

Quantifying the Benefits of Polymer Modified Asphalt

P3 Symposium
Laramie Wyoming
July 15, 2009

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Billings Montana

- **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

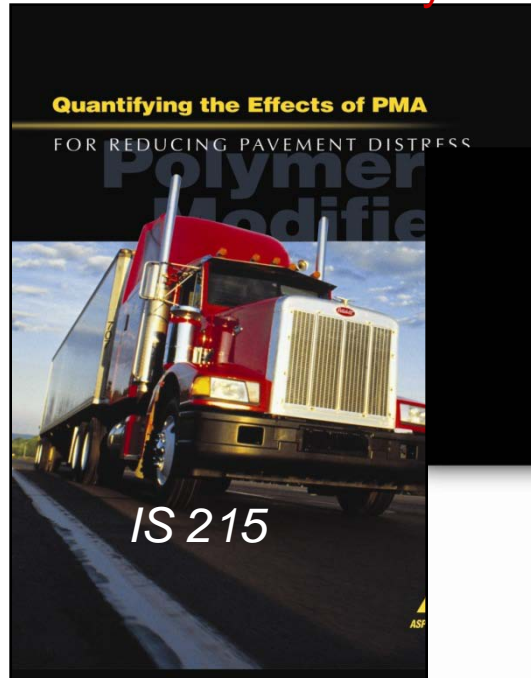
Design Engineer's Perspective

- 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?*

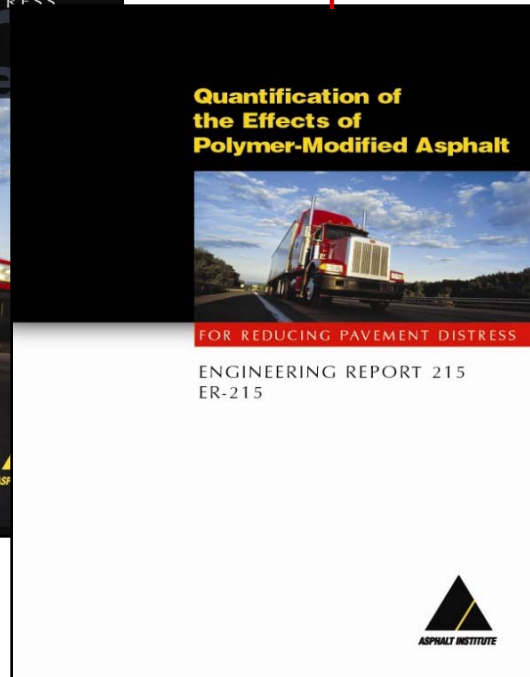
Quantifying the Effects of PMA for Reducing Pavement Distress

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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”



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

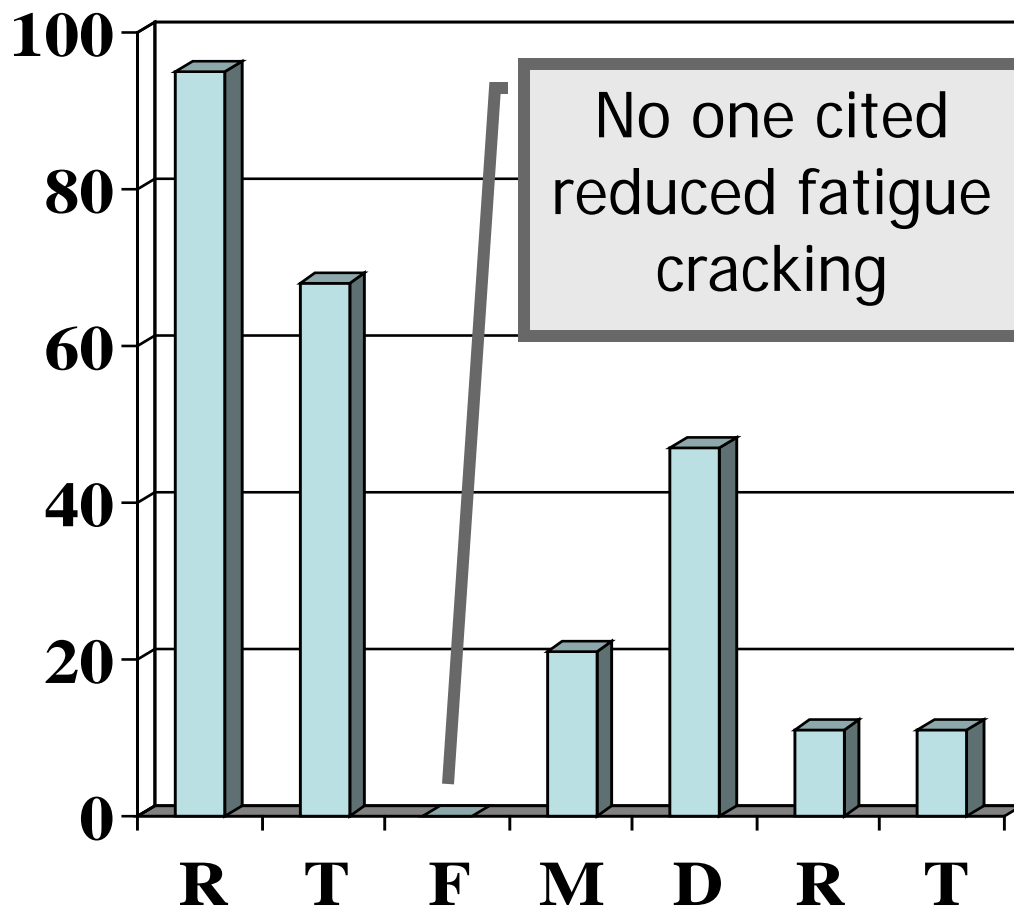
- PI: Harold L. Von Quintus, P.E.
- Associate: J. Mallela



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?



Response, %

- R = Rutting
- T = Thermal Cracking
- F = Fatigue Cracking
- M = Moisture Damage or Stripping
- D = Durability
- R = Raveling
- T = Tenderness

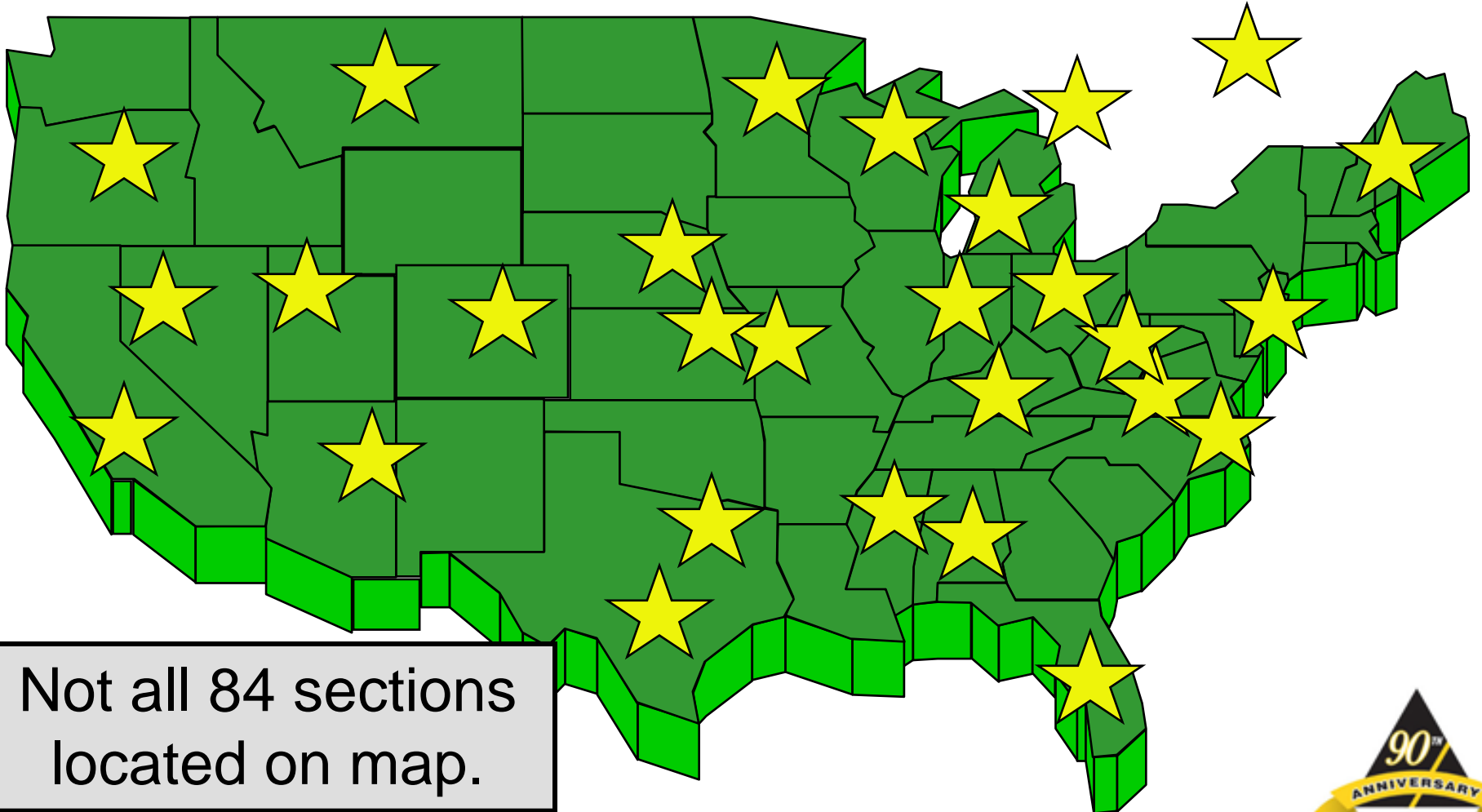
Field Test Sections

- 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

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Not all 84 sections located on map.

Pavement Surface Distress Data Collected/ Compared

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Already Thru
LTPP

In this study

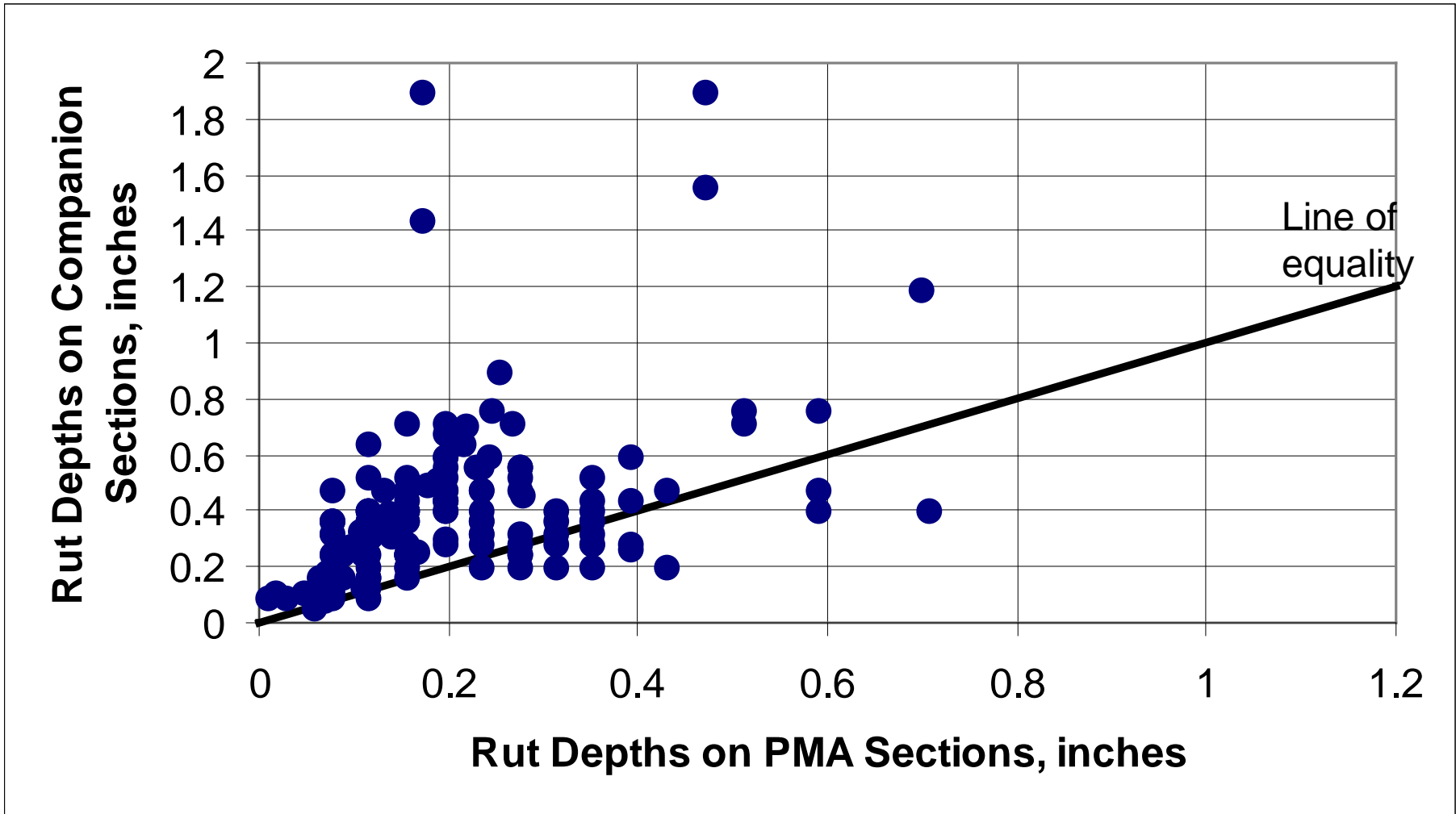
- Fatigue Cracking
- Rutting
- Thermal Cracking

Experimental Factorial – 32 Cells

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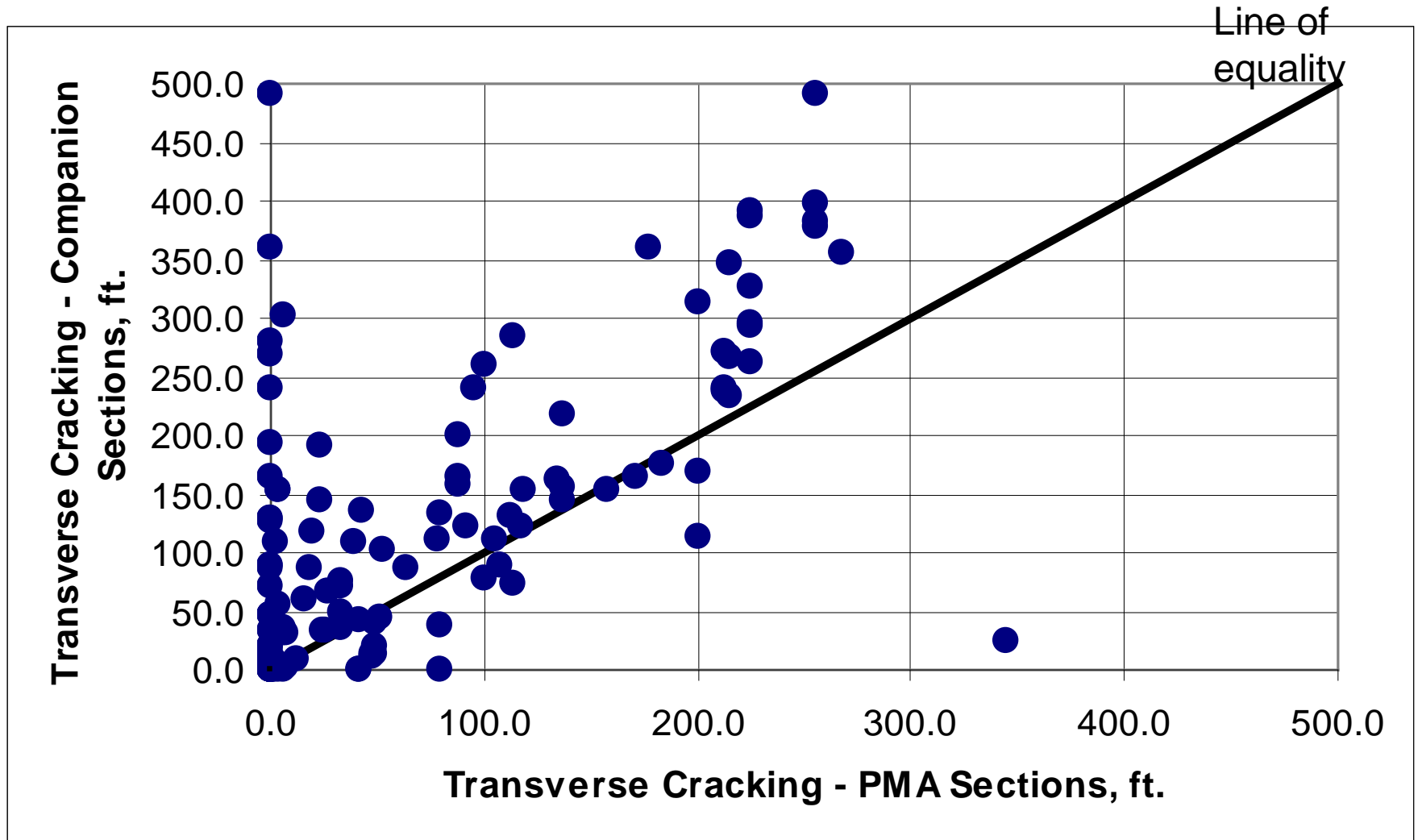
Pavement Cross Section	Base Foundation	Climate			
		Freeze		Non-Freeze	
		Wet	Dry	Wet	Dry
Thin HMA (<4")	Fine-Grained	2	2	4	3
	Coarse-Grained	3	3	3	3
Thick HMA (4-8")	Fine-Grained	2	2	2	3
	Coarse-Grained	2	2	3	2
Full-Depth (>8")	Fine-Grained	0	1	2	2
	Coarse-Grained	0	1	2	2
HMA Overlays	HMA	3	3	6	6
	PCC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

Direct Comparisons - Rutting

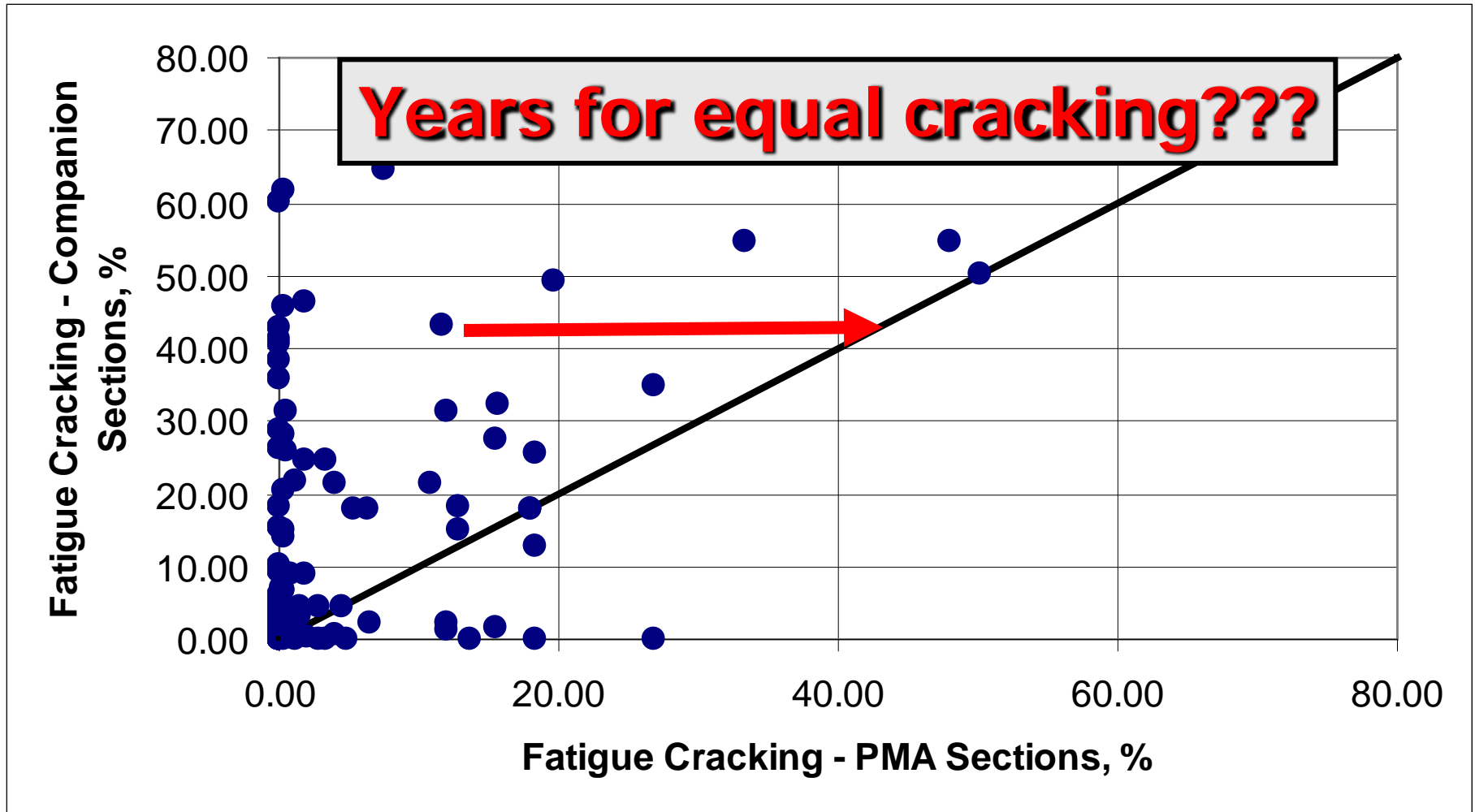


- age of these sections varies

Distress Comparisons - Transverse Cracking



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 DI 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

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Assumptions: Unmodified mixes designed for 20 yrs, PMA in wearing surface and bases

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

Assumptions: Unmodified mixes designed for 20 yrs, PMA in wearing surface and bases

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 Conventional LCCA Timeline and Revised PMA Timelines Based on Study Results

Years	5	10	15	20	25	30	35	40
Conv. Unmod. Mixes	R. Maint.		R. Maint.		R. Maint.		R. Maint.	
		Mill - Fill		Struc. Over.		Mill - Fill	Struc. Over.	
PMA in Surface (2-4")		R.M.				R.M.		
				Struc. Over.			Struc. Over.	
PMA in Surface and Bases			R.M.			R.M.		
				Mill - Fill			Mill - Fill	

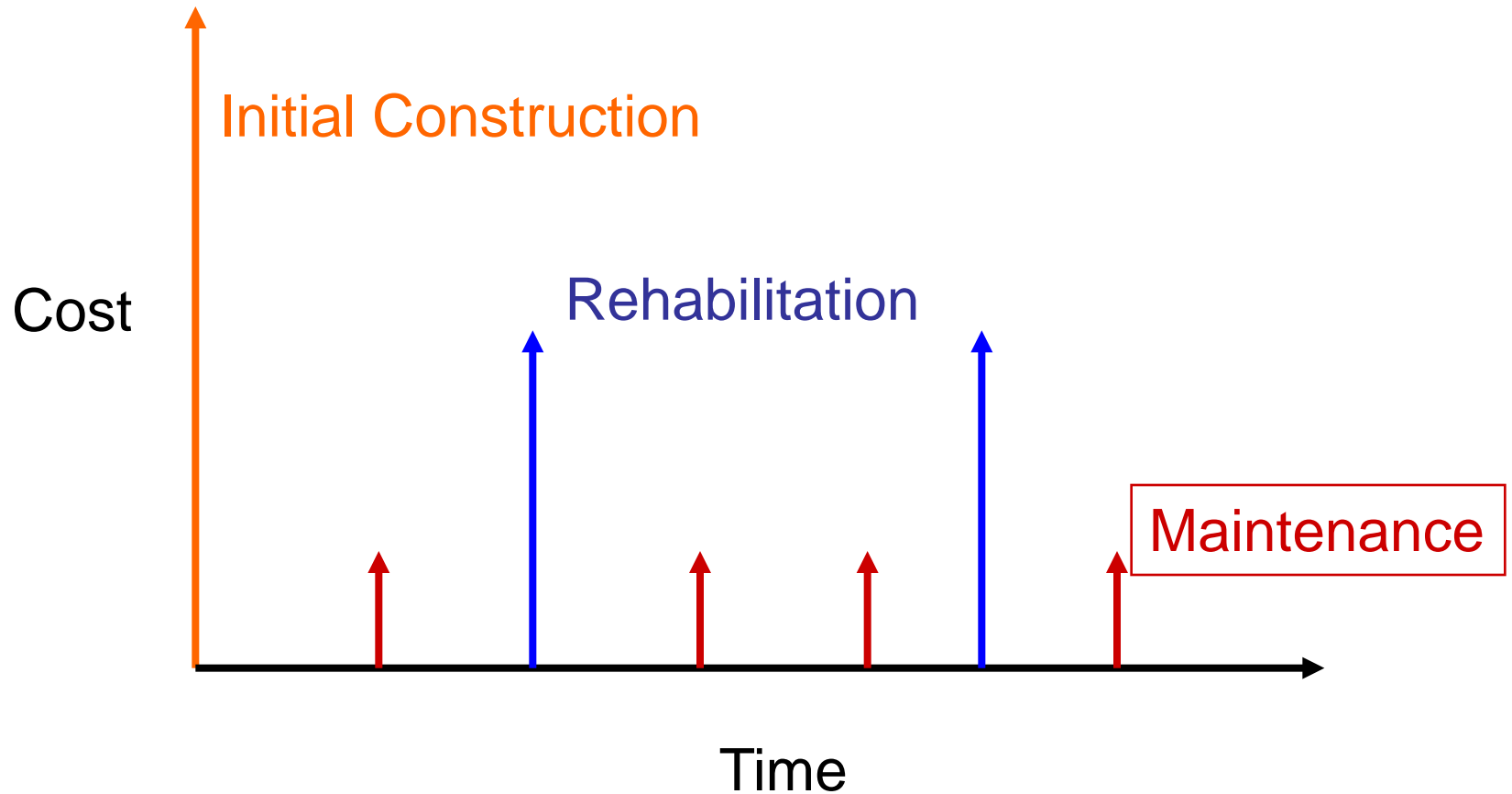
***PMA benefits quantified,
but does it make sense
economically?***

Purpose of Life Cycle Cost Analysis

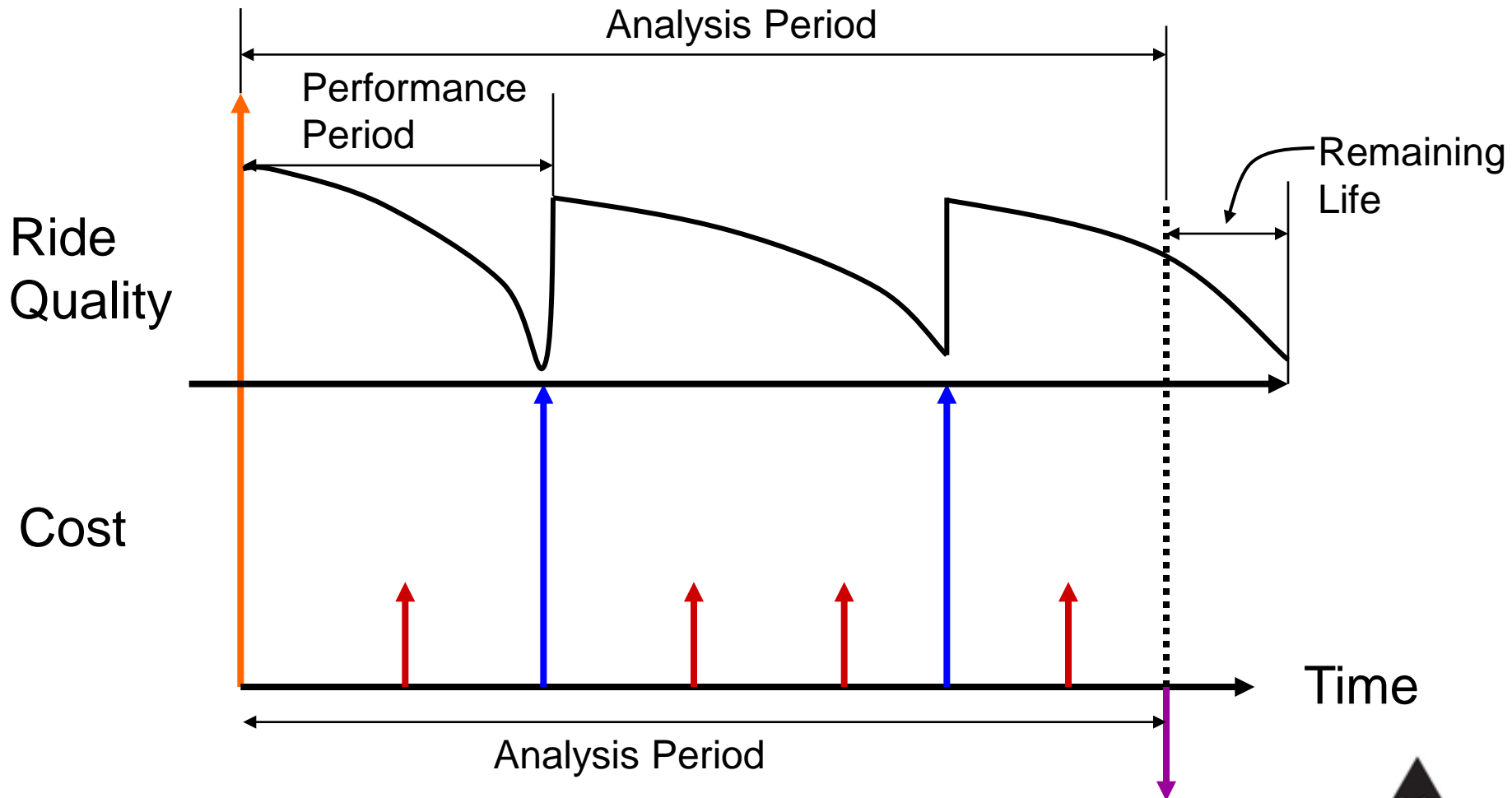
- **To evaluate the overall long-term economic efficiency between competing alternative investment options**

Traditionally used to HMA alternative versus PCC alternative

The Life Cycle



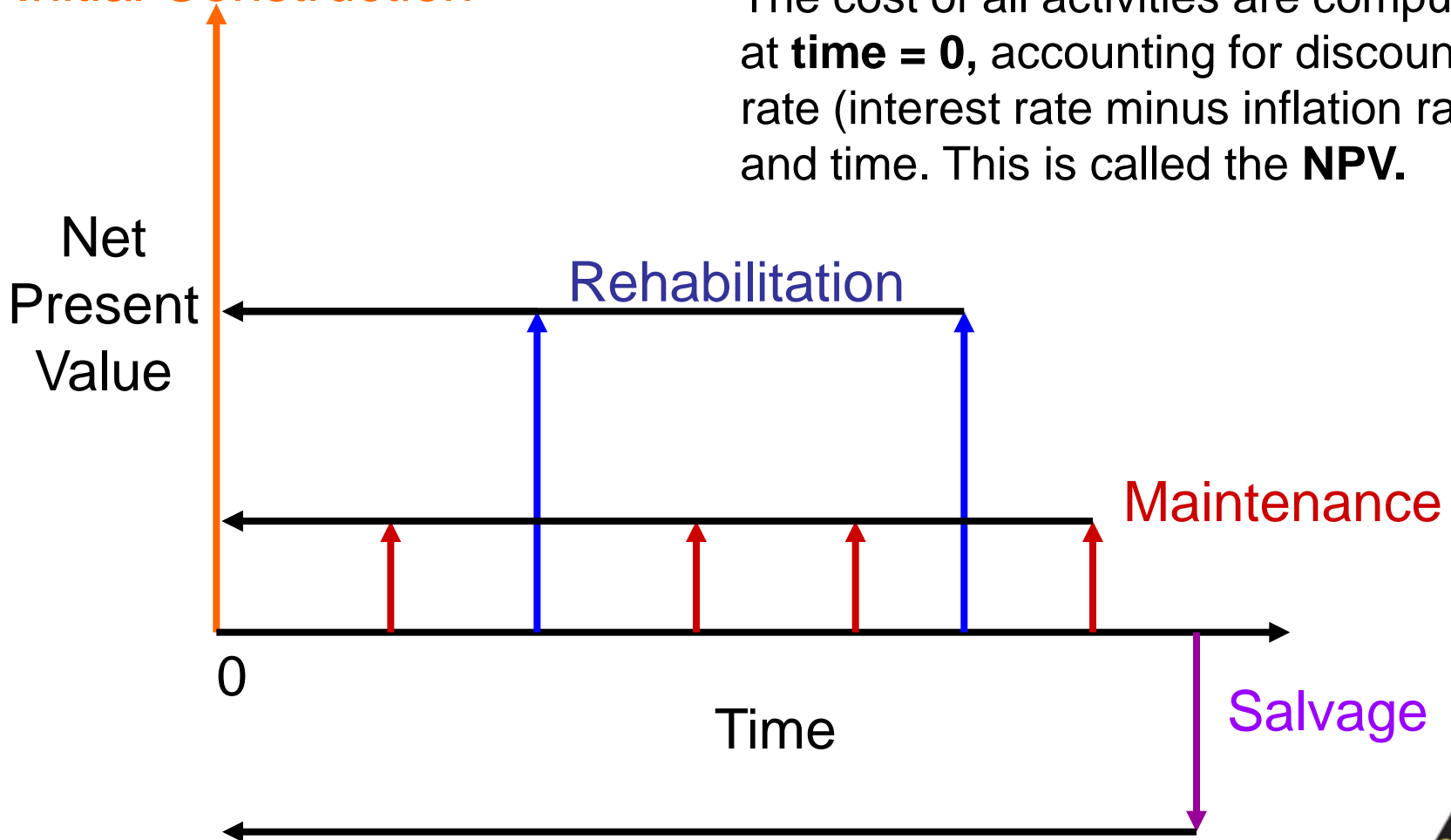
Performance



Net Present Value (NPV)

Initial Construction

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 Its Enhanced Performance

- **Compare Unmodified Alternative to PMA Alternatives**
- **Example Follows, But...**
- **Each Agency Must Evaluate Using Own Inputs:**
 - **Prices, Performance Periods, Designs, Strategies, Discount Rate, User Costs, Etc**

LCCA Tools

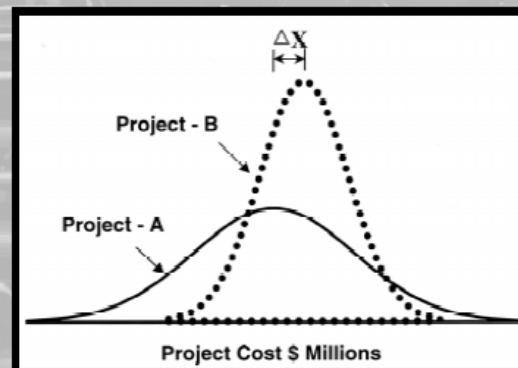


U.S. Department
of Transportation
**Federal Highway
Administration**

Publication No. FHWA-SA-98-079

Life-Cycle Cost Analysis in Pavement Design

- In Search of Better Investment Decisions -



Pavement Division Interim Technical Bulletin
September 1998

- Asphalt Pavement Alliance Software
 - LCCA
 - LCCAEpress
- FHWA
 - RealCost

Assumptions for Following Example

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<u>14.5" HMA Pavement</u>	<u>Discount Rate: 4%</u>		<u>No User Costs Considered</u>
	<u>Analysis Period = 40 yrs.</u>		
<u>Prices</u>			
Wearing (PG 64-22)	\$36/ton	\$1.97/sy-in	
Wearing (PG 76-22)	\$41/ton	\$2.24/sy-in	(15% increase for PMA)
Binder (PG 64-22)	\$35/ton	\$1.91/sy-in	
Binder (PG 76-22)	\$40/ton	\$2.19/sy-in	
Base (PG 64-22)	\$35/ton	\$1.91/sy-in	
Base (PG 76-22)	\$40/ton	\$2.19/sy-in	
Milling		\$1.40/sy	
HMA Patching		\$36/sy	
<u>Quantities (per mile)</u>			
Mainline: 2-lanes @ 12 ft ea.		14,080sy	
Shoulders: 1 @ 10 ft and 1 @ 4 ft		8,212sy	
<u>References</u>			
Prices from Maryland's "Pavement Selection Process"			
Maintenance from "Pa DOT Pub. 242, Pavement Policy Manual"			
Performance Scenarios are Examples from "Quantifying Effects of PMA"			



Alternative 1: Unmodified - All Layers

Year	Construction Item and/or Material	Quantity	Unit	Cost/Unit
0	10" HMA Base (3 - 10 EAL)	14080	sy	\$ 19.10
0	2.5" HMA Binder (3 - 10 EAL)	14080	sy	\$ 4.78
0	2" HMA Wearing (3 - 10 EAL)	14080	sy	\$ 3.94
0	10" HMA Base (0.3 - 3 EAL)	8212	sy	\$ 19.10
0	2.5" HMA Binder (0.3 - 3 EAL)	8212	sy	\$ 4.78
0	2" HMA Wearing (0.3 - 3 EAL)	8212	sy	\$ 3.94
0	Maint. & Protection of Traffic @2.3%	1	ls	\$14,264
0	Mobilization @5.5%	1	ls	\$34,109
10	Deep Patch 1% (mainline)	141	sy	\$ 36.00
10	Mill 2" (mainline)	14080	sy	\$ 1.40
10	2" hma overlay (mainline)	14080	sy	\$ 3.94
10	Maint. & Protection of Traffic @2.3%	1	ls	\$ 1,846.05
10	Mobilization @5.5%	1	ls	\$ 4,414.48
18	Mill 2"	22292	sy	\$ 1.40
18	Deep Patch 3% (mainline)	422	sy	\$ 36.00
18	#60 scratch course	422	ton	\$ 36.00
18	2.5" hma overlay (binder)	14080	sy	\$ 4.78
18	2" hma overlay (wearing)	14080	sy	\$ 3.94
18	#60 scratch course	246	ton	\$ 36.00
18	2.5" hma overlay (binder)	8212	sy	\$ 4.78
18	2" hma overlay (wearing)	8212	sy	\$ 3.94
18	Maint. & Protection of Traffic @2.3%	1	ls	\$6,091
18	Mobilization @5.5%	1	ls	\$14,566
28	Same Scenario as Year 10	1	ls	\$86,524
34	Same Scenario as Year 18	1	ls	\$285,492
20	Total Annual Maintenance (\$1825/yr)	40	yr	\$ 1,825.00
				Total

<u>Yr.</u>	<u>Activity</u>	<u>Cost,\$</u>	<u>NPW,\$</u>
0	10" Base 2.5" Binder 2" Wearing	668K	668K
10	2" mill/fill 1% patching (not on shoulders)	87K	58K
18	2" mill 3% patching scratch 2.5" Binder 2" Wearing (incl. shoulders)	285K	141K
28	Same as yr.10	87K	29K
34	Same as yr.18	285K	75K
Annual	Maint (\$1.8K/yr)	73K	33K
Total NPW: 1,005K			

Alternative 3: Modify Wearing Course (top 2" incl. shoulders) and Base (Bottom 4") – Perpetual Pymt.

Interest				
4				
Year	Construction Item and/or Material	Quantity	Unit	Cost/Unit
0	4" HMA Modified Base (3 - 10 EAL)	14080	sy	\$ 8.76
0	6" HMA Base (3 - 10 EAL)	14080	sy	\$ 11.46
0	2.5" HMA Binder (3 - 10 EAL)	14080	sy	\$ 4.78
0	2" HMA Wearing (3 - 10 EAL)	14080	sy	\$ 4.48
0	4" HMA Base (0.3 - 3 EAL)	8212	sy	\$ 8.76
0	6" HMA Base (3 - 10 EAL)	8212	sy	\$ 11.46
0	2.5" HMA Binder (0.3 - 3 EAL)	8212	sy	\$ 4.78
0	2" HMA Wearing (0.3 - 3 EAL)	8212	sy	\$ 4.48
0	Maint. & Protection of Traffic @2.3%	1	ls	\$15,115
0	Mobilization @5.5%	1	ls	\$36,144
18	Mill 2"	22292	sy	\$ 1.40
18	2" hma overlay (wearing)	14080	sy	\$ 4.48
18	2" hma overlay (wearing)	8212	sy	\$ 4.48
18	Maint. & Protection of Traffic @2.3%	1	ls	\$3,015
18	Mobilization @5.5%	1	ls	\$7,209
34	SameScenario as Year 18	1	ls	\$141,301
20	Total Annual Maintenance (\$1825/yr)	40	yr	\$ 1,825.00
				Total

<u>Yr.</u>	<u>Activity</u>	<u>Cost,\$</u>	<u>NPW,\$</u>
0	10" Base 2.5" Binder 2" Wearing	709K	709K
18	2" mill/fill (incl. shoulders)	141K	70K
34	Same as yr.18	141K	37K
Annual	Maint (\$1.8K/yr)	73K	33K
Total NPW:		849K	

Summary of Costs and Savings

<u>Alternative</u>	<u>Initial Cost</u>	<u>Increase</u> [#]	<u>NPV</u>	<u>Savings</u>
1) Unmodified – All Layers (resurface yr 10 & 28, structural overlay yr 18 & 34)	668K	-	1,005K	-
2) Modify Wearing Course (2") (structural overlay yr 18 & 34)	682K	2.0%	941K	6.5%
2a*) Modify Wearing (2") & Binder (2.5") (structural overlay yr 18 & 34)	698K	4.5%	964K	4.5%
3) Modify Wearing (2") & Base (4") (Perpetual Pvmt: resurface yr 18 & 34)	709K	6.0%	849K	15.5%
3a*) Modify Wearing, Binder & Base (Perpetual Pvmt: resurface yr 18 & 34)	725K	8.5%	864K	14.0%

**Note: Alternatives 2a and 3a offer a more conservative approach*

#Note: 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
 - Discount Rate
 - Time to First Overlay / Effective Life

The Next Step:

- Develop PMA Specific Calibration Factors for Rutting and Fatigue for New AASHTO M.E. Pavement Design Guide
 - P.I.: Harold Von Quintus (ARA)
 - P.M.: Mark Buncher (AI)
 - Jointly funded by FHWA, AMAP and Asphalt Institute Affiliate Members
 - Started January, 2007. Six Month Effort.

Product—ER-235

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Calibration Factors for Polymer-Modified Asphalts

USING M-E BASED DESIGN METHODS



ER-235





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Events

Mississippi Valley Conference (AASHTO)

-Amway Grand Plaza, Grand Rapids, Michigan - July 15, 2009

National Conference of State Legislatures

-Pennsylvania Convention Center, Philadelphia, Pennsylvania - July 20, 2009

68th Annual Meeting of SASHTO

-Beau Rivage – Convention Center, Biloxi, Mississippi - August 28, 2009

2009 APWA International Public Works Congress & Exposition

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6/1/2009 [APA announces winners of 2008 Perpetual Pavement Awards](#)

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.



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Questions?

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