Binder ETG Meeting
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Performance of Asphalt Mixtures Containing Polyphosphoric Acid

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APPLIED RESEARCH ASSOCIATES, INC.
An Employee Owned Company

Acknowledgements

Study Sponsor:

- Asphalt Institute, Mark Buncher
- FHWA

PPA Task Force:

- John D'Angelo
- Terry Arnold
- Mike Anderson
- Gayle King
- Fran Miknis
- Olga Puzic
- Gerald Reinke
- Henry Romagosa

Presentation Overview

1. **Overview & Study Objectives**
2. **Field Projects**
3. **Summary of Findings**

Study Objectives

1. Quantify effect of PPA as compared to non-PPA modified mixtures in terms of surface distress.
2. Identify site features and/or mixture properties/features that maximize effect of PPA relative to performance.

Reported Concerns with PPA

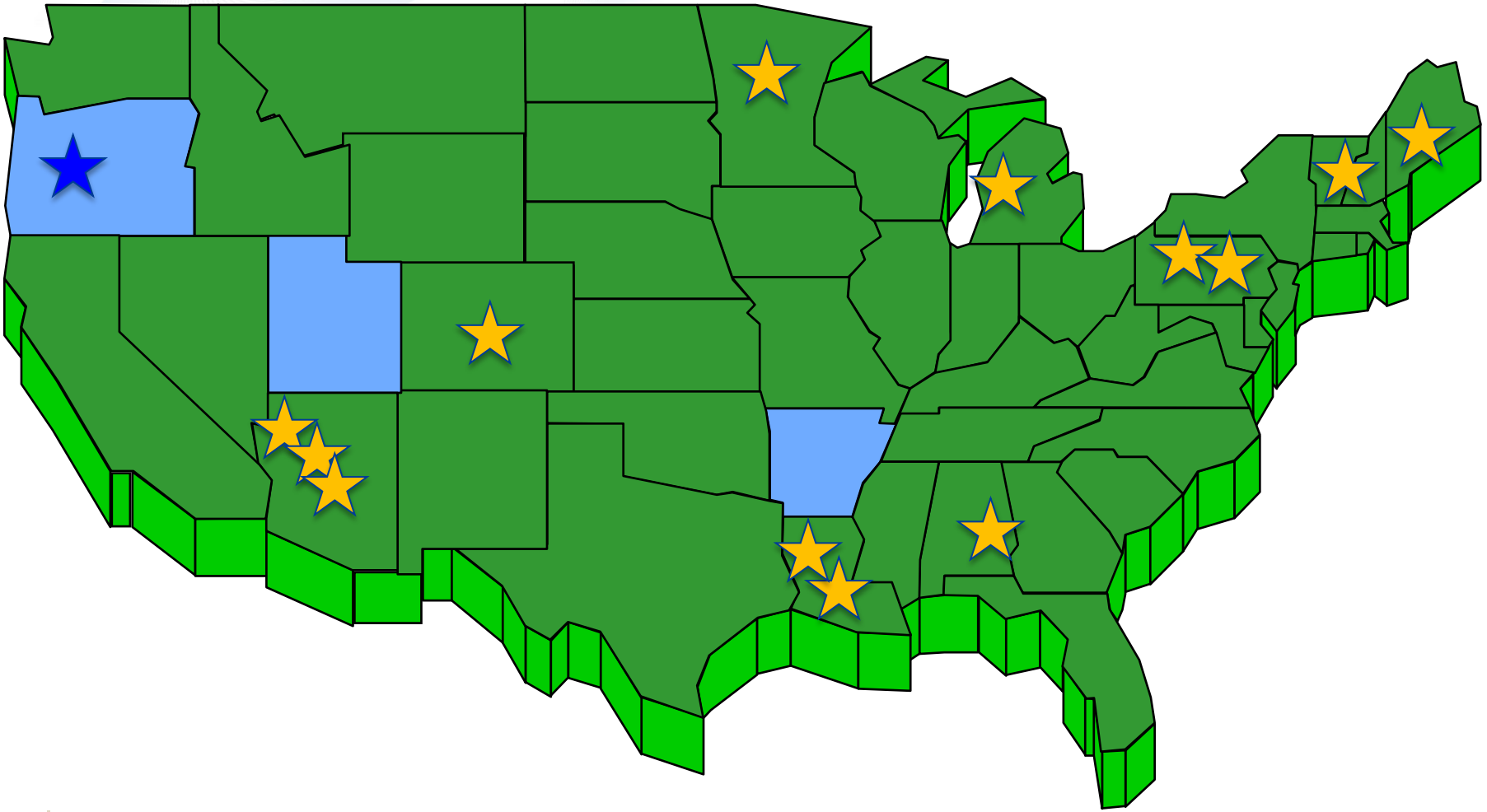
- PPA plus anti-stripping additive = problems.
- PPA plus lime or amines is not a long-term solution.
- Use of PPA = Increased moisture damage; < 0.85%.
- 1+ percent of PPA = Reduced strength because of increased water absorption.
- Fracture resistance decreases when PPA is used as a replacement for SBS.

Literature Overview

2012 FHWA Tech Brief States:

- "Sections have been in place for over 10 years with good performance.
- Sections have been placed in hot desert climates, hot wet climates, and cold wet climates.
- Negative interactions with aggregate types such as limestone have not been identified in any of the field projects."

Field Project Locations



- Project location; some include multiple projects.
- Many projects available but no companion sections.

Summary

Range of PPA:	0.25 to 1.0 percent.
Aggregate Type:	Granite, Gravel, Limestone.
Anti-Stripping:	None, Hydrated Lime, Amines.
Climate:	Hot-Dry, Hot-Wet, Cold-Dry, Cold-Wet.
Structure:	Reconstruction, Overlay.
Layer Thickness:	2 to 8 inches.
Age:	2 to 16 years (average age = 10.8 years)

Arizona US-93

PPA Section

2001 Reconstruction; 0.5 inches Asphalt Rubber Friction Course and 5 inches of HMA; PG 76-16

Non-PPA Section

Arizona SR-85

PPA Section

2001 Reconstruction; 0.5 inches Asphalt Rubber Friction Course and 7 inches of HMA; PG 76-16

Non-PPA Section

Michigan US-31

PPA Section

2005
Overlay of JPCP;
3 to 4 inches Dense Graded Mix;
PG 64-28

Non-PPA Section

Pennsylvania SR-153

PPA Section

1998
Overlay of Flexible Pavement;
4 inches Dense Graded Mix;

PPA: PG 64-28
Non-PPA: PG 64-22

Non-PPA Section

Maine SR-1

PPA Section

Non-PPA Section

2007
Reconstruct;
8 inches Dense
Graded Mix;

PPA: PG 58-28
Non-PPA: PG-64-28

Louisiana I-10

PPA Section

1998
Overlay of
Rubblized
JPCP;
5 inches
Dense Graded
Mix;

PG 76-22

Non-PPA Section

Louisiana I-20 & I-12

PPA Section

1998 Overlay of Rubblized JPCP; 5 inches Dense Graded Mix;

PG 76-22

Non-PPA Section

Comparison of PPA-Modified Sections

Type of Distress		Michigan US-31		Maine SR-1	
		PPA-Modified	Non-PPA	PPA-Modified Test Section 1; PG 58-28	Non-PPA Modified Test Section 2; PG 64-28
Cracking	Transverse, ft./mi.	210	250	0	0
	Longitudinal; ft./mi.	100	80	0	0
	Alligator; % of total lane area	0	0	0	0
	Reflection; ft./mi.	None	None	NA	NA
Patches; % lane area		Very Low	Very Low	0	0
Rut Depth Category		None	None	Very Low	Very Low
Mix Shoving/Distortions		None	None	None	None
Raveling		None	None	None	None
Bleeding				None	None

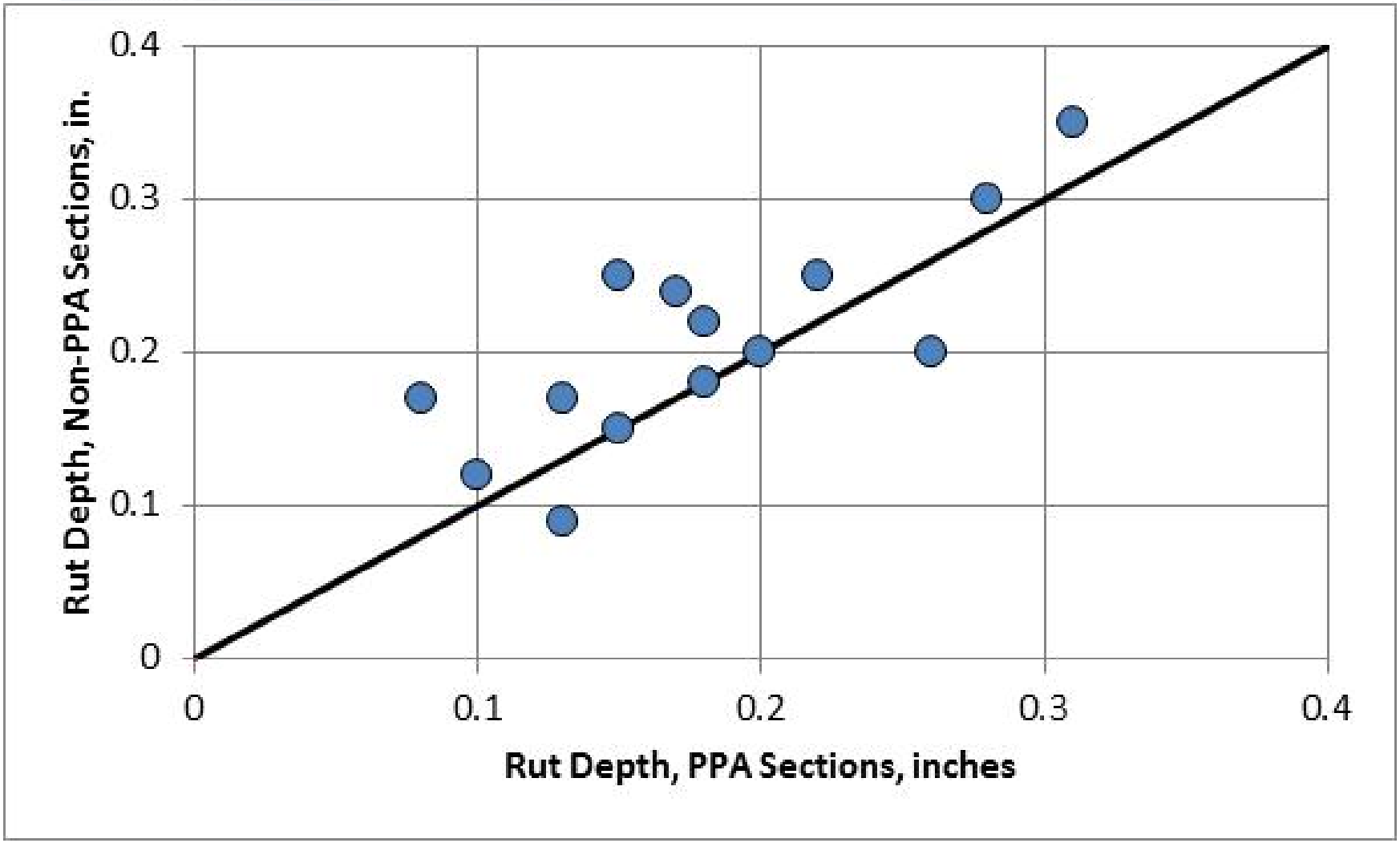
Comparison of PPA-Modified Sections

Type of Distress		Arizona US-93		Arizona SR-85	
		PPA-Modified	Non-PPA	PPA-Modified	Non-PPA
Cracking	Transverse, ft./mi.	1,470	SB Lane – 2,100 NB Lane – 750	Southern – 1,900 Northern – 0	Southern – 2,000 Northern – 0
	Longitudinal; ft./mi.	Combined with Alligator Cracking			
	Alligator; % of total lane area	31	24	Southern – 10 Northern – 35	Southern – 10 Northern – 25
	Reflection; ft./mi.	NA	NA	NA	NA
Patches; percent lane area		0	0	0	0
Rut Depth Category		Low (0.28 in.)	Low (0.30 in.)	Very Low (0.20 in.)	Very Low (0.20 in.)
Mix Shoving/Distortions		None	None	None	None
Raveling		None	Minor	None	Minor
Bleeding		None	None	None	None

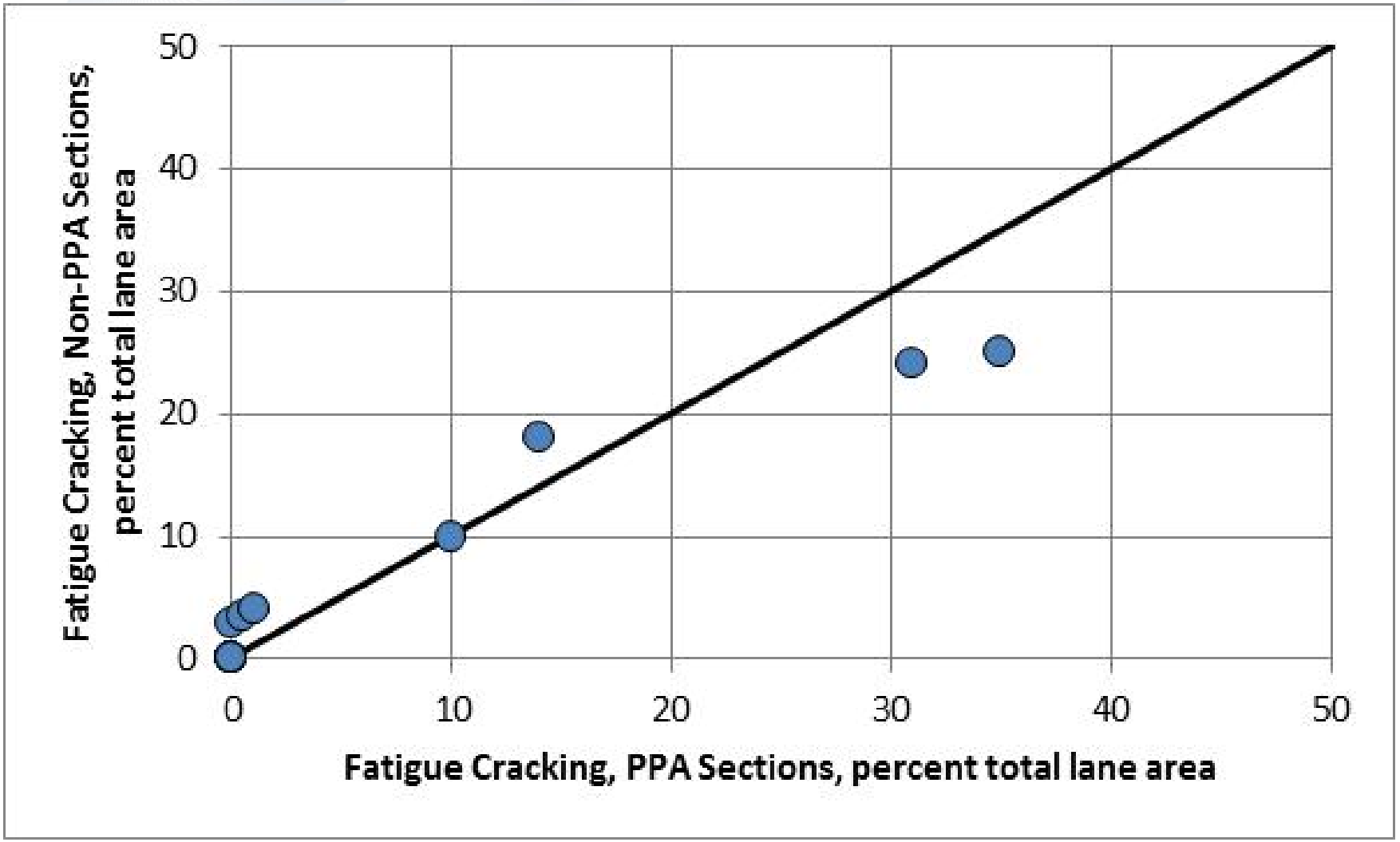
Summary

RAVELING				
Level of Non-PPA Sections	Level for PPA Sections			
	None	Low	Moderate	High
None	**12**	**1**		
Low	**1**	**1**		
Moderate			**0**	
High				**0**

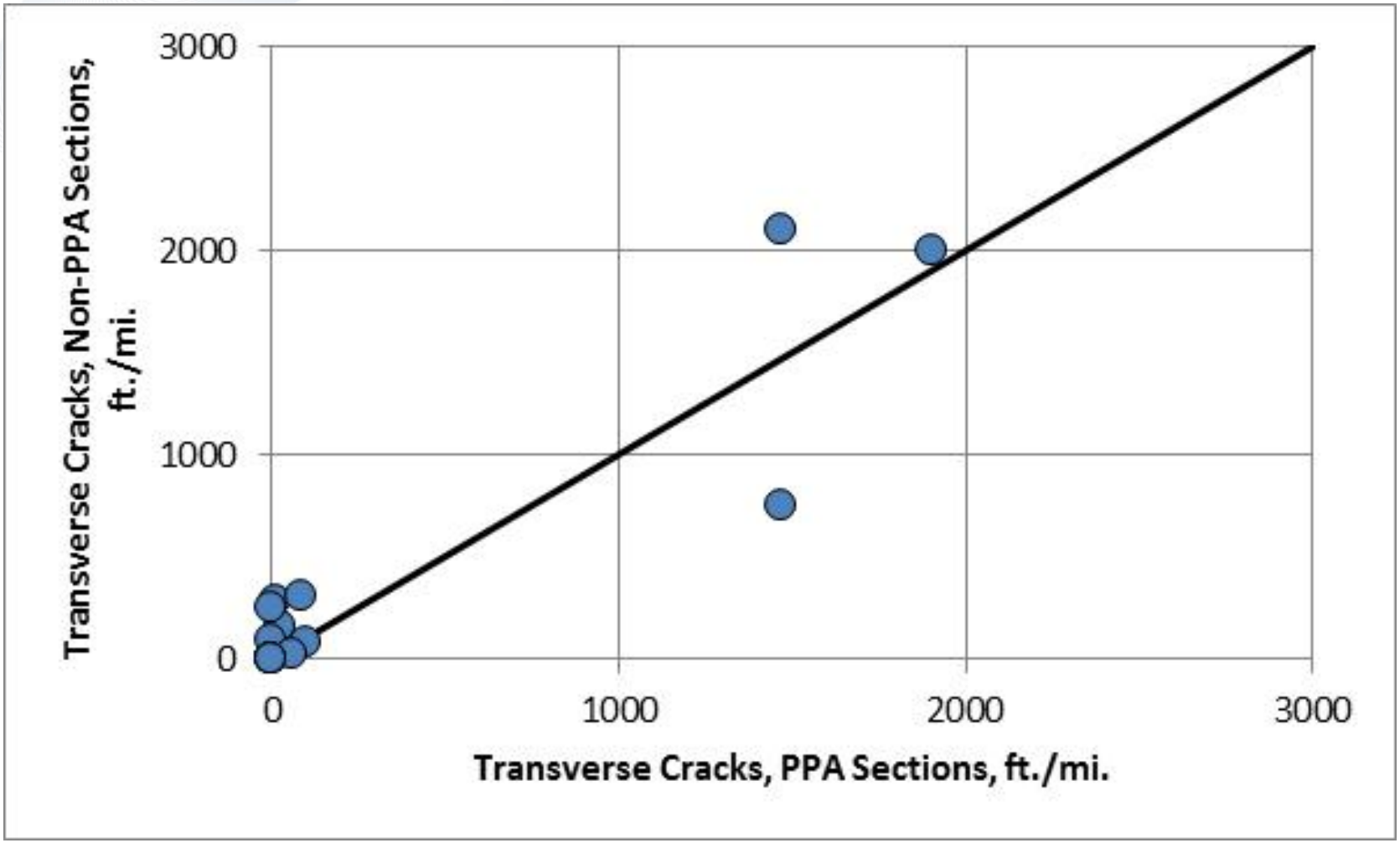
Summary



Summary



Summary



Findings

1. *Quantify difference between PPA and non-PPA modified mixtures in terms of surface distress.*

No consistent and significant difference in performance between the PPA modified and non-PPA modified sections.

Thus, field results support the statements made in the FHWA 2012 Tech Brief.

Findings

2. *Identify site features and/or mixture properties & features that maximize effect of PPA relative to performance.*

Insufficient data available and too many confounding factors to determine any mixture characteristics or site features that increase or decrease distress/service life.

Recommendations

Develop structured experimental plan using NCAT and MnRoad to answer two questions:

1. Does PPA negate the impact of lime and/or amines.

2. What level or amount of PPA maximizes performance as related to mixtures without PPA; or what amount of PPA should be avoided which are detrimental to performance.

Project/Information Provided by:

- Bob McGennis and Paul Burch – Arizona
- Mansour Solaimanian and Tim Ranirez – Pennsylvania
- Jeff Pensfield, Michigan Paving and Materials Co.
- Chris Tilley (FHWA) and Eric Thibodeau – New Hampshire
- Bill Thompson and Dale Peabody - Maine
- Chris Abadie – Louisiana
- Jay Goldbaum and Michael Stanford - Colorado

Comparison of PPA-Modified Sections

Type of Distress		PA SR-152		PA SR-15	
		PPA-Modified Section 690	Non-PPA; Section 650	PPA-Modified Sections	Non-PPA
Cracking	Transverse, ft./mi.	280	1,600	0	100
	Longitudinal; ft./mi.	265	680	95	50
	Alligator; % of total lane area	0	0	0	200
	Reflection; ft./mi.	NA	NA	NA	NA
Patches; % lane area		14	18	NA	NA
Rut Depth Category		Very Low to Low	Low	0.26	0.20
Mix Shoving/Distortions		None	None (localized to one area)	NA	NA
Raveling		Low to Mod.	Low to Mod.	Minor	None
Bleeding		None	None	None	None

Comparison of PPA-Modified Sections

Type of Distress		LA I-10		LA I-20 & I-12	
		PPA-Modified Sect. 450-04	Non-PPA Modified Section 450-91	PPA-Modified I-20 Section 451-05	Non-PPA Modified I-12 Section 454-02
Cracking	Transverse, ft./mi.	13.5	292	85	310
	Longitudinal; ft./mi.	191	287	45	215
	Alligator; % of total lane area	6.4	119.7	0	210.2
	Reflection; ft./mi.	NA	NA	NA	NA
Patches; % lane area		0	0	0	19
Rut Depth Category		0.17	0.24	0.10	0.12
Mix Shoving		None	None	None	None
Raveling		None	None	None	None
Bleeding		None	None	None	None

Comparison of PPA-Modified Sections

Type of Distress		MnRoads		MnRoads Acid Study	
		PPA-Modified; Section 33	Non-PPA Modified Section 15; AC-20	PPA-Modified Section 34; SBS+PPA	Non-PPA Modified Section 35; SBS
Cracking	Transverse, ft./mi.	0	365	0	0
	Longitudinal; ft./mi.	0	0	0	0
	Alligator; % of total lane area	0	0	0	0
	Reflection; ft./mi.	NA	NA	NA	NA
Patches; % lane area		0	0	0	0
Rut Depth Category	Max.	0.30	0.32	0.44	0.29
	Avg.	0.13	0.17	0.13	0.09
Mix Shoving/Distortions		None	None	None	None
Raveling		None	None	None	None
Bleeding		None	None	None	None

Comparison of PPA-Modified Sections

Type of Distress		MnRoads Fly-Ash Studdy	
		PPA-Modified Asphalt Section 79; PPA Only	Non-PPA Modified Asphalt Section 15; AC-20
Cracking	Transverse, ft./mi.	55	365
	Longitudinal; ft./mi.	0	0
	Alligator; % of total lane area	0	0
	Reflection; ft./mi.	NA	NA
Patches; % lane area		0	0
Rut Depth Category		Max. Value – 0.31 Avg. Value – 0.08	Max. Value – 0.32 Avg. Value – 0.17
Mix Shoving/Distortions		None	None
Raveling		None	None
Bleeding		None	None