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Mitigation Strategies for Reflective Cracking in Pavements

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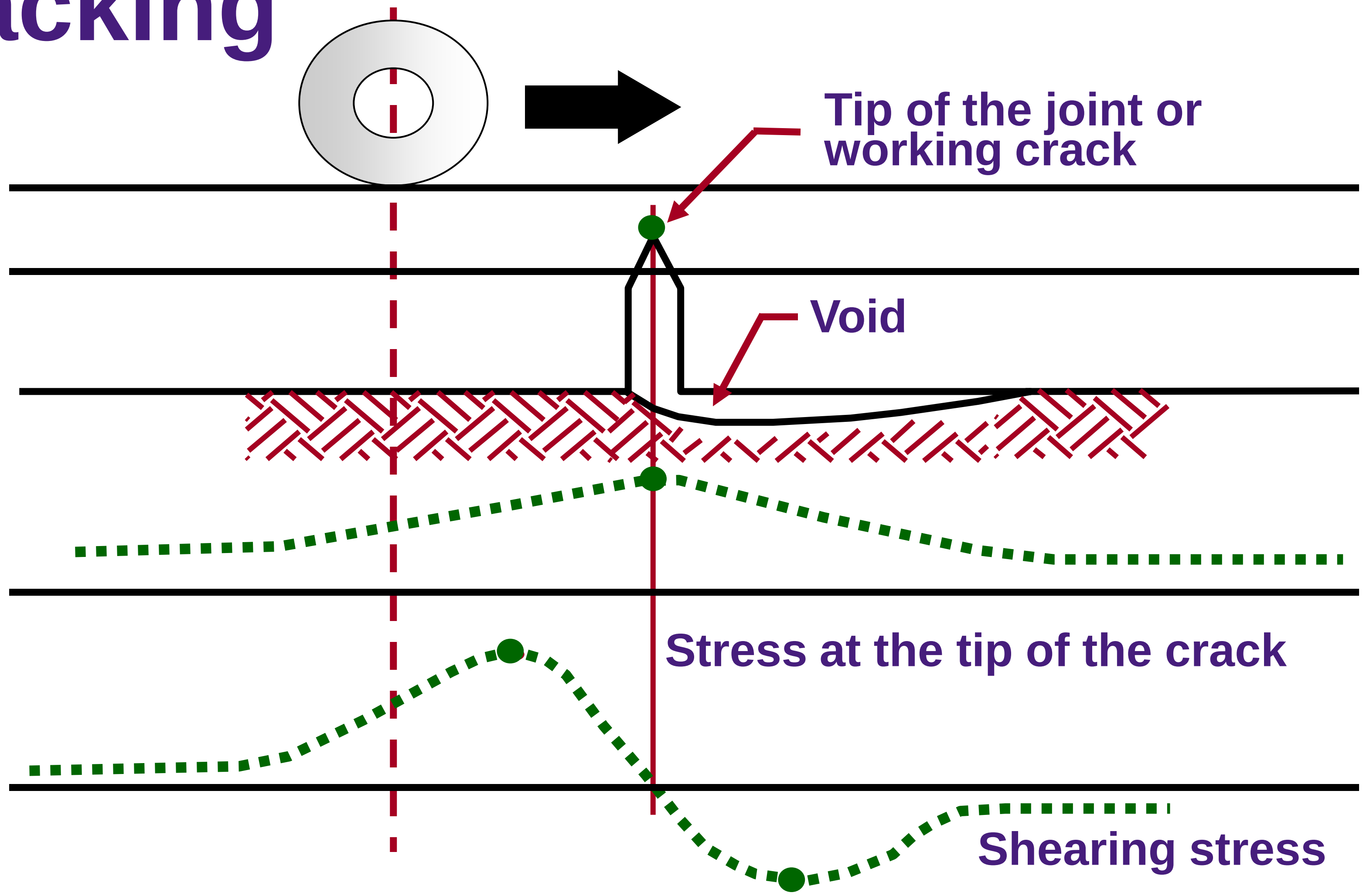
Introduction

- Reflection of existing cracks and joints from underlying PCC and asphalt pavement is known as reflective cracking
- One of the major modes of failure in rehabilitated pavements
- HMA overlays are not cost-effective against reflective cracking
- Various crack control methods have been introduced since 1970s → Mixed experiences

Mechanisms of Reflective Cracking



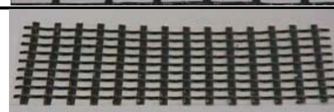
Research Objectives

- Conduct an in-depth literature review of research studies on reflective cracking
- Conduct a survey of the state practices to address reflective cracking

Topics in the Synthesis

- Types and effectiveness of reflection crack control treatments
- Performance and cost-effectiveness
- Selection criteria for different crack control strategies
- Knowledge gaps and unresolved questions

Crack Control Treatments

Treatment	Picture	Functions	Estimated Cost
Galvanized Steel Netting		Reinforcement	3.00 – 5.00 $\$/yd^2$
Geogrid		Reinforcement	1.80 – 4.00 $\$/yd^2$
Geonet		Reinforcement	3.00 – 4.00 $\$/yd^2$
Glass-Grid		Reinforcement	4.00 – 7.00 $\$/yd^2$
Paving Fabric		Stress Relief	0.60 – 1.05 $\$/yd^2$
Geocomposite		Stress Relief	8.00 – 9.20 $\$/yd^2$

Crack Control Treatments

Treatment	Picture	Functions	Estimated Cost
SAMI		Stress Relief	
Rubblization		Eliminates movement in concrete layer	5.00 – 6.00 $/yd^2$
NovaChip		Stress Relief	3.00 – 4.00 $/yd^2$
Strata		Stress Relief	4.00 – 5.00 $/yd^2$
Saw and Seal		Control reflective cracking by sawing overlay	1.00 - 2.00 $/ft.

LITERATURE REVIEW GEOSYNTHETICS

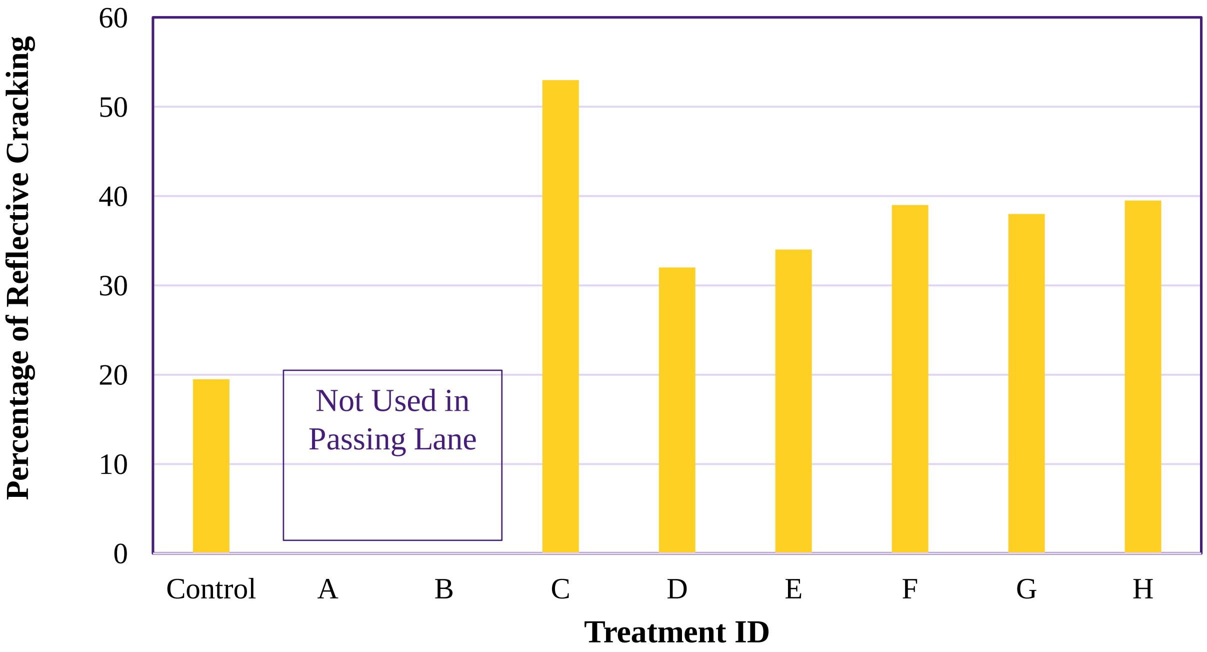
Paving Fabrics (Shuler 2004)

- Investigated the use of paving fabrics in delaying reflective cracking:
  - 18 test sections were evaluated with eight treatment methods
  - Five years monitoring period
  - 4in. Overlay was applied after milling
  - Heavy traffic (20 million ESALs)

Treatment	ID
90 Pound Petromat	A
120 Pound Petromat	B
Petrotac	C
ProGuard	D
Crack sealers without routing	F and H
Crack sealers with routing	E and G

Paving Fabrics (Shuler… 2004)

- A number of treatments performed better than the control section
- Control section performed better in the passing lane
- Construction and repair costs were the least for the control section



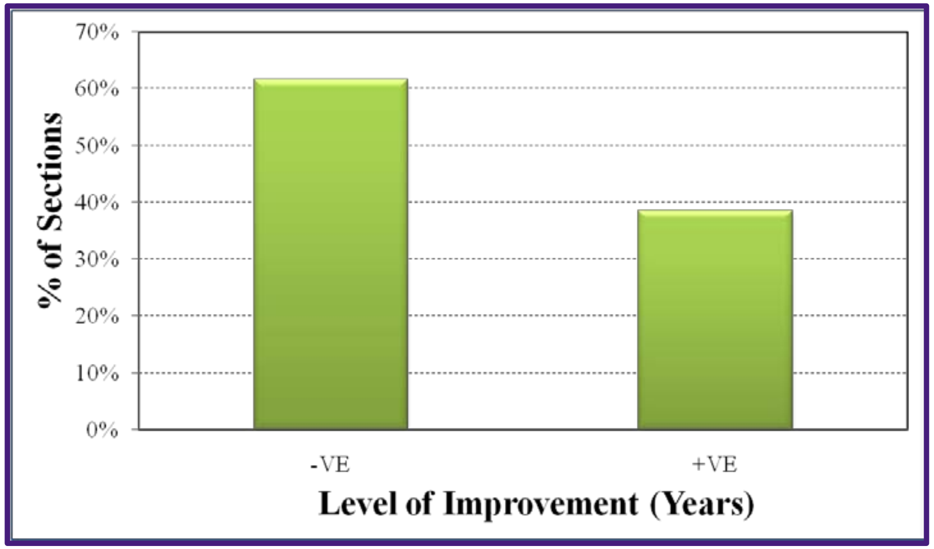
Glasgrid (Bischoff and Topel 2003)

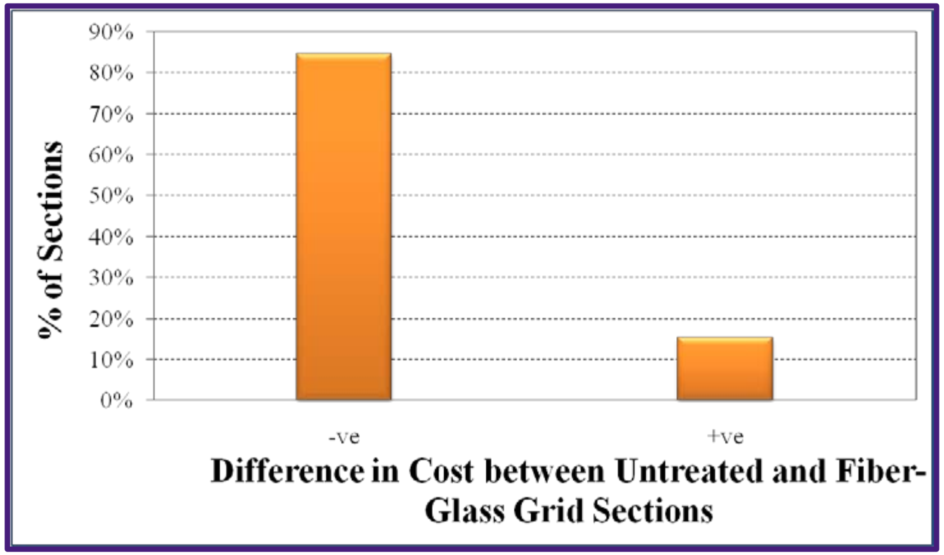
- Glasgrid was placed in 5-foot widths across transverse joints on top of JPCP
- Single and double strand grid
- 1.5 in. asphalt overlay - 10 years monitoring period
- Glasgrid was not effective in delaying reflective cracking

Average % Reflective Cracking per Test Section						
Section	Years After Construction					
	1	2	3	4	5	10
Double Strand	53	69	76	91	91	108
Single Strand	55	61	68	83	83	106
Control	59	73	86	87	87	105

Glasgrid (Elseifi and Bandaru 2011)

- Evaluated the performance and cost-effectiveness of 13 in-service rehabilitated pavements constructed with Glasgrid





Factors Influencing Geosynthetics Performance

- Existing pavements
  - More successful with rehabilitated flexible pavements
- Movement at the joints
  - More successful with stable joints
- Traffic
  - More successful with light traffic
- Construction
  - Good bonding key to good performance (tack coat,…)

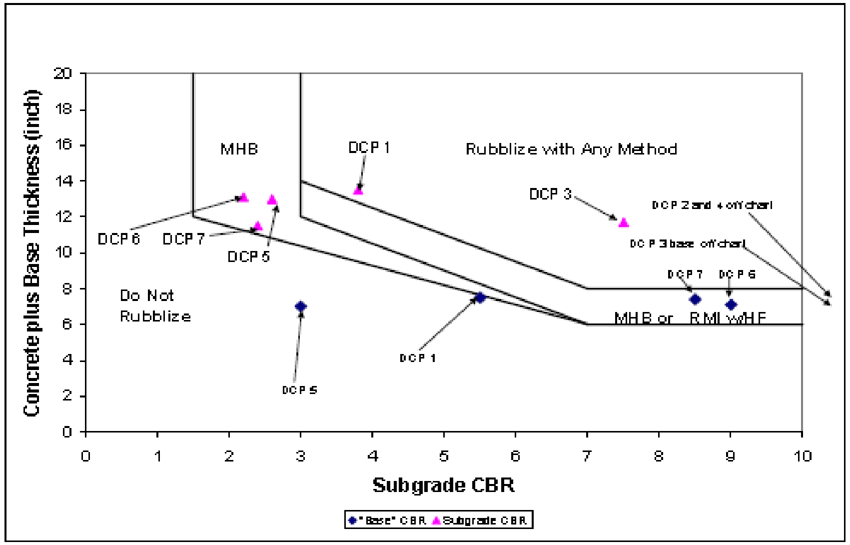
FRACTURED SLAB APPROACHES

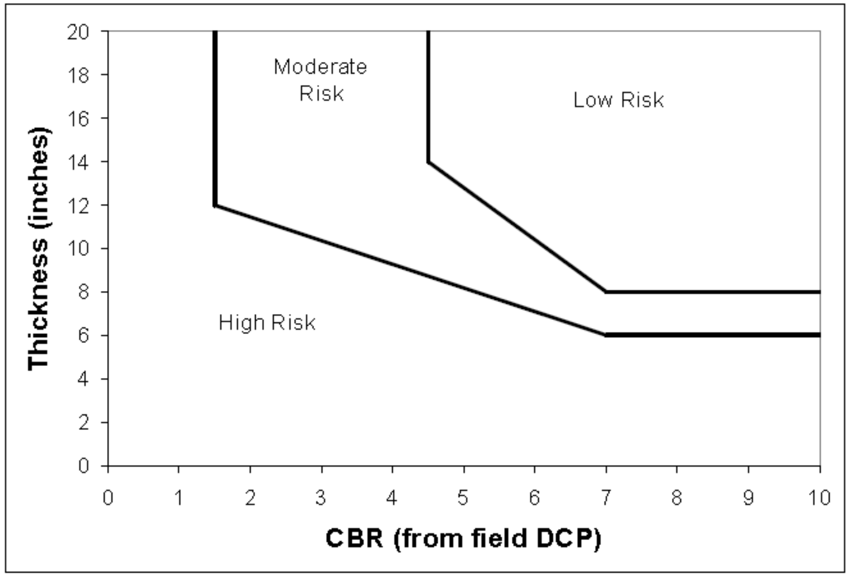
Rubblization (Sebasta and Scullion 2007)

- Evaluated the performance of rubblization for concrete pavements:
  - Five field projects were evaluated and monitored
  - Prior and after construction evaluation was performed using GPR, FWD and DCP
  - Tests performed to identify areas of moisture accumulation and weak support beneath the slab

Rubblization (Sebasta and Scullion 2007)

- Two factors to consider in selecting rubblization:
  - Drainage conditions
  - Subgrade support beneath the slab
- Modulus of rubblized layer increased with age (from 114 to 323 ksi)
- The Illinois rubblization selection chart and a modified chart version were presented





LITERATURE REVIEW
AC INTERLAYER

NovaChip®

- Ultrathin bonded wearing course - NovaChip
- A thin (3/8 to 3/4in) gap graded HMA layer placed on top of a Novabond® membrane, which is a polymer-modified asphalt emulsion
- Pretreatment of existing joints is recommended (crack sealing)

NovaChip®(Russel at al. 2008)

- Conducted a field study in Washington State
- NovaChip used instead of 1-in dense HMA on top of a deteriorated flexible pavement
- NovaChip perform well for about six years
  - Service life around 8 to 9 years
- NovaChip on high traffic roads is limited

NovaChip (Russel et al. 2008)

- Evaluated cost effectiveness of NovaChip compared to HMA Class G:
  - Evaluated for low volume roads
  - Cost ranges from $3.00 to $4.00 per square yard
  - Cost of NovaChip ® was comparable to dense HMA
    - Base cost of NovaChip was twice that of HMA

Rehabilitation Type	Estimated Time Between Treatments (yrs.)	Annual Worth ($/Lane Mile)	Annual Worth ($/Square Yard)
BST	6	2,700	0.28
HMA Class G	7	8,300	0.89
NovaChip	8 to 9	7,800 - 8,600	0.83 - 0.92
HMA Class A or ½ in Superpave	10	11,100	1.18

Saw and Seal


Within 3 days of Overlay
Asphalt Paving
Cut Joints
3mm wide by 25mm deep
Clean Joints
Seal Joints
Rubberized asphalt sealant
Mark Joint Locations

Saw and Seal (Elseifi et al. 2011)

- Evaluated the field performance of saw and seal treatment method to control reflective cracking
  - 15 in-service pavements with a service life of 6 to 14 years
- Assessed performance and cost-effectiveness of saw and seal treatment method

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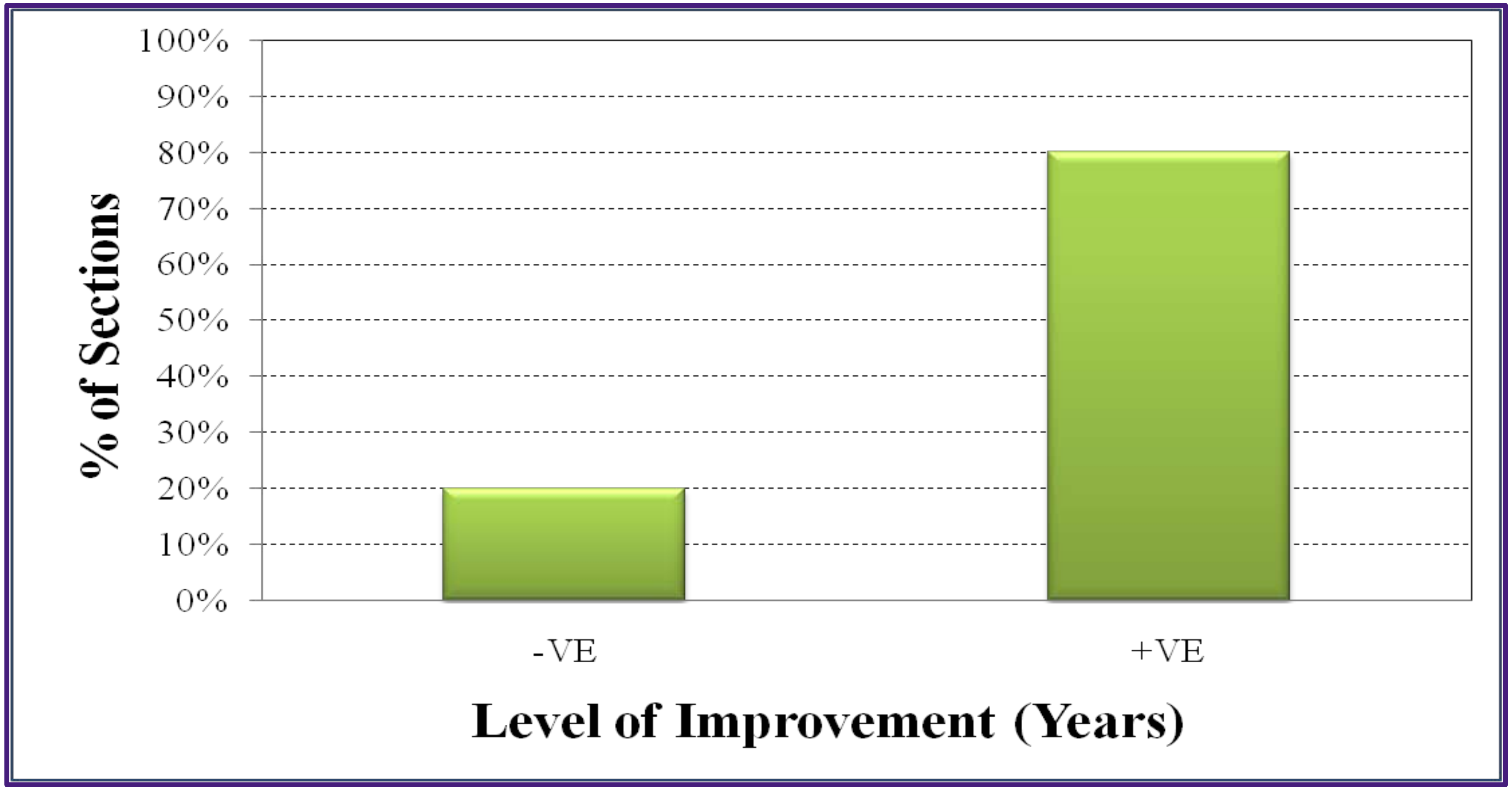
Results: Levels of Improvement



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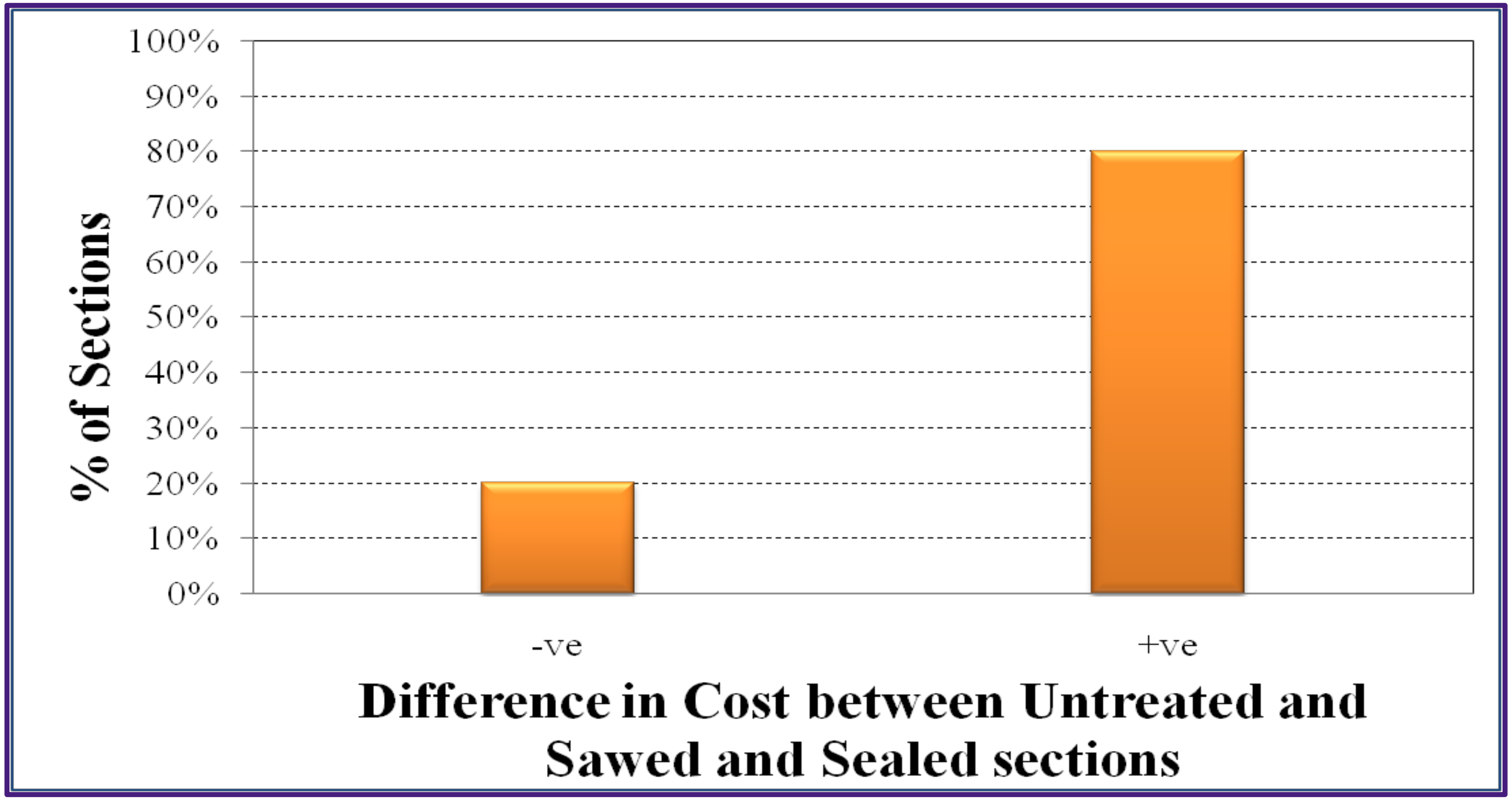
Results: Cost Analysis

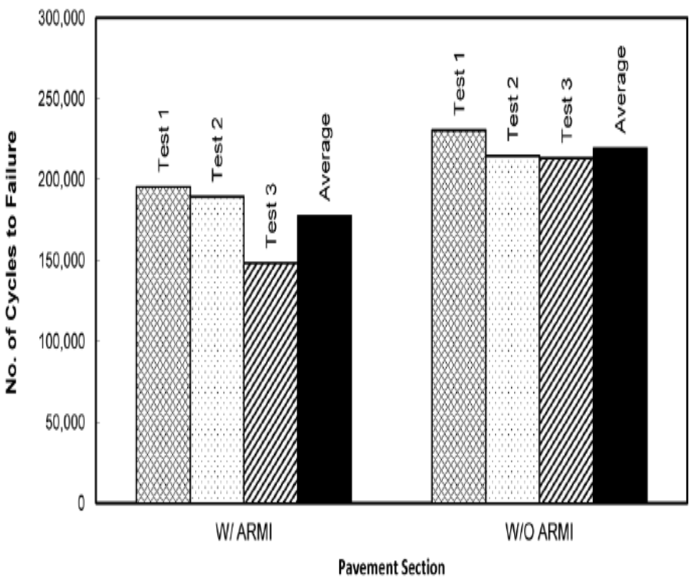


SAMI (Greene et al. 2012)

- Evaluated the performance of ARMI
  - Spray asphalt rubber binder (0.6 to 0.8 gsy)
  - Apply No. 6 stone (0.26 to 0.33 ft^3 per square yard)
  - Roll the stone with a pneumatic tire roller
- APT and long term field performance
  - Five test lanes were designed and constructed
  - Composite Specimen Interface Cracking (CSIC) test was performed

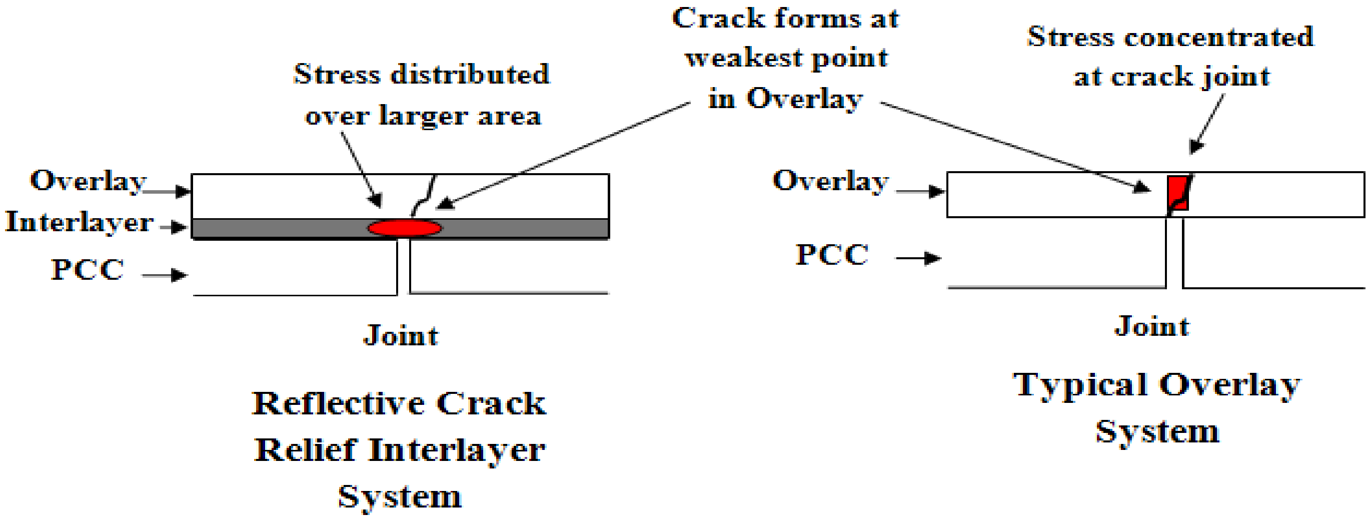
SAMI (Greene et al. 2012)

- Sections without ARMI outperformed sections with ARMI
- Recommended not to consider ARMI as a primary treatment method against reflective cracking
  - ARMI increased the rutting when subjected to combination of slow moving load and high temperature
  - Sections without ARMI provided better performance in the CSIC test



STRATA® (Bischoff 2007)

- A polymer-rich dense fine aggregate mixture placed on the existing pavement and is then overlaid
- Recommended on structurally-sound pavement

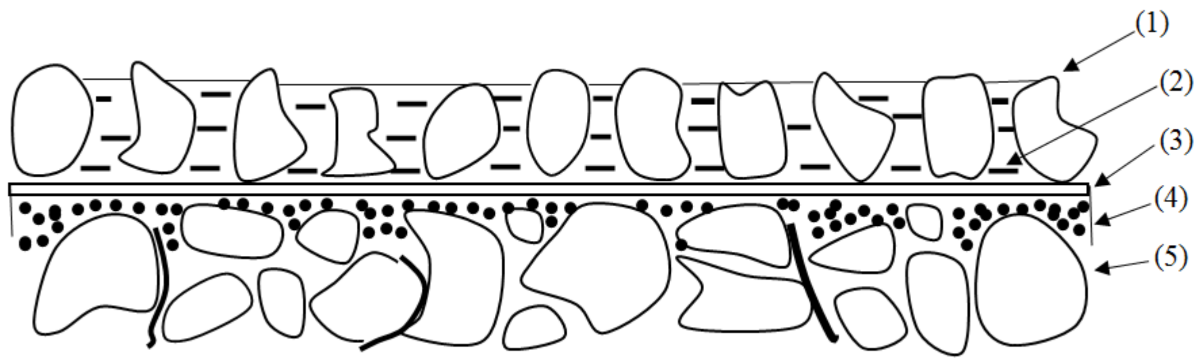


STRATA® - (Bischoff 2007)

- Described the field evaluation of the STRATA system in Wisconsin
  - Two sections on I94 were evaluated
- First section:
  - One section with STRATA performed similarly to the control section
  - STRATA section performed the best with only 6% reflective after 4 years
- Second section:
  - One of the control section performed the best
- Bischoff recommended not using the STRATA system in Wisconsin

Chip Seal/Paving Fabric (Davis and Miner 2010)

- Evaluated the use of nonwoven paving fabrics under chip seal
- 33 field projects were analyzed



Legend:
(1) Sealing aggregate
(2) Main Binder application
(3) Geotextile
(4) First Binder application (tack or bond coat)
(5) Weak or cracked base

Chip Seal (Davis and Miner 2010)

- Results:
  - In warm climates (e.g., Texas and California), incorporation of fabric improved life of chip seal by 50-70%
  - In Michigan, test section with chip seal and paving fabric performed well compared to control section
- Shall not be used for roads with:
  - Vertical grades greater than 10%
  - ADT greater than 10,000
  - Severe freeze-thaw cycles
  - Poor drainage conditions
- Binder application rates:
  - 0.30 and 0.35 gal/yd^2 for cold climate
  - 0.25 and 0.30 gal/yd^2 for hot climate

Collective Evaluation (Powell 2012)

- Evaluated the field performance of pavement preservation treatments:
  - fog seals, crack seals, chip seals, overlay, ultra-thin bonded wearing course
- Crack sealing stopped the development of interconnected cracks observed in the control section

SURVEY OF THE STATE PRACTICES

Responses to Survey

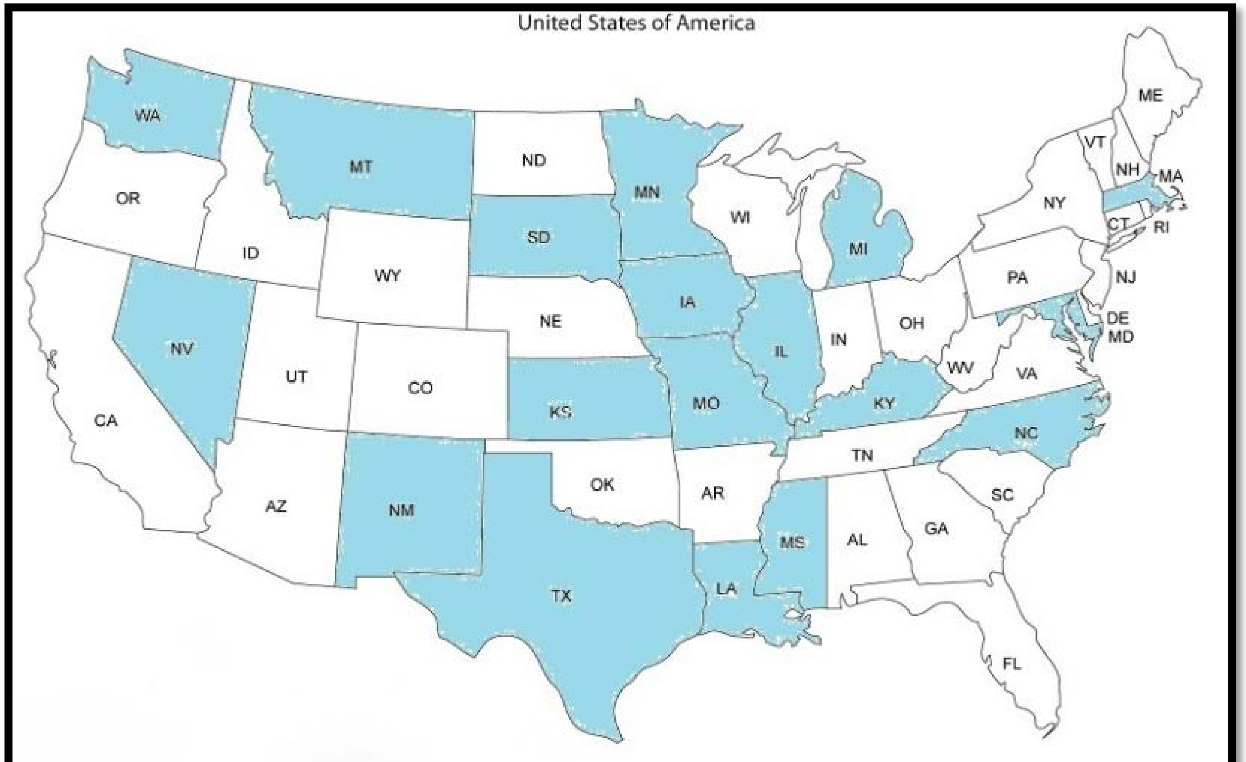


Figure 1: States Response to Nationwide Survey

35 responses

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Regular Actions

- Does your state take regular actions to address reflective cracking in HMA overlay?

- Majority (63%) of states take regular actions
- 37% of highway agencies do not take specific regular actions to address reflective cracking

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Other Treatments

- Other treatment methods:
  - Cold-in-place recycling (CIR)
  - SMA
  - Rubber seals
  - Open-graded crack relief interlayer

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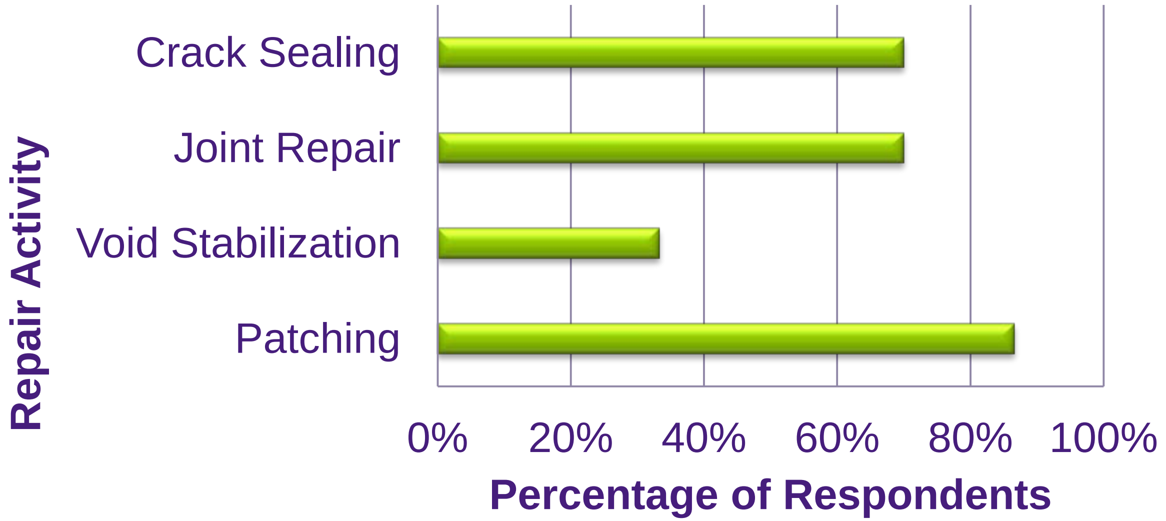
Pre-Construction Repair

- What pre-construction repair activities do you recommend prior to HMA overlay application?
  - Patching, crack sealing (for both rigid and flexible pavements) and joint repair (for PCC pavements) are recommended by most respondents



Recommendations

- The performance of a number of treatment methods has been mixed
- A number of treatment methods have predominantly shown benefits

For Asphalt Pavements	Pros and Cons
Crack sealing and overlay	Pros: Low cost and suitable for asphalt pavements Cons: Reflective cracking may appear
Chip seal and open-graded interlayers	Pros: low cost and adequate control of reflective cracking
Full-depth reclamation	Pros: prevent reflective cracking, suitable for heavily trafficked pavements, environmental friendly Cons: Cost
Cold-in place Recycling	Pros: prevent reflective cracking Cons: not suitable for heavily cracked pavements

Recommendations

For PCC Pavements	Pros and Cons
Saw and seal	Pros: Low cost and well-proven performance
Chip seal and open-graded interlayers	Pros: low cost and adequate control of reflective cracking, can be used with weak subgrade
Rubblization	Pros: Eliminates slab action and high probability for success Cons: Cost, requires adequate subgrade support, side work cost
NovaChip	Pros: well-proven performance in some states, does not require adjustments to side structures Cons: Little data on performance and cost

What's Next?

- Objectives:
  - Assess cost-effectiveness of recommended treatments on in-service pavement sections across the STC
  - Develop guidelines for the control of reflective cracking
- Research Tasks:
  - Identify field sections
  - Collect construction and cost data from bids
  - Collect performance data from PMS in the STC states
  - Assess Cost-effectiveness of treatment methods
  - Develop software to assist in treatments' selection

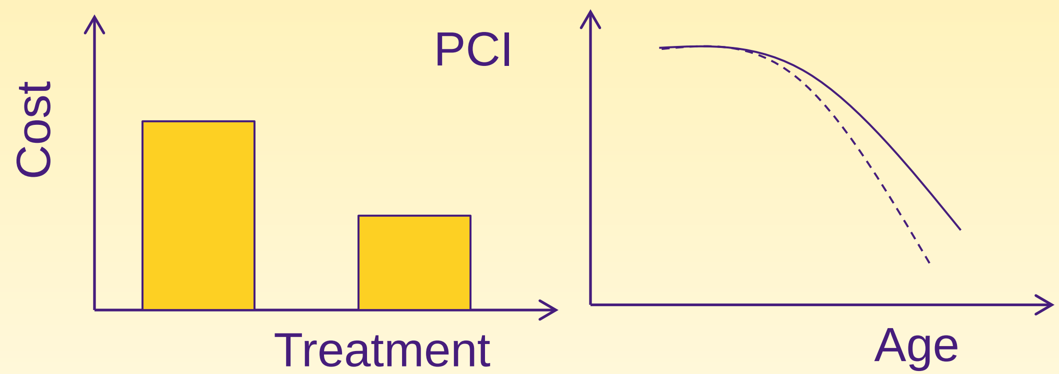
What's Next?

- Treatment Methods:
  - Crack sealing and overlay
  - Chip seal interlayer
  - Open-graded interlayer
  - Cold-in-place recycling
  - Saw and seal
  - Rubblization
  - NovaChip

Main Outcome

Input:
- Pavement type
- Pavement distress
- Subgrade condition
- Pavement age
- Desired service life
- Level of investment

Output:
- Recommended treatment
- Expect service life
- Savings vs. regular overlay



QUESTIONS?