# *Quantifying the Benefits of Polymer Modified Asphalt*

North Central Asphalt User Producer Group Meeting
Madison, WI
Feb 4-5, 2009

Mark Buncher, Ph.D., P.E.
Director of Engineering, Asphalt Institute

# Overview



- **PMA Performance Study Quantifying the Benefits of PMA**
  - 1st Article Reprint
- **LCCA Basics**
  - Review
- ***Understanding the True Economics of Using PMA through LCCA***
  - 2nd Article Reprint
  - Example
- **A Few Other AI Initiatives (if time allows)**

# Design Engineer's Perspective

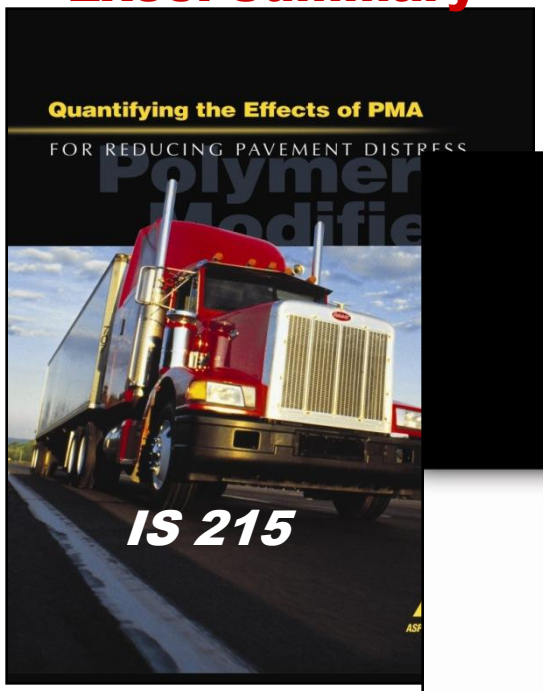


- PMA is One of Many Tools Available
- Performance Benefits Acknowledged
  - Many Lab and Field Studies
- Still, the Big Question Remains:
  - ***How Do I Quantify the Benefits of PMA?***

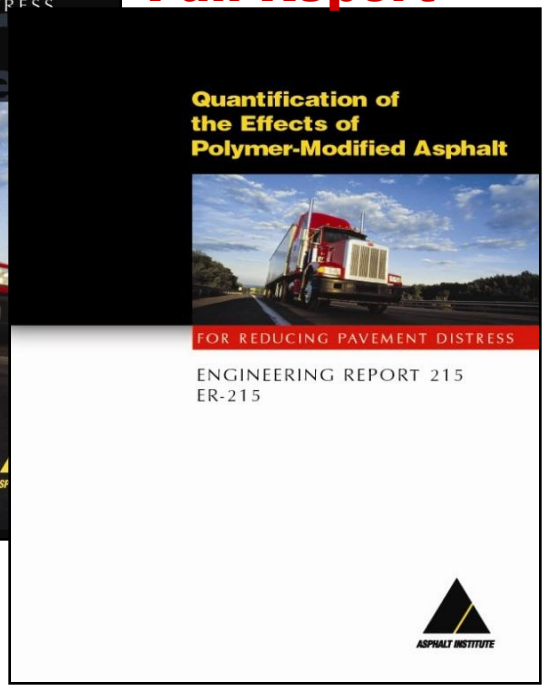
# *Quantifying the Effects of PMA for Reducing Pavement* Distress

asphalt institute

**Exec. Summary**




**Full Report**




This study (published by AI in Feb 2005) uses national field data to determine enhanced service life of pavements containing polymer modified binders versus conventional binders. The data is from a variety of climates and traffic volumes within North America.

Same study documented in 2007 TRB Paper (07-3230):
"*Quantification Of The Effect Of Polymer Modified Asphalt On Flexible Pavement Performance*"

w.asphaltinstitute.org

# 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
- KRATON Polymers
- Polimeri Europas Americas
- Ultrapave

# Study Team



## Project Team

- PI: Harold L. Von Quintus, P.E.
- Associate: J. Mallela

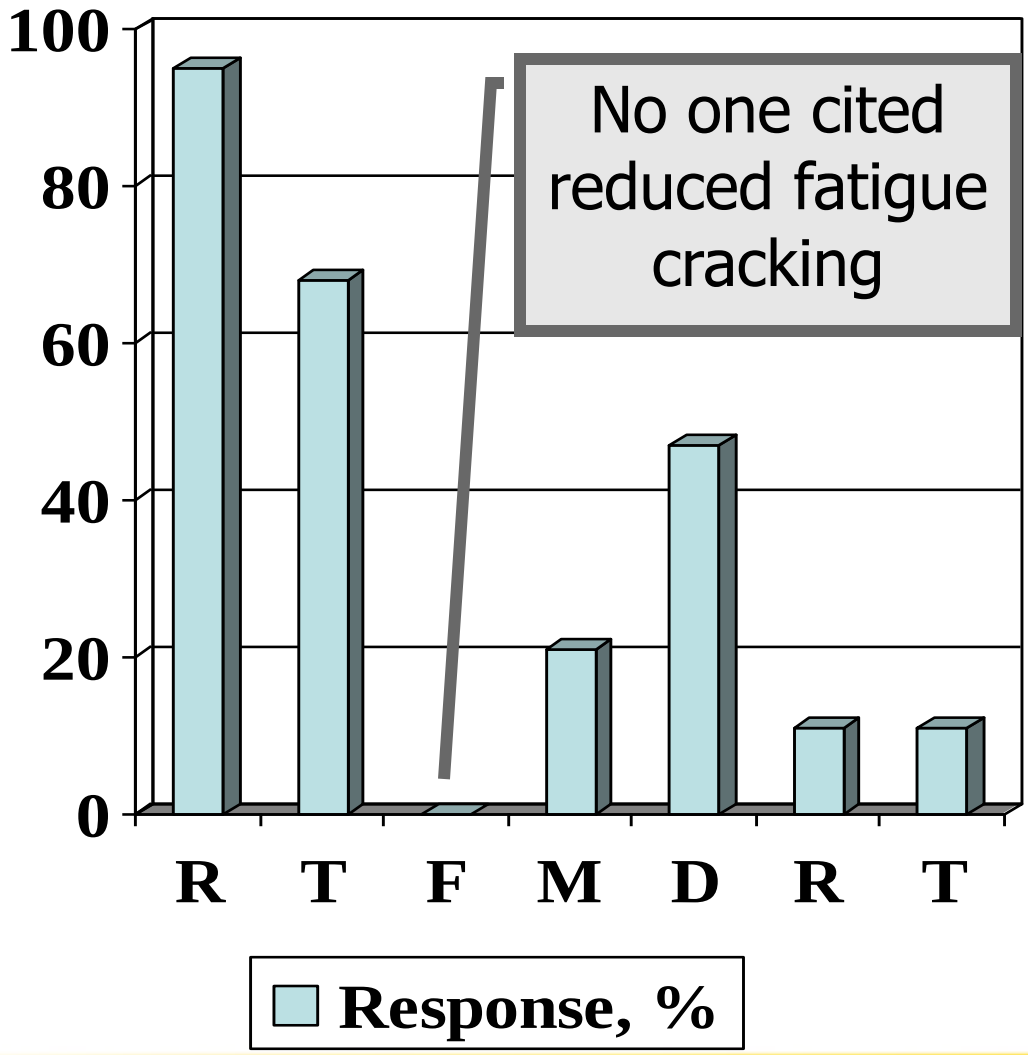
# Study Objectives



1. Quantify the effect of using PMA as compared to conventional-unmodified HMA mixtures in terms of:
   - Reducing occurrence of distresses
   - Increasing pavement life
2. Identify conditions that maximize effect of PMA to increase pavement & overlay life
   - PMA more effective in certain conditions, and less effective in others

# Agency Survey: Reasons for Using PMA?






R = Rutting

T = Thermal Cracking

F = Fatigue Cracking

M = Moisture Damage or Stripping

D = Durability

R = Raveling

T = Tenderness

# Field Test Sections

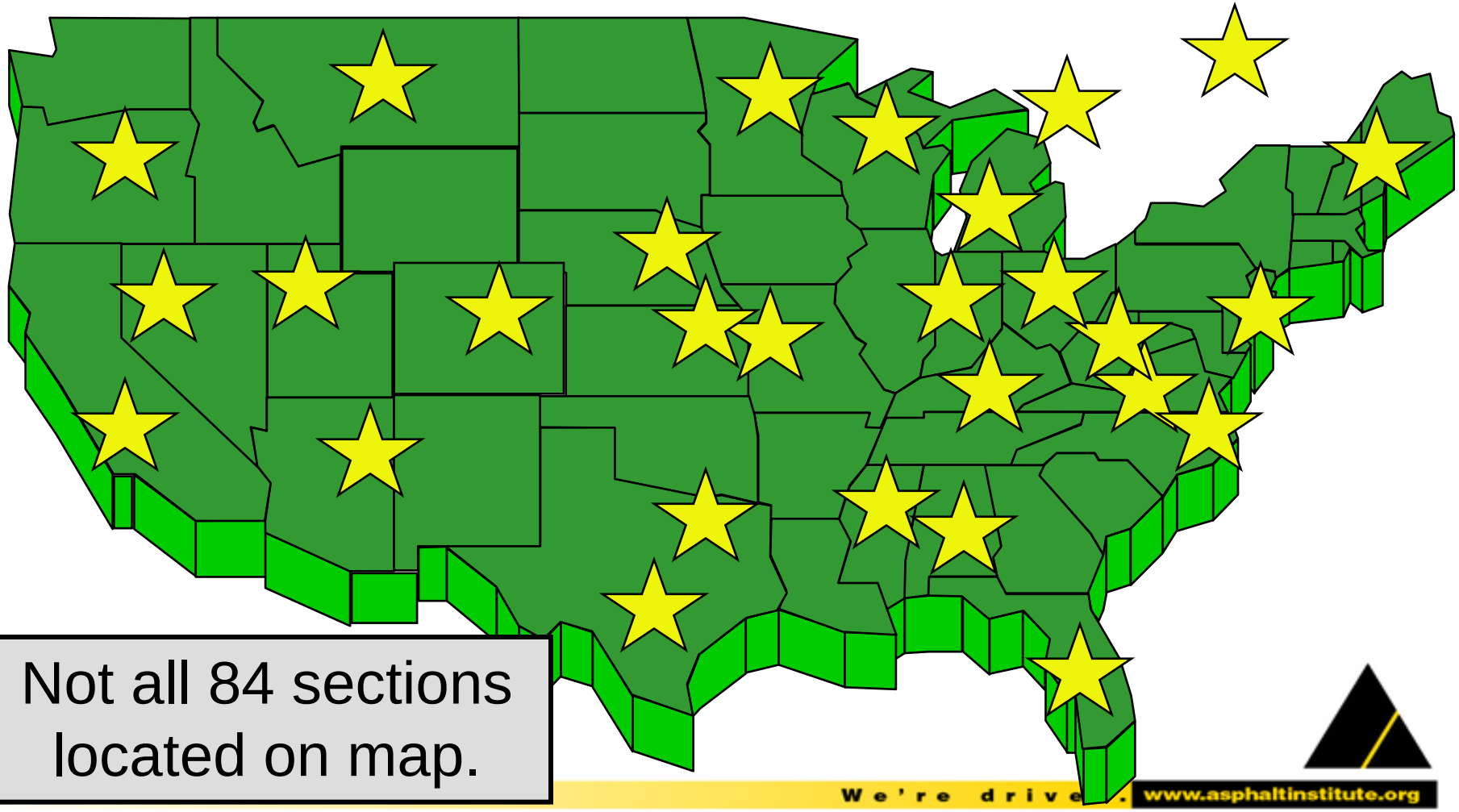


- FHWA's LTPP
  - **SPS-1; SPS-5; SPS-6; SPS-9**
  - **GPS-1; GPS-2; GPS-6; GPS-7**
- M.T.Ontario Modifier Study
- Accelerated Pavement Tests
  - **FHWA ALF**
  - **NCAT Test Track**
  - **California HVS Studies**
  - **Ohio Test Road**
  - **Corp of Engineers**

# Locations of Test Sections

- PMA and At Least One Unmodified Companion





Not all 84 sections located on map.

# Pavement Surface Distress Data Collected/ Compared

asphalt institute

**Already Thru LTPP**

**In this study**

- Fatigue Cracking
- Rutting
- Thermal Cracking

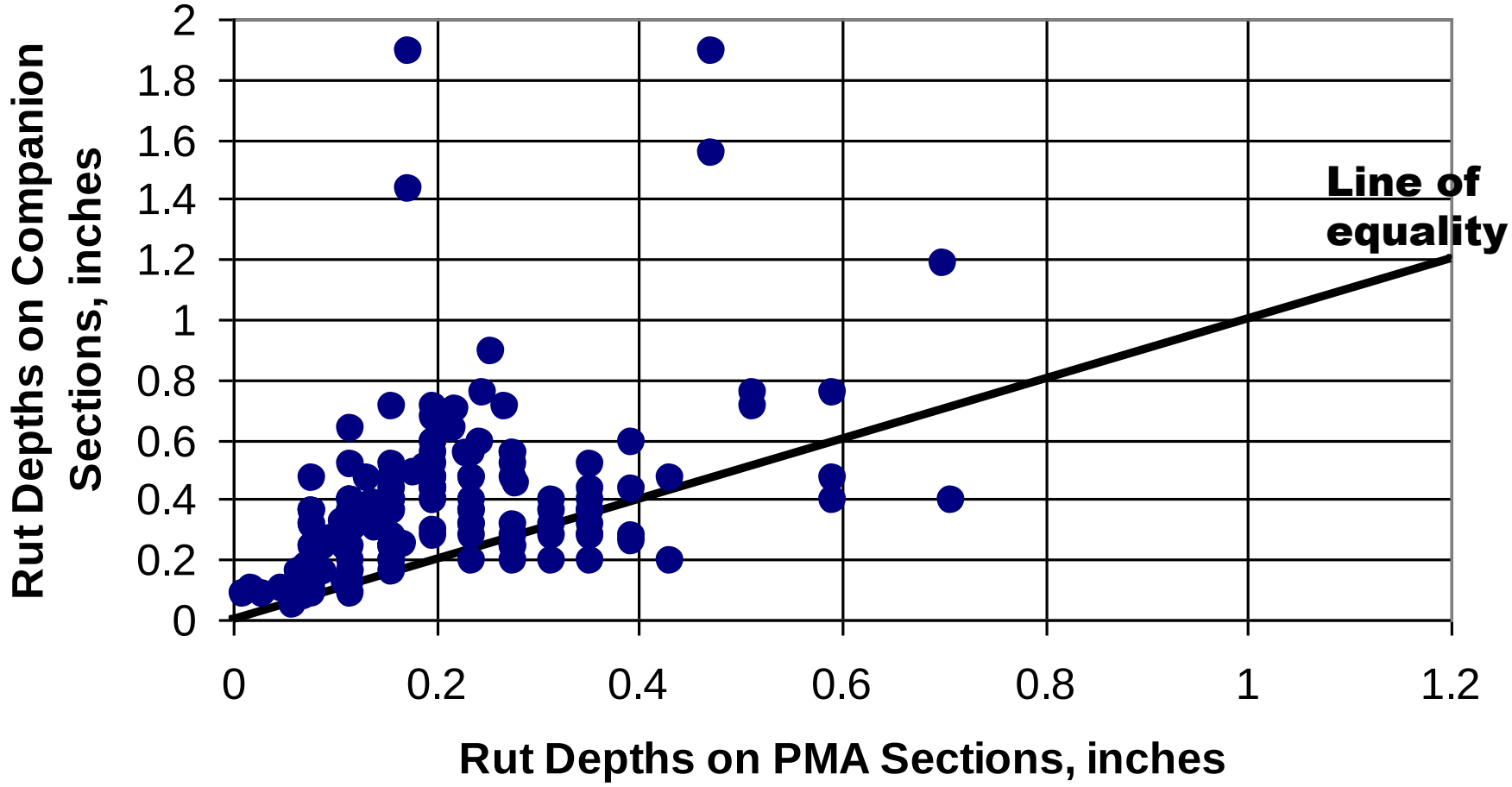
# Experimental Factorial – 32 Cells

asphalt institute

| Pavement Cross Section | Base Foundation | Climate | | | |
|---|---|---|---|---|---|
| | | Freeze | | Non-Freeze | |
| | | Wet | Dry | Wet | Dry |
| Thin HMA (<4”) | Fine-Grained | 2 | 2 | 4 | 3 |
| | Coarse-Grained | 3 | 3 | 3 | 3 |
| Thick HMA (4-8”) | Fine-Grained | 2 | 2 | 2 | 3 |
| | Coarse-Grained | 2 | 2 | 3 | 2 |
| Full-Depth (>8”) | Fine-Grained | 0 | 1 | 2 | 2 |
| | Coarse-Grained | 0 | 1 | 2 | 2 |
| HMA Overlays | HMA | 3 | 3 | 6 | 6 |
| | PCC | 4 | 3 | 4 | 4 |
| **84 Total PMA and Companion Sections** | | 16 | 17 | 26 | 25 |

# Direct Comparisons – Rutting

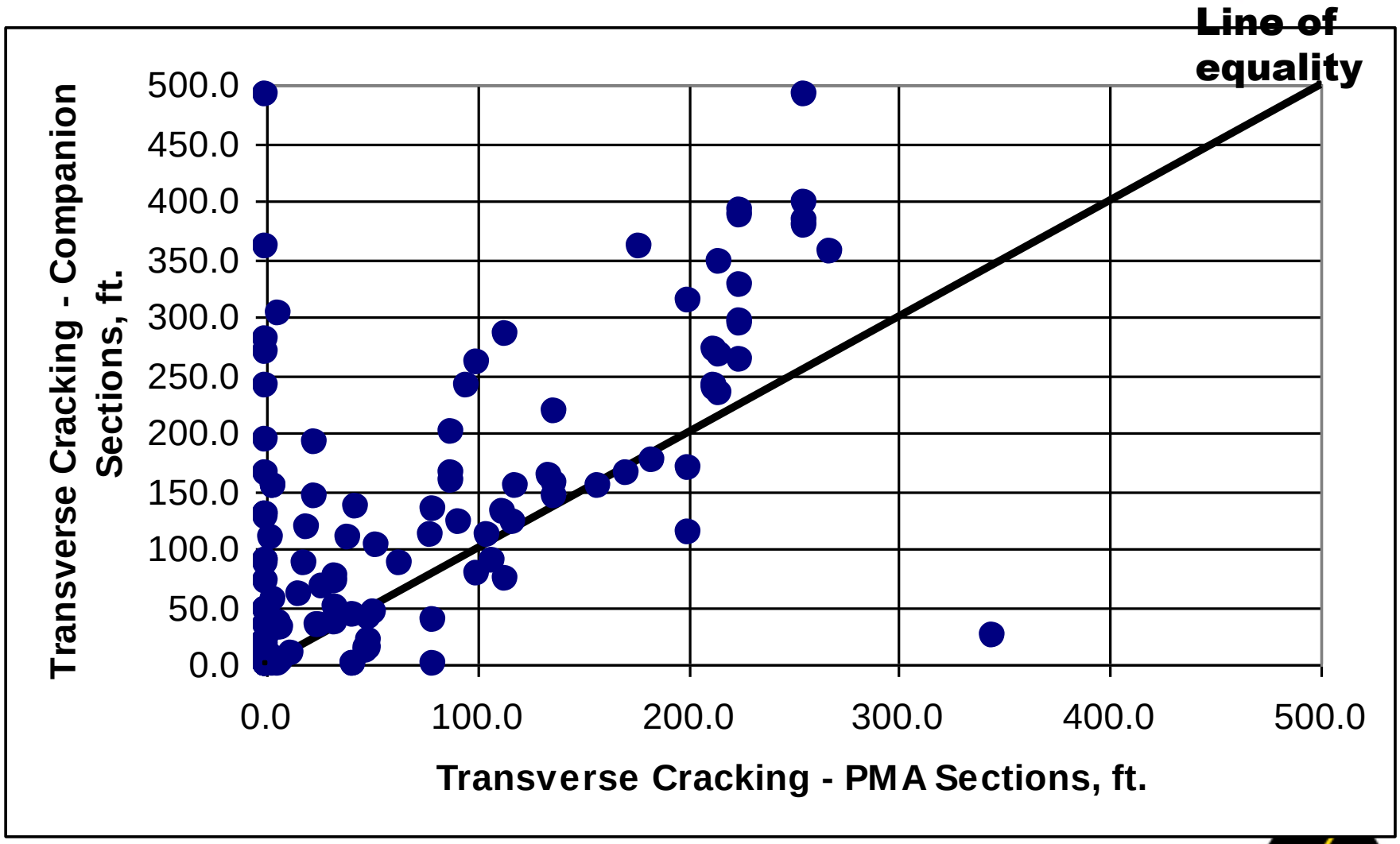





- age of these sections varies

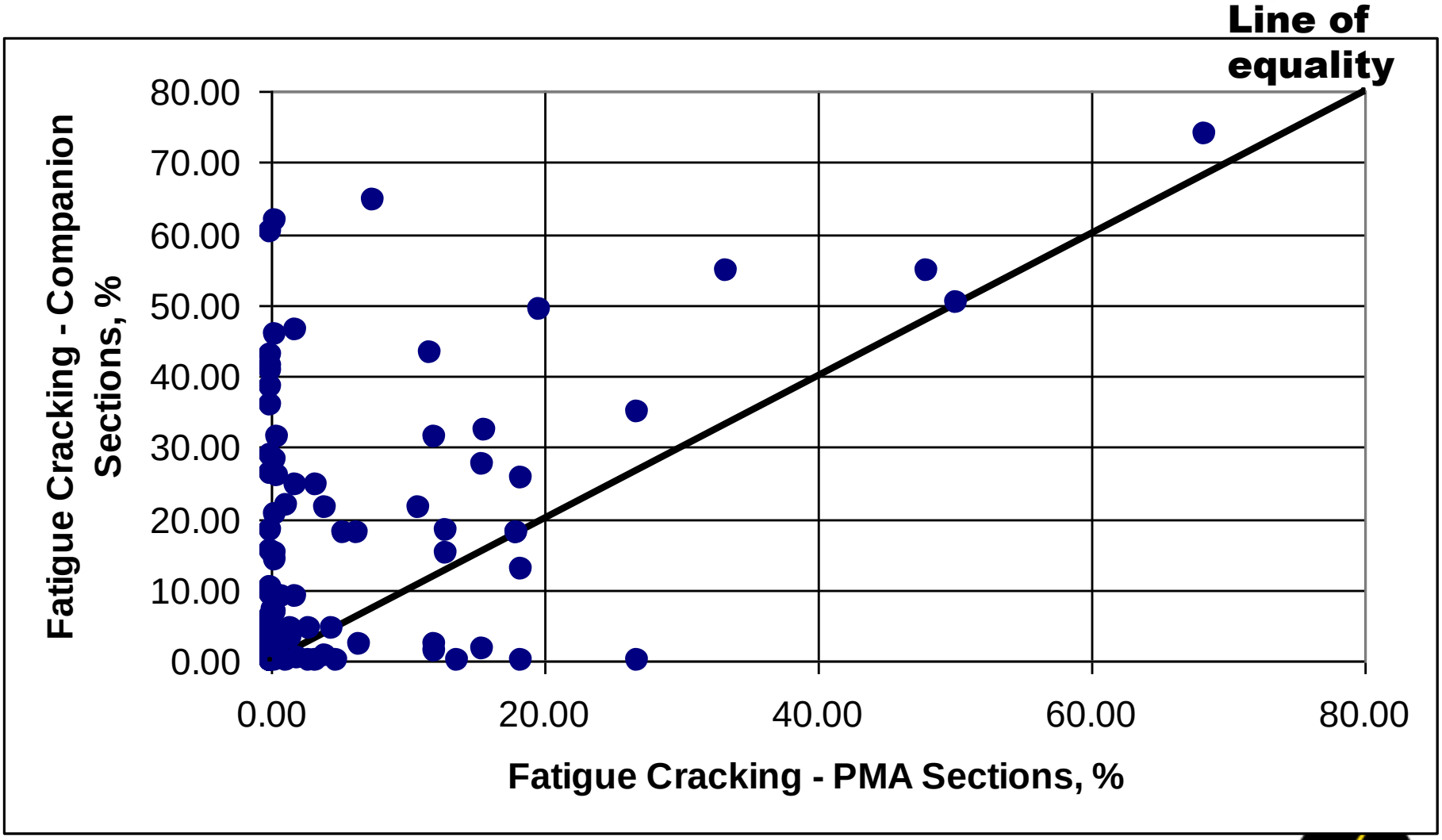
# Distress Comparisons – Transverse Cracking





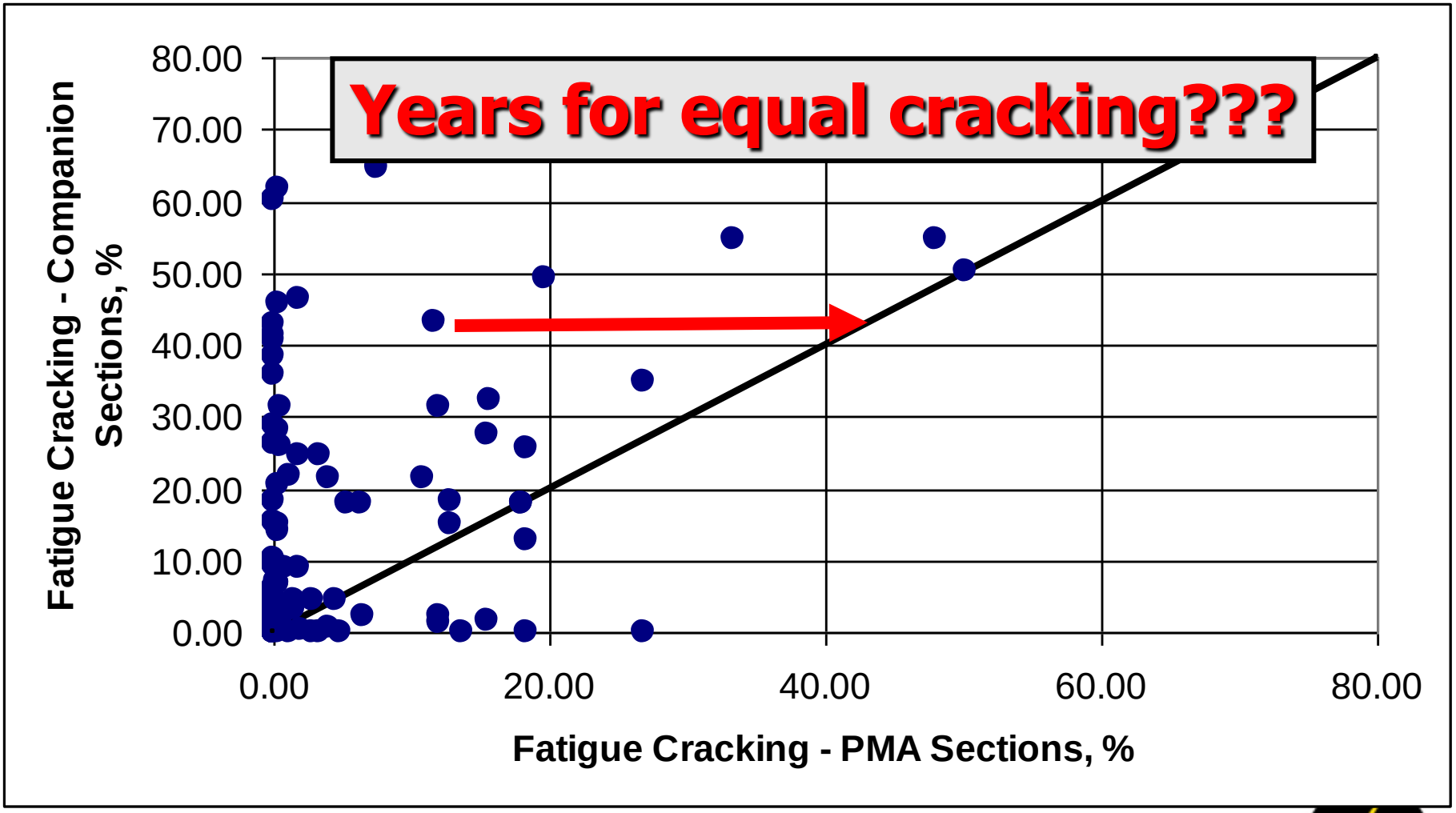
# Distress Comparisons – Fatigue Cracking





# Direct Comparisons Useful, But Still Have NOT Quantified Extended Service Life of PMA





# Mechanistic-Empirical Analysis



- Use distress prediction models from new M.E. Pavement Design Guide for:
  - Fatigue Cracking
  - Rutting
- Damage Indices (DI =n / $N_f$) computed using factorial cell specific calibration
  - For each of the 32 cells
- Compare D.I. to the actual field distress measurements for both PMA and unmodified sections to obtain different “expected service lives”

# Summary of Expected Increase in Service Life, Years, Based on M-E Damage Based Analysis

asphalt institute

Assumptions: Unmodified sections designed for 20 yr. life. Also, PMA in top 4 inches.

| Site Factor | Condition Description | | Added Life |
|---|---|---|---|
| Foundation | Non-expansive, coarse soils | | 5-10 |
| | Expansive and plastic soils (PI>35) | | 2-5 |
| | Frost Susceptible in cold climate | | 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 |

# Continued:
# Summary of Expected Increase in Service Life, Yrs

asphalt institute

Assumptions: Unmodified sections designed for 20 yr. life. Also, PMA in top 4 inches.

| 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 |

# Generic LCCA Timeline for Conventional Unmod. versus Revised Timelines for PMA Based on Study

| Years | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 |
|---|---|---|---|---|---|---|---|---|
| Conv. Unmod. Mix | | Mill - Fill | | Struct. Over. | | Mill - Fill | | Struct Over. |
| PMA in top 4 inches | | | | Struc. Over. | | | | Struct Over. |
| PMA in top 4 inches and in Base | | | | Mill - Fill | | | | Mill - Fill |

***PMA benefits quantified, but does it make sense economically?***

# Purpose of Life Cycle Cost Analysis

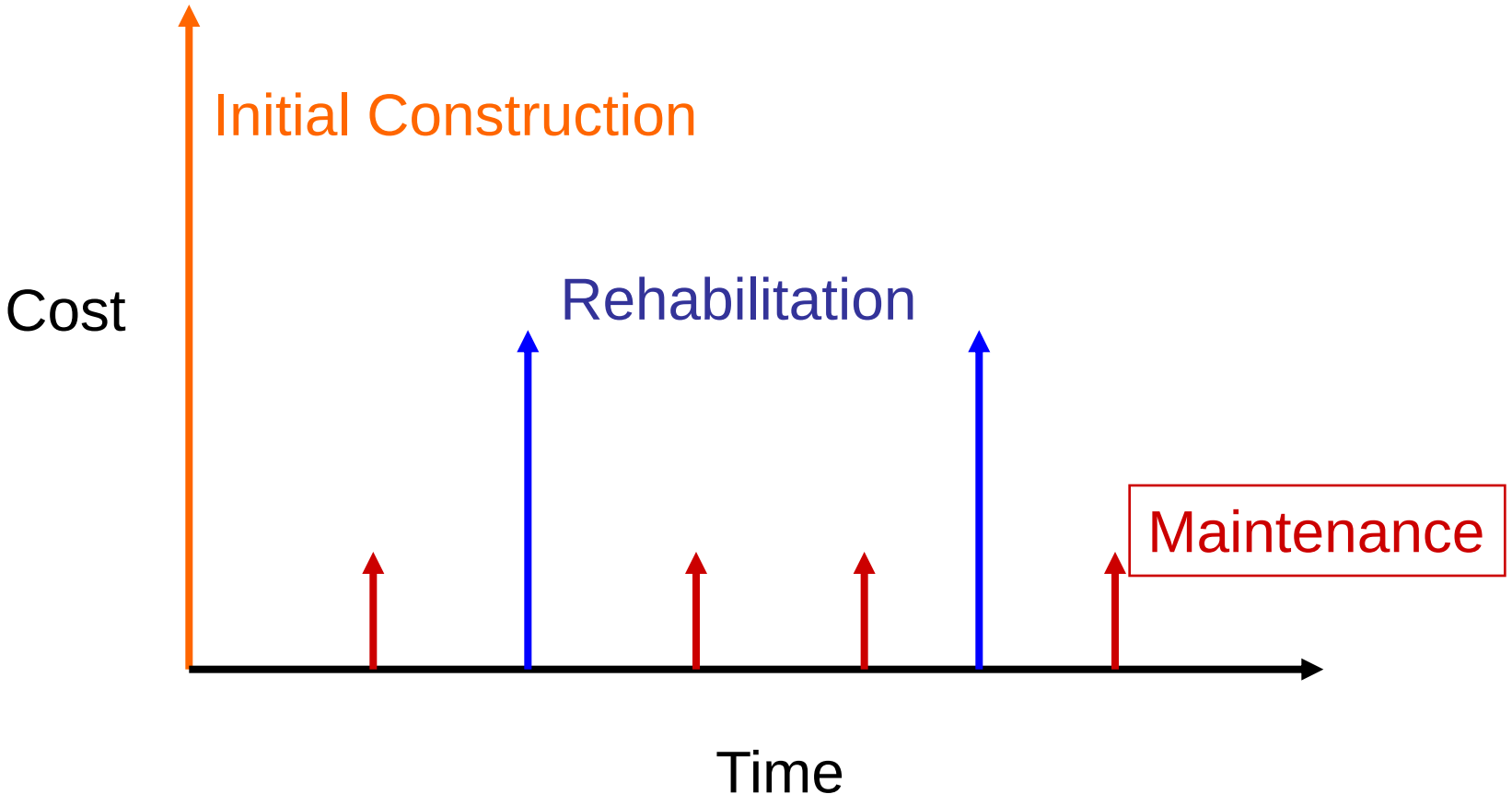


- **To evaluate the overall long-term economic efficiency between competing alternative investment options**

**Classic use is HMA alternative versus PCC alternative, but doesn't have to be.**

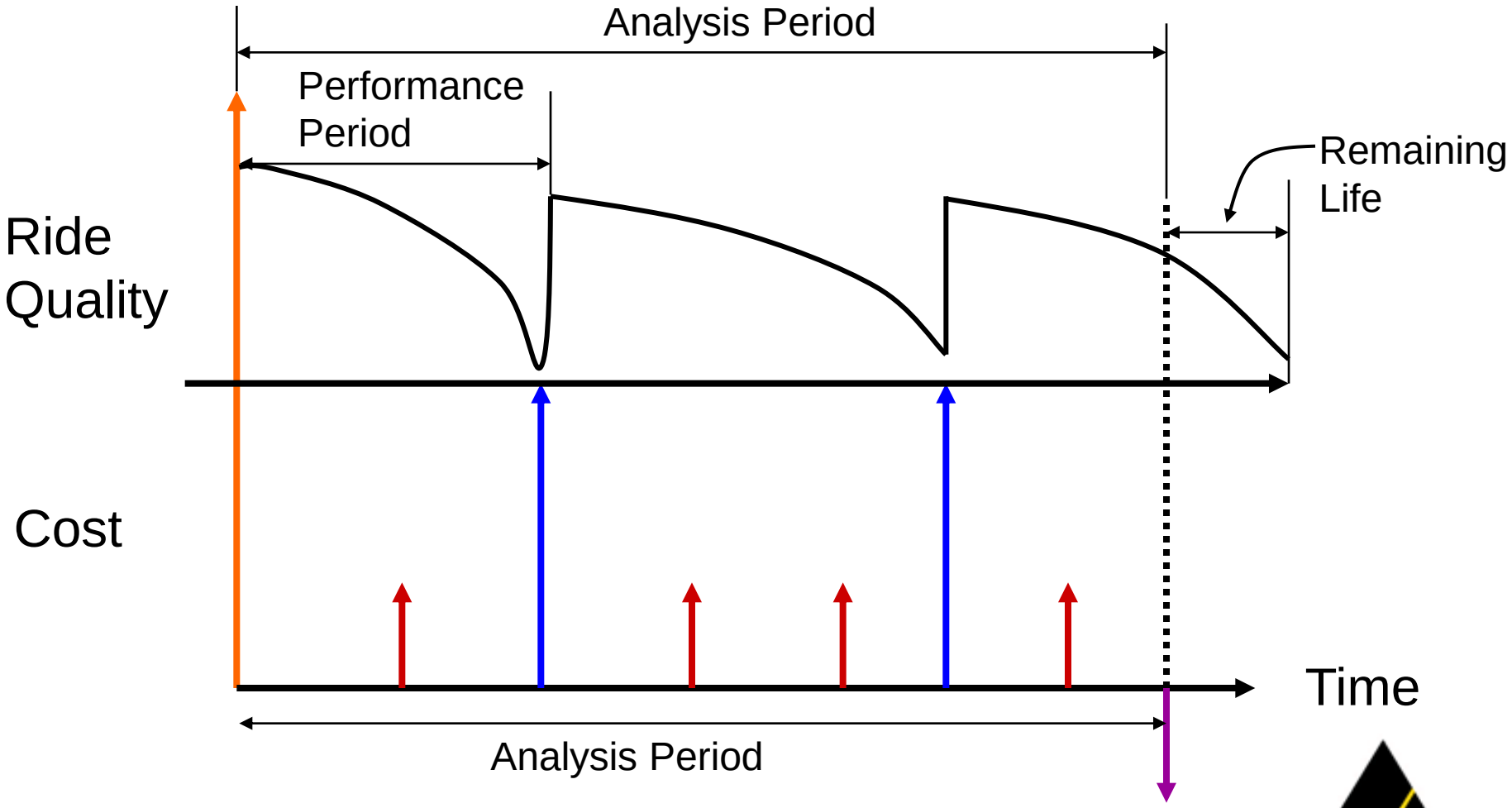
# The Life Cycle





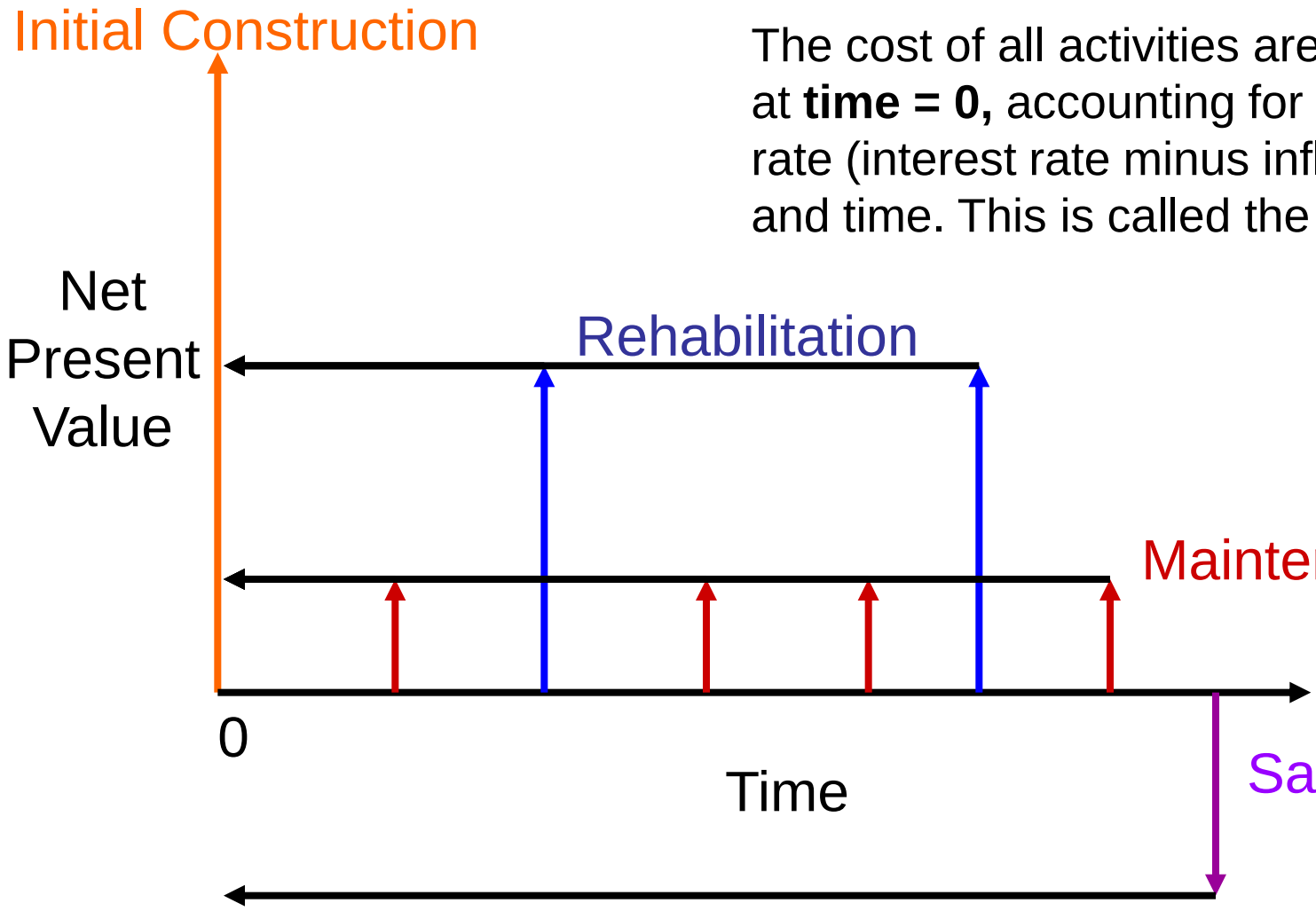
# Performance





# Net Present Value (NPV)






The cost of all activities are computed at **time = 0,** accounting for discount rate (interest rate minus inflation rate) and time. This is called the **NPV.**

# Economics of Using PMA



Use LCCA to Evaluate Actual Cost or Savings of Using PMA, Recognizing It's Enhanced Performance

# LCCA for PMA



- **Compare Unmodified Alternative to PMA Alternatives**
- **Example Follows, But…**
- **Each Agency Must Evaluate Using Own Inputs:**
  - **Prices, Performance Periods (time to 1st overlay and subsequent overlays) , Thickness Designs, Timing Strategies, Discount Rate, User Costs, Etc**

# What LCCA Inputs for HMA Alternatives Are the Most Critical?



- Greatest Impact
  - Initial Costs
  - Time to 1st Overlay
- Less Impact
  - Future Overlay Costs
  - Future Overlay Performance Periods
  - Especially in the Far Future
- Must Recognize Use of Premium Mixes or Materials (PMA)
  - Through Higher Costs but also Longer Performance Periods

# Example



- 14 inch thick HMA pavement
- 2 lanes with shoulders
- 4% discount rate
- 40 year analysis period
- No user costs considered
- PMA mixtures cost 15% more

# Example Summary of Initial Costs (per lane mile) and Savings

| Alternative | Initial Cost | %Increase[#] | NPV | %Savings |
|---|---|---|---|---|
| 1) Unmodified – All Layers (resurface @ yr 10 & 28, structural overlay@ yr 18 & 34) | $668K | - | $1,005K | - |
| 2) Modify top two lifts (4.5”) (structural overlay @ yr 18 & 34) | $698K | 4.5% | $964K | 4.5% |
| 3) Modify top two lifts (4.5”) and bottom base lift (4”) (resurface @ yr 18 & 34) (Serving as Perpetual Pavement) | $725K | 8.5% | $864K | 14.0% |

[#] *Cost to use PMA equates to approx. 1% of initial cost per inch modified*

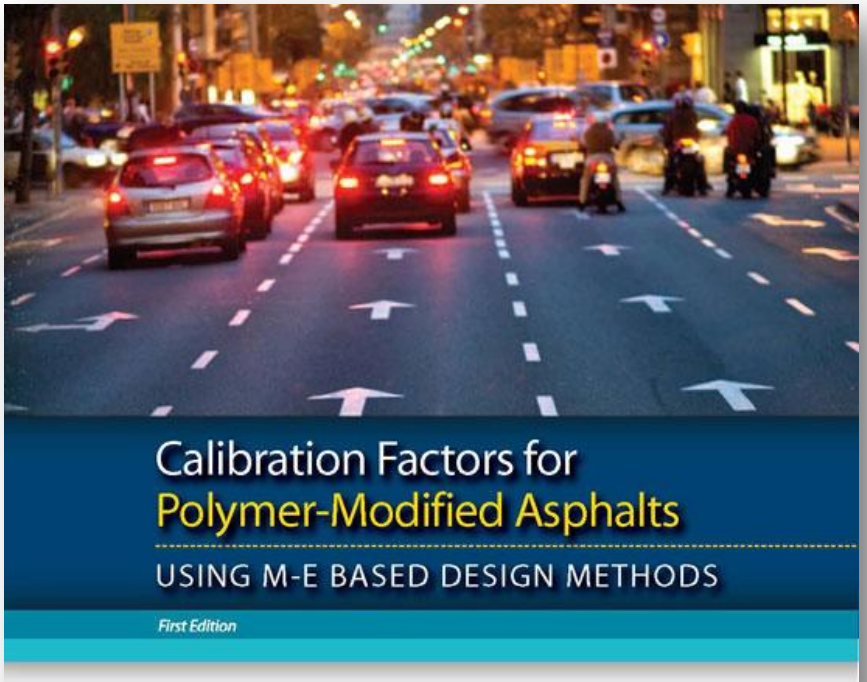
# Conclusions



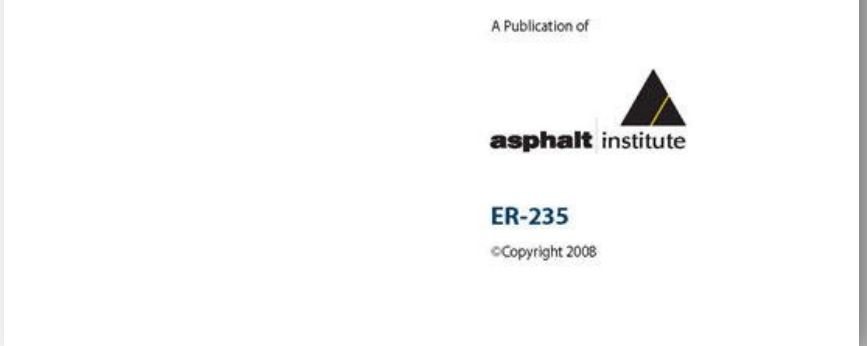
- PMA Benefits Quantified Through:
  - Decreased Distress Levels
  - Increased Service Life
- LCCA Can Be Utilized to Understand the True Economics of PMA
  - Depends on Performance Assumptions

# A.I. Engineering Report - 235

asphalt institute




***Author: Harold Von Quintus, P.E.***




*Calibration Factors for Polymer-Modified Asphalts Using M-E Based Design Methods*

- Presents calibration factors for rutting, fatigue cracking, and transverse cracking specific to polymer-modified asphalt (PMA) mixtures for use with the new Mechanistic-Empirical Pavement Design Guide (MEPDG).

- Analysis and methodology provided for adjusting calibration factors of asphalt mixtures to better predict the improved performance expected when using PMA.


The End
SAUDI ARABIAN
السعودية

# Mix Design Technology Certification Course

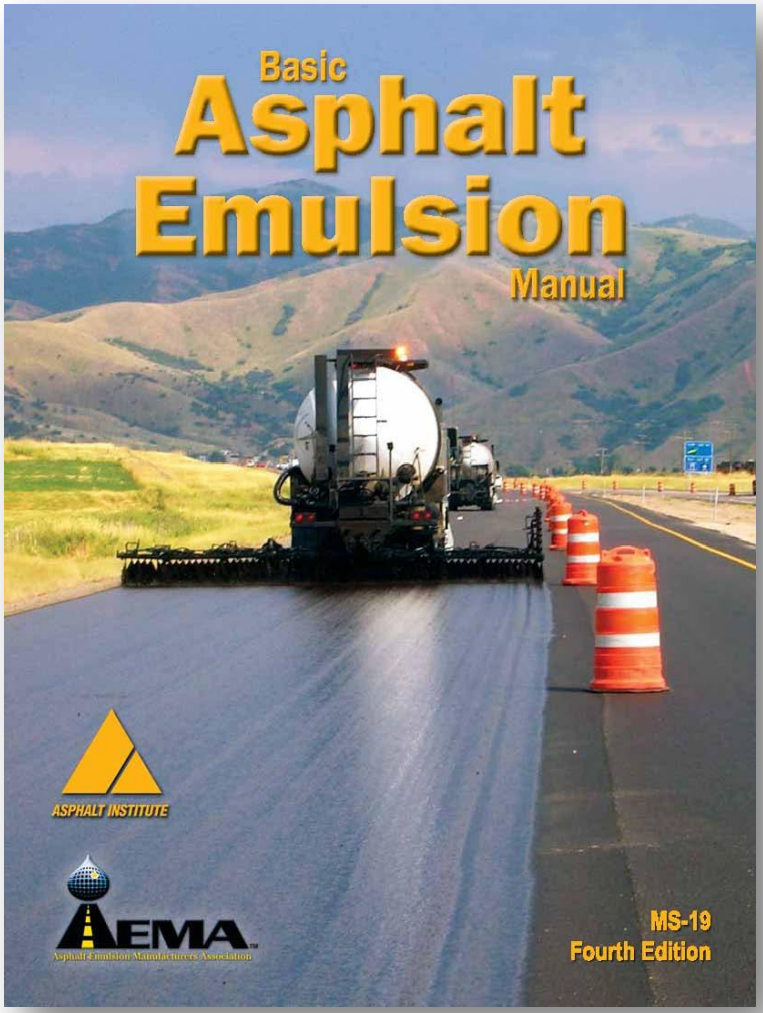
asphalt institute


- ***Feb 24 - 27, 2009***
- ***AI Lab and HQ, Lexington, KY***

- **Material selection**
- **Proportioning and volumetric analysis**
- **Sample preparation and mix testing**
- **Gyratory and Marshall compaction**
- **Hands-on lab activities**
- **RAP utilization**
- **SMA, OGFC and Warm Mix**
- **Optional certification exam**

# MS-19
# *Basic Asphalt Emulsion Manual*

asphalt institute




- New Edition
  - Available Jan '09
  - Price: $60
- Co-publish with AEMA
- Joint AI and AEMA Technical Writing Team
- Complete Rewrite of Content

# Airport Asphalt Pavement Workshop

asphalt institute


- Apr. 7–9, 2009
- Chicago
- Airfield Topics Covered:
  - Materials
  - Design
  - Construction
  - QC/QA
  - Preservation Practices
- All Lessons Specific to Airfields

# AAPTP Project 06–05: *Guidelines for Use of Highway Specs for HMA Airport Pavements*



- **Research Team:**
  - AI Regional Engineers
- **Objective**
  - Comprehensive document that provides guidance to airport designers on the selection and modification of state highway specifications for use on airport HMA pavement projects serving less than 60,000 lb aircraft.
- **Key Issues**
  - PWL, joint density as pay item, use of contractor QC as basis of material acceptance
- **To be completed in next few months**

# Binder Spec Database





## State Binder Specs

**Description:** The Asphalt Institute and PRI Asphalt Technologies have collaborated to develop this binder specification database. Available below (as downloadable pdf files) are individual documents for each of the 50 state highway agencies summarizing their respective asphalt binder specifications. A few additional agencies are also provided. A standardized format is used to list specification methods and criteria, PG-plus tests and requirements, typical grades, exclusions, and the agency's website where specifications can be found.

**Updating:** AI and PRI will periodically contact the Binder or Materials Engineer listed on each document to review the agency's information for accuracy. Corrections or comments may be e-mailed to us by using the link below. Changes will only be made after confirmation by the individual listed for that agency.

**Disclaimer:** While care has been taken to provide the most accurate and current information, users are warned that there may be inaccuracies and recent specification revisions may not be reflected. **To ensure the most accurate information, the particular agency should be contacted.**

Click **HERE** to fill out the form for corrections or comments.

All documents are in Adobe PDF format. You need the free Adobe Reader to view these files. If you do not have the reader you can download by clicking on the Get Adobe Reader button.

Get Adobe Reader

| | | | | |
|---|---|---|---|---|
| Alabama | Alaska | Arizona | Arkansas | California |
| Colorado | Connecticut | Delaware | Florida | Georgia |
| Hawaii | Idaho | Illinois | Indiana | Iowa |
| Kansas | Kentucky | Louisiana | Maine | Maryland |
| Massachusetts | Michigan | Minnesota | Mississippi | Missouri |
| Montana | Nebraska | Nevada | Nevada (Clark County) | New Hampshire |
| New Jersey | New Mexico | New York State | North Carolina | North Dakota |
| Ohio | Oklahoma | Oregon | Pennsylvania | Rhode Island |
| South Carolina | South Dakota | Tennessee | Texas | Utah |
| Vermont | Virginia | Washington | Washington DC | West Virginia |
| Wisconsin | Wyoming | | | |

| | |
|---|---|
| **State:** COLORADO | **Materials:** Re: Section 702 SUPERPAVE PG Binders, CDOT's Standard Specifications for Road & Bridge Construction |
| **Date Last Reviewed:** 4-4-2005 | **Web Address:** www.colorado.gov |
| **Materials Engineer:** Tim Aschenbrener | **Contact Info:** tim.aschenbrener@dot.state.co.us |

**ASPHALT BINDER:**

| | | |
|---|---|---|
| 702.01 (b) | **Description**: | Supplier must be certified in accordance with CP 11. Samples of PG Binder for acceptance shall be sampled on the project as stated in the Schedule of Field Materials Manual. |
| 702.01 (a) | **PMA's** | None stated. |
| | **Exclusions:** | Asphalt shall not be Acid or Alkaline modified. Shall not contain any used oils that have not been re-refined or reprocessed. No modifiers shall be added that do not comply with Environmental rules and regulations including 40 CFR Part 261.6(a)(3)(v) and 266/Subpart C. Modifiers shall not be carcinogenic. |

| PROPERTY | | Test Method AASHTO or Other | Requirements by Performance Grade, PG (Common Grades) | | | | |
|---|---|---|---|---|---|---|---|
| | | | 58-28 | 58-34 | 64-22 | 64-28 | 76-28 |
| **ORIGINAL:** | | | | | | | |
| Flash Point, °C | | T 48 | 230 min. | | | | |
| Rotational Viscosity, Pa Xs | 135°C | TP 48 | 3.0 max. | | | | |
| Dynamic Shear, kPa (G* /sin *, 10 rad./sec.) | At grade temperature | T 315 | 1.0 min. | | | | |

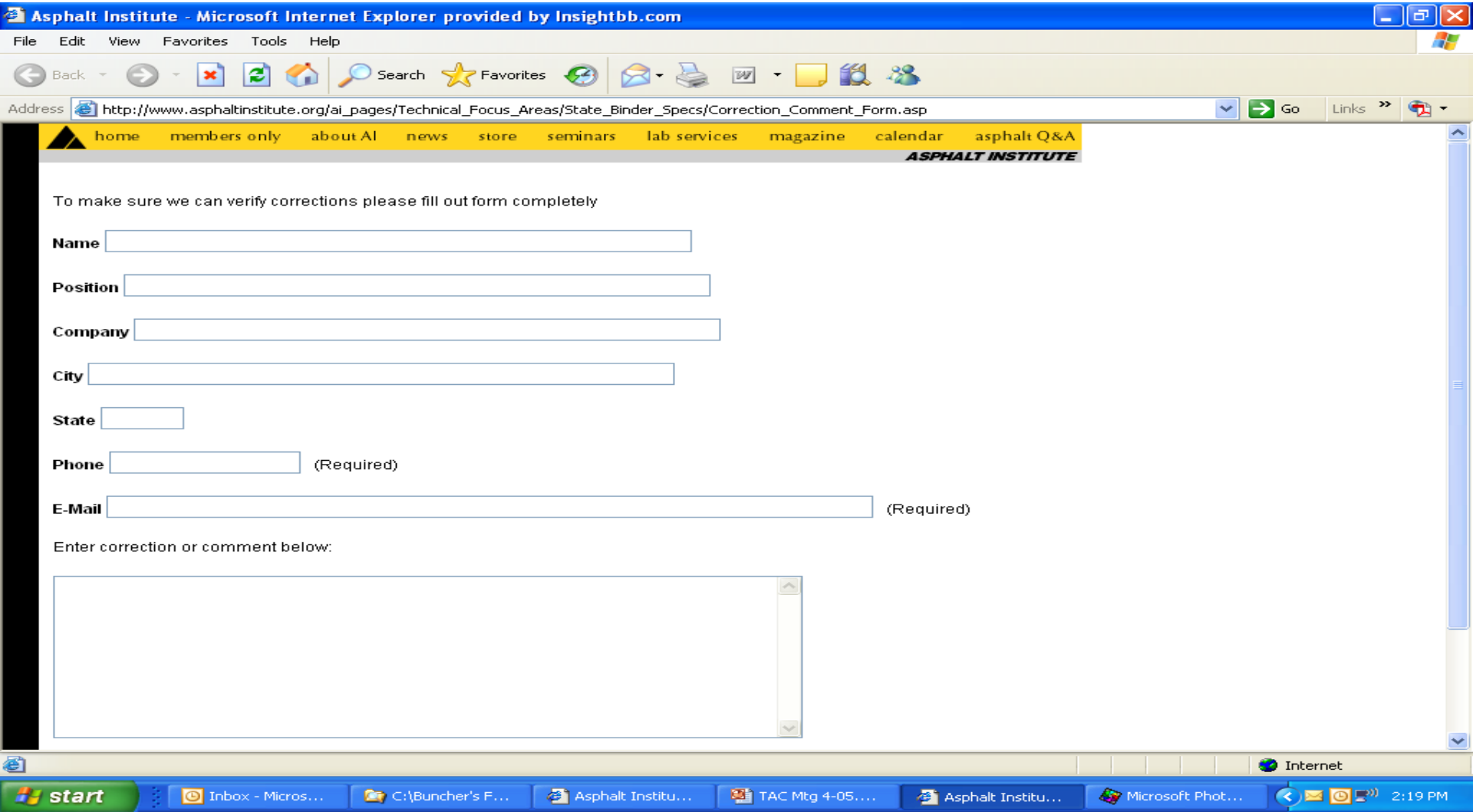
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | At grade temperature | T313 | -18°C | -24°C | -12°C | -18°C | |
| Direct Tension, (1mm/min.), % Strain[1] | At grade temperature | T 314 | 1.0 min. - referee test | | | | |
| | | | -18°C | -24°C | -12°C | -18°C | |

**PG PLUS REQUIREMENTS:** YES

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **ORIGINAL:** | | | | | | | | |
| Ductility, (5 cm/min.), cm | | 4°C | T 51 | -- | -- | -- | 50 min. | -- |
| Toughness & Tenacity | Toughness, N-m | 25°C | CP L 2210 | -- | -- | -- | 110 min. (12.4) | -- |
| | Tenacity, N-m | | | -- | -- | -- | 75 min. (8.5) | -- |
| Acid or Base Modification[2] | | | CP L 2214 | Pass | | | | |
| **RTFOT PROPERTIES:** | | | | | | | | |
| Elastic Recovery, % | | 25°C | CP L 2211 A | -- | -- | -- | -- | 50 min. |
| Ductility, cm (5 cm/min.) | | | T 51 | -- | -- | -- | 20 min. | -- |

**Notes:**

1. Direct Tension measurements are required when needed to show conformance to M 320.
2. The Department will test for acid and alkaline modification during binder certification process. Thereafter, the Department will randomly test for acid and alkaline modification.


Asphalt Institute - Microsoft Internet Explorer provided by Insightbb.com
File Edit View Favorites Tools Help
Back Search Favorites
Address http://www.asphaltinstitute.org/ai_pages/Technical_Focus_Areas/State_Binder_Specs/Correction_Comment_Form.asp
Go Links
home members only about AI news store seminars lab services magazine calendar asphalt Q&A
ASPHALT INSTITUTE
To make sure we can verify corrections please fill out form completely
Name
Position
Company
City
State
Phone (Required)
E-Mail (Required)
Enter correction or comment below:
Internet
start
Inbox - Micros...
C:\Buncher's F...
Asphalt Institu...
TAC Mtg 4-05....
Asphalt Institu...
Microsoft Phot...
2:19 PM


No Kidding, The End
SAUDI ARABIAN
Questions?