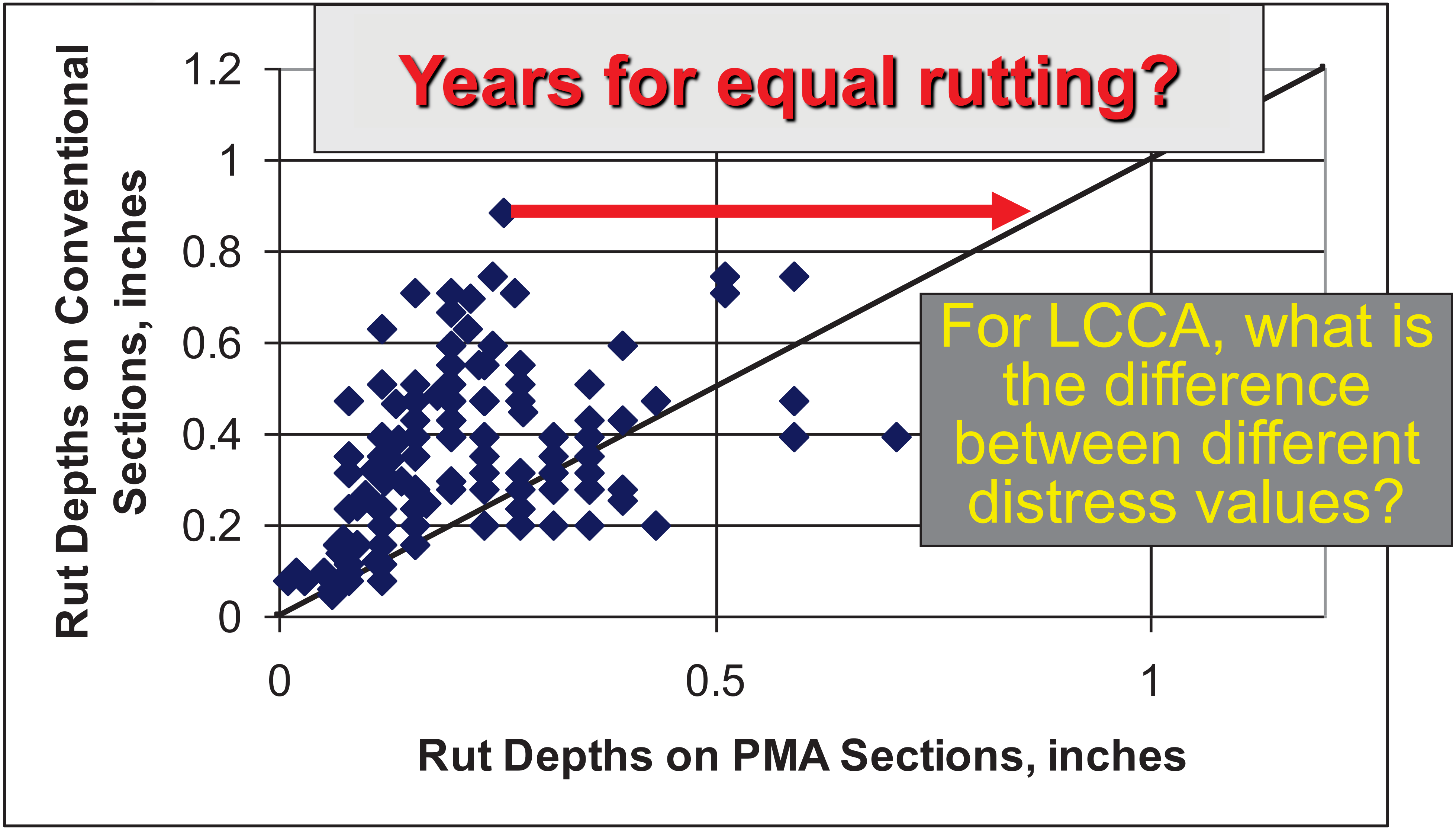
Enhanced Performance Based on Damage Analysis



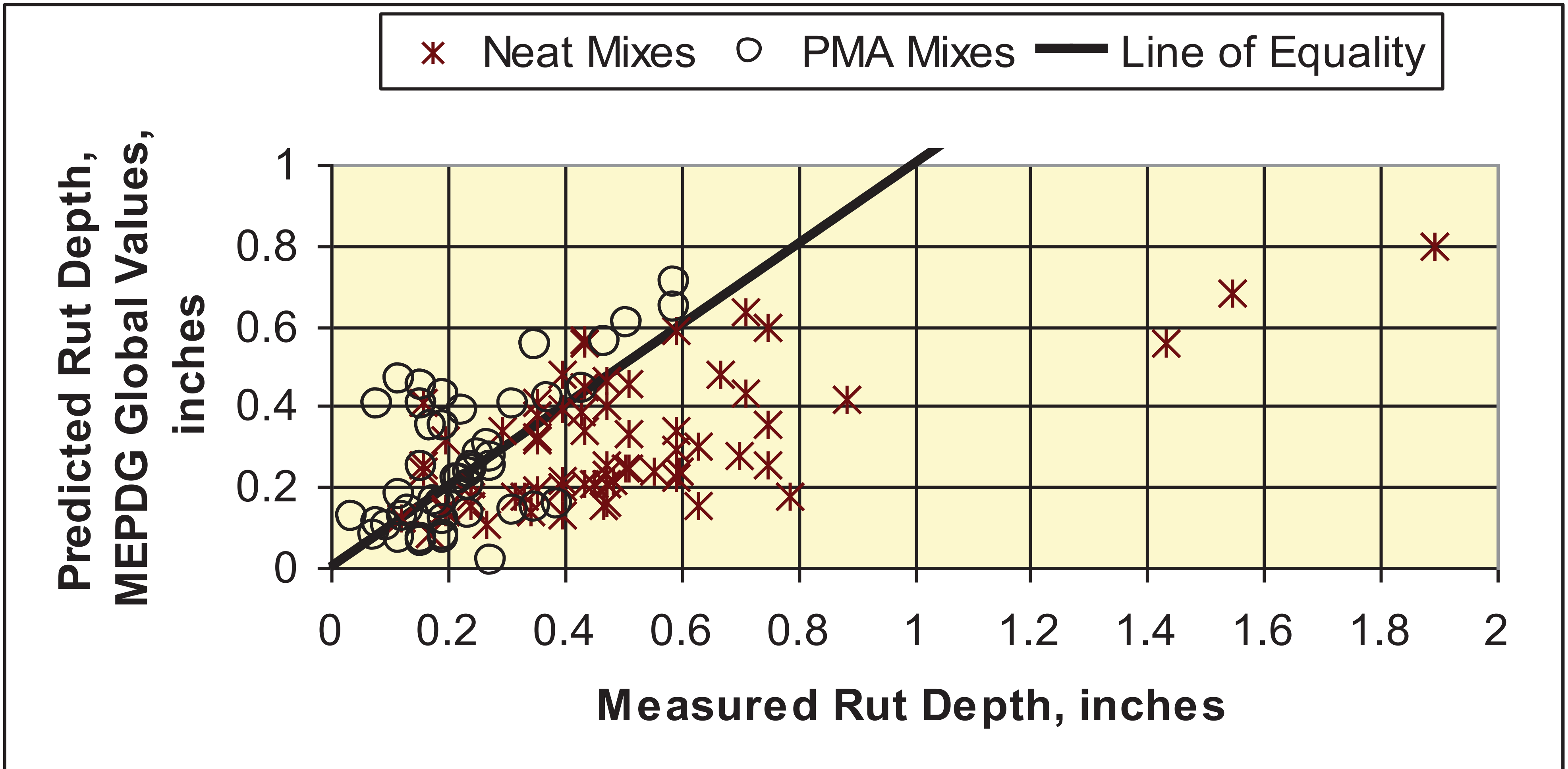
Number of Test Sections – Experimental Factorial

Type of Pavement Structure	Segments with PMA Mixtures
Conventional	17
Deep-Strength	14
Full-Depth	10
HMA over HMA	14
HMA over PCC	15

Quantifying the Effects of PMA

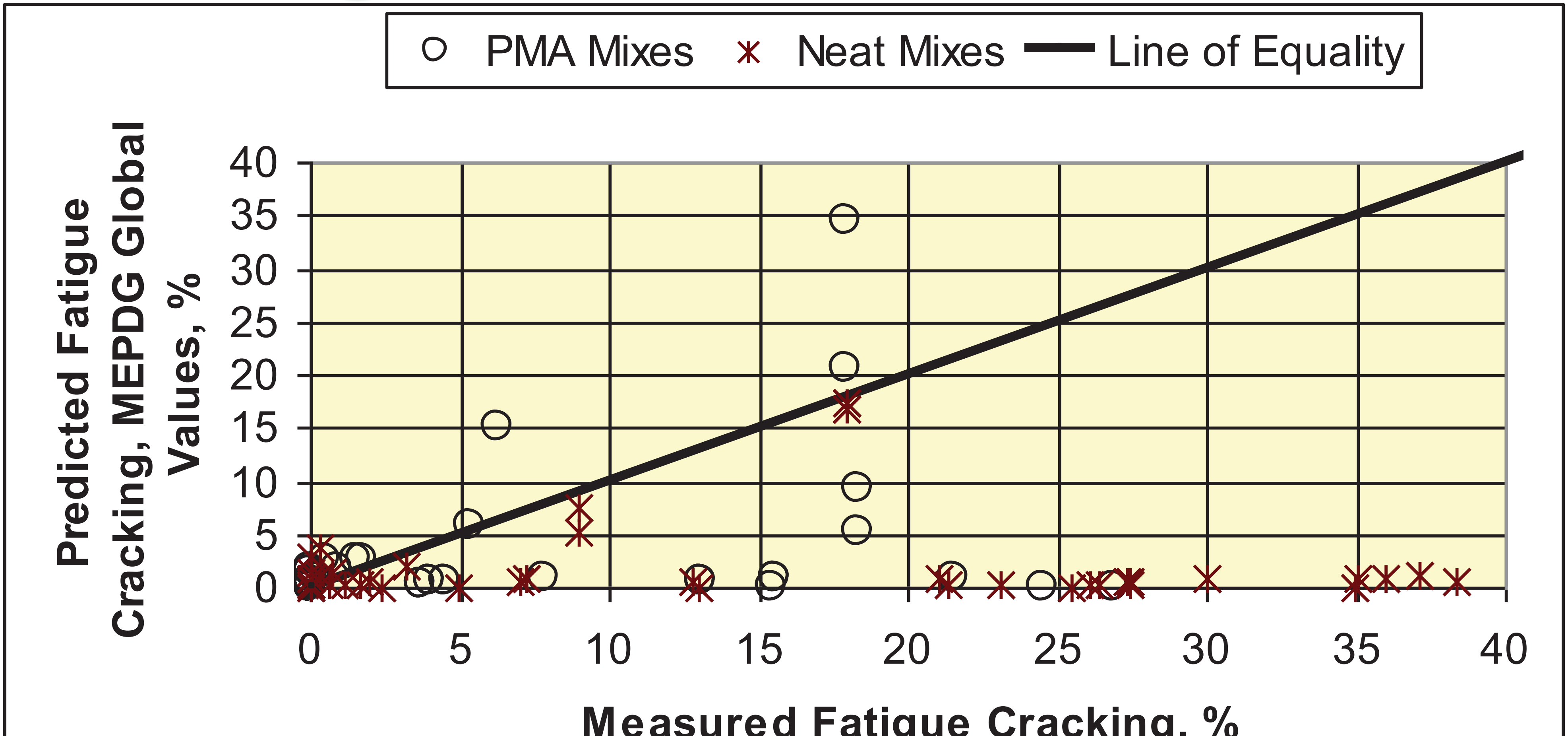


Predicted Rutting Using MEPDG Global Values



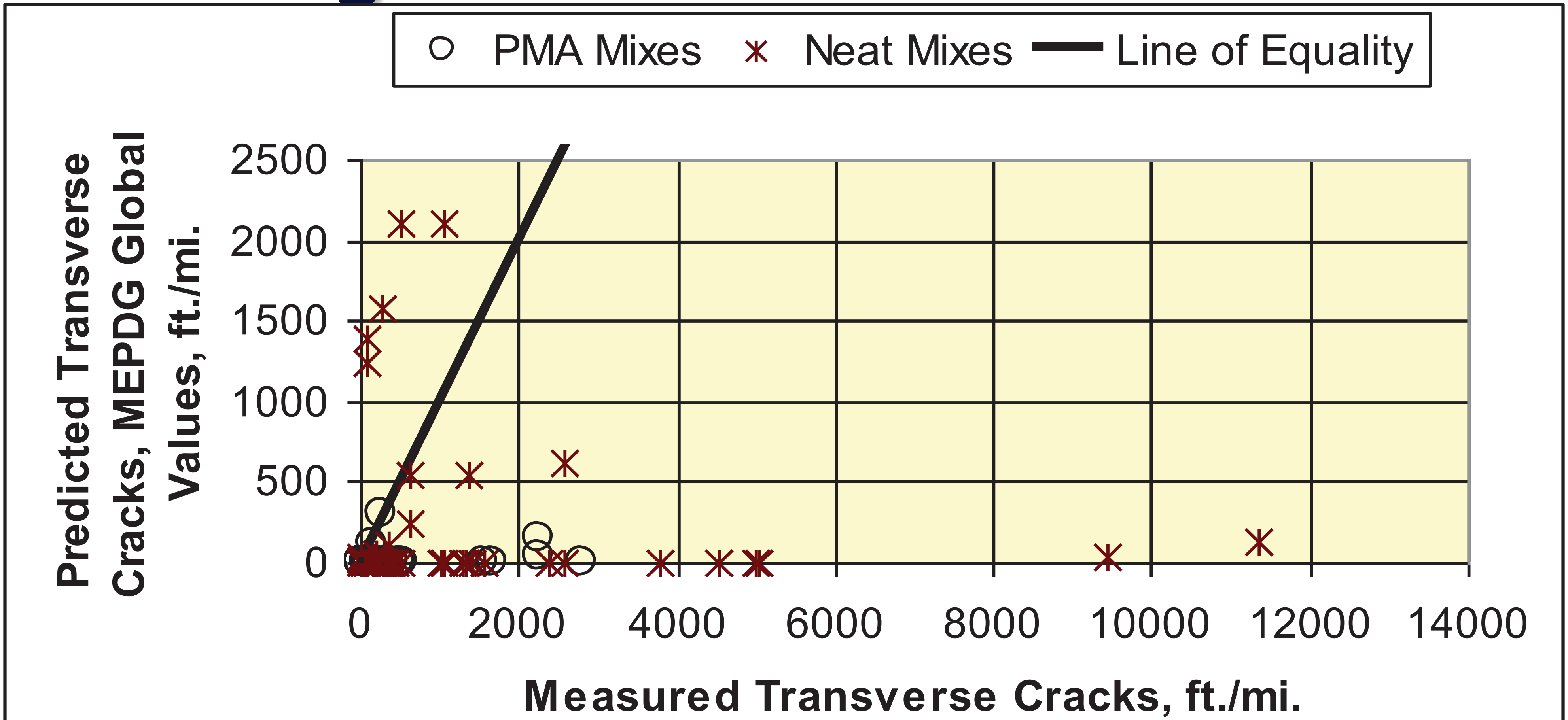
MEPDG global calibration factors for rutting.

Predicted Fatigue Cracking Using MEPDG Global Values



MEPDG global calibration factors for fatigue cracks.

Predicted Transverse Cracking Using MEPDG Global Values



MEPDG global calibration factors for transverse cracks.

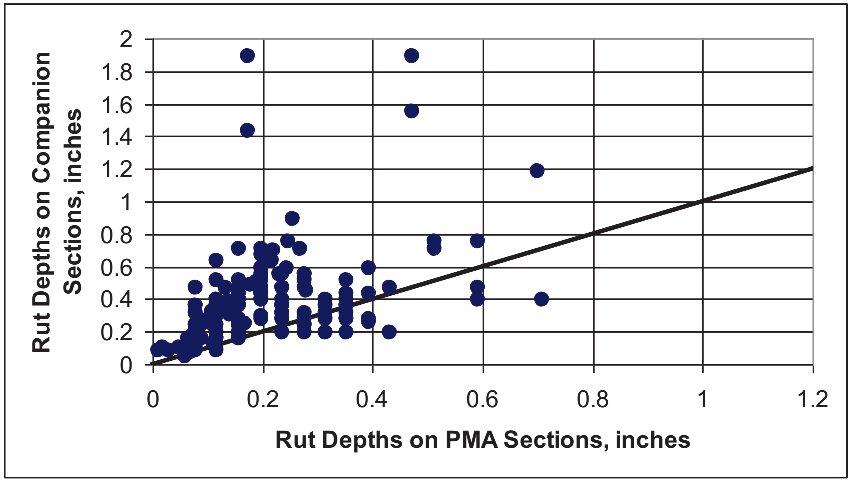
Summary of Measured Distress Comparisons

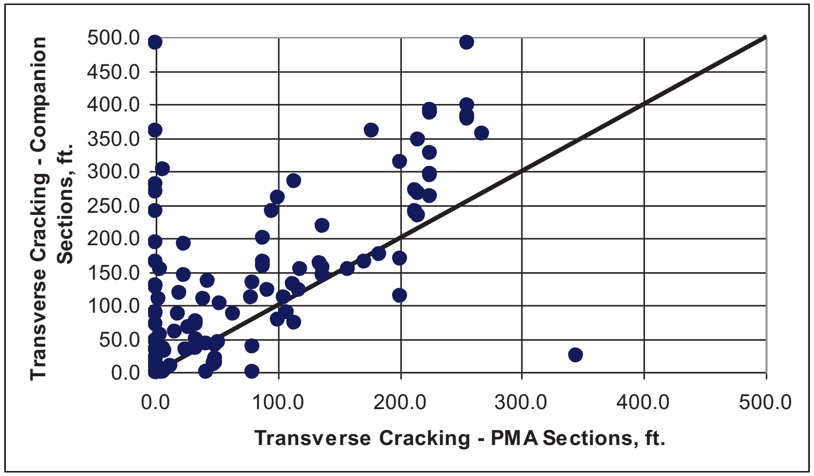
PMA sections have:

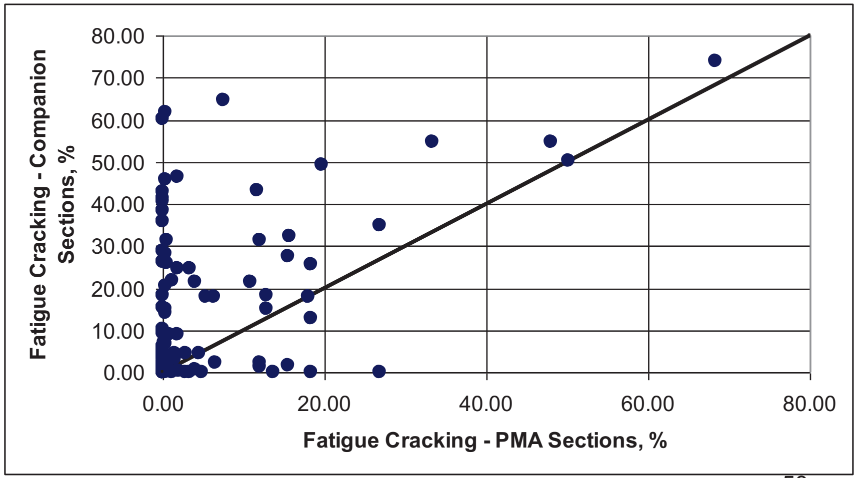
1. ***Less rutting***; difference not related to time & traffic.
2. ***Less fatigue cracks***; difference not related to time & traffic.
3. ***Less transverse cracks***; difference increases with time.

Findings

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







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Findings

- Analysis using MEPDG version 1.0 confirms need for **different calibration factors** for predicting performance of PMA mixtures.