

NCHRP 10-114

**Developing Performance and Safety Specifications for
Rejuvenating Seals**

**AASHTO TSP-2 - Emulsion Task Force (ETF) Meeting
June 29, 2023**

Research Team



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Background

Rejuvenating seals

- Designed to penetrate into the asphalt material near the pavement surface to renew the hardened/oxidized asphalt binder.
 - Rejuvenators can be combined with emulsified asphalt binders and/or other materials (e.g., polymers) to seal low-severity surface cracks and inhibit raveling.
- Can be applied to preserve asphalt pavement surfaces functional and structural integrity from age hardening and deterioration.
 - Not recommended for pavements with low surface permeability, poor surface texture, large cracks, rutting, shoving, or other structural deficiencies.

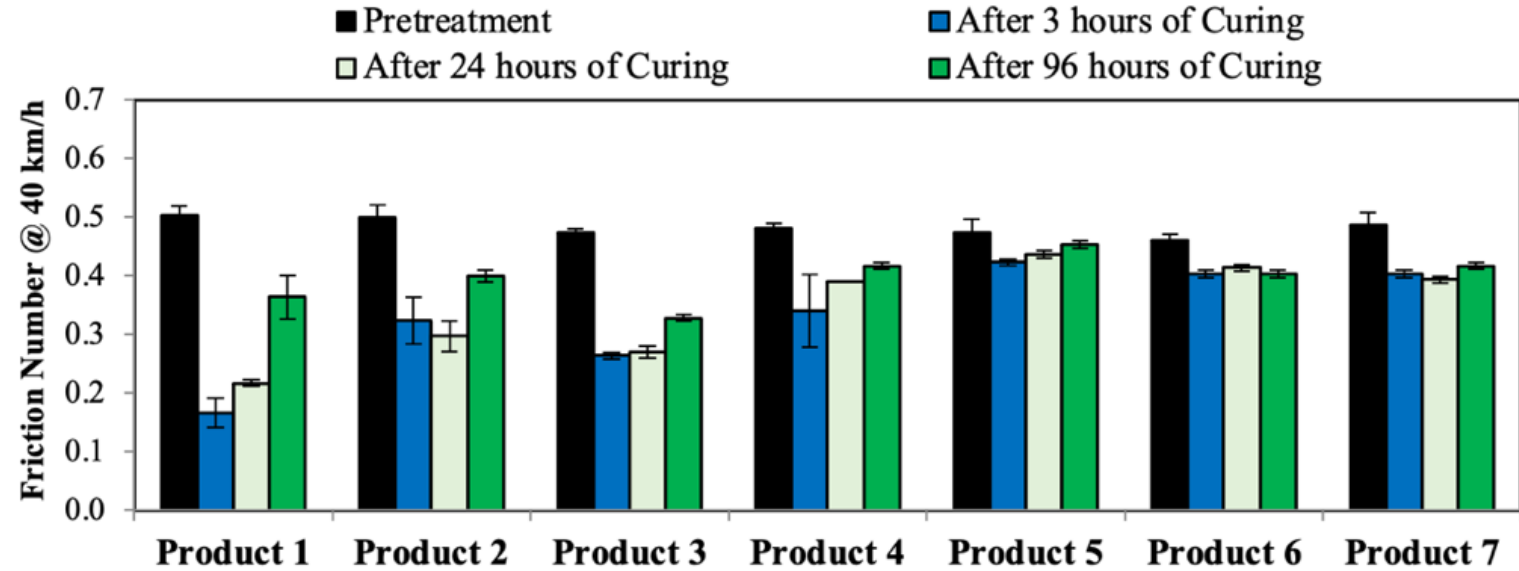
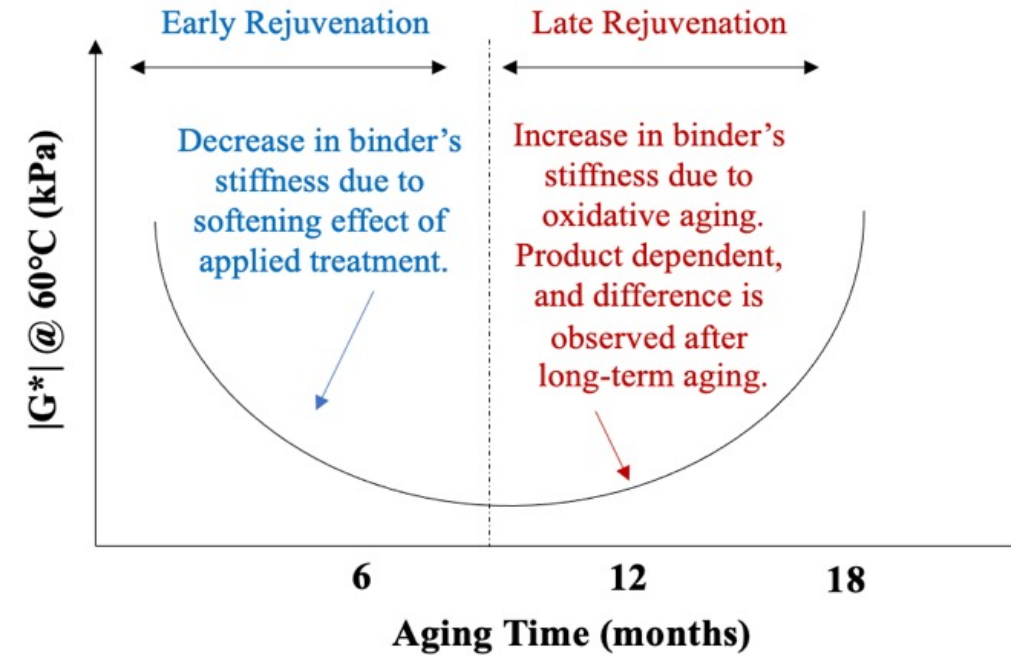


Research Motivation

- Information about the composition and long-term field performance benefits of rejuvenating seals is lacking.
 - Challenging the development of specifications and approval of products.
- The FAA procedure P-632 (Bituminous Pavement Rejuvenation) is used to evaluate the performance of rejuvenating seals.
 - Evaluation based on rheological properties of the extracted binders two and four weeks after application.
 - Friction characterization is performed between 24 and 96 hours after treatment application, with a minimum of 24 hours between tests.
- These products will immediately decrease the friction and skid resistance of the pavement.

Research Motivation

Findings from NCAT Field Study



Objectives

- Characterize rejuvenating seals based on chemistry and rheology,
 - Determine how different rejuvenating compounds are penetrating and rejuvenating the underlying pavement,
 - Determine how the desired performance for a rejuvenating seal is measured and quantified (laboratory and field),
 - Determine the life-extending benefit (LEB) and impact on friction properties of a rejuvenating seal (laboratory and field), and
 - Guide on selecting a rejuvenating seal's optimum dose and application rate.
-
- **36 months: 08/04/2022 to 08/04/2025**



Task 1. Literature Review



- **Objectives**

- Characteristics of rejuvenators based on chemistry and rheology
- Differences between softening and rejuvenating products

- **Literature Review Topics**

- Asphalt Chemical Composition
- Oxidative Aging Process in Asphalt
- Influence of Oxidative Aging on Cracking Behavior of Asphalt
- Rejuvenation
 - Recycling Agents
 - Understanding the Chemistry of Relaxation
- Rheological Characterization of Oxidized Asphalt Binders
- Chemical Evaluation of Oxidized Asphalt Binder



Task 2. Review Previous Work

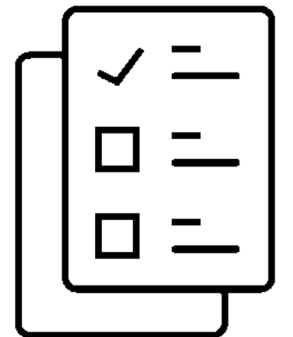


- **Objective**
 - Gather information on preservation treatments similar to rejuvenating seals and current rejuvenating technologies used for rejuvenating seals.
- **Literature Review Topics**
 - Spray-Applied Strategies for Improving Durability of Asphalt Pavement Surfaces
 - Fog Seals
 - Rejuvenating Seals and Specifications
 - Friction Testing of Asphalt Pavement Surfaces
 - Laboratory and Field Evaluation of Surface Strategies for Improving Durability of Asphalt Pavement
 - Effect of Surface Treatments on Asphalt Binder Properties
 - Effect of Surface Treatments on Friction of Pavement

Task 2. Review Previous Work

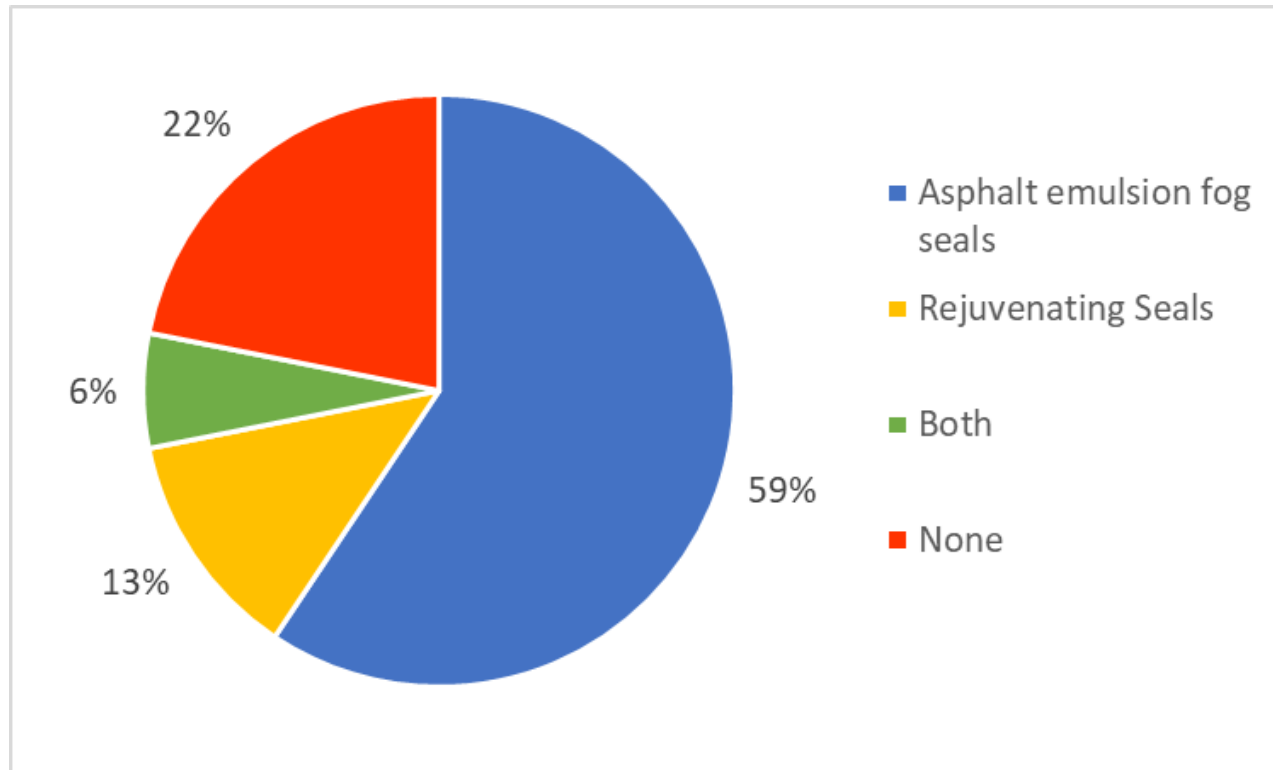


- **State Highway Agencies Survey**
 - NCAT's list of contacts
 - AASHTO Committee on Maintenance
 - National Center for Pavement Preservation
- **Topics of interest**
 - Pavement surface age, treatment type and application rate,
 - Test methods employed,
 - Pre-treatment friction and macro texture measurements,
 - Post-treatment friction and macro texture measurements,
 - Extended friction and macro texture monitoring,
 - Traffic level and traffic speed.



Survey Responses

Specifications/special provisions

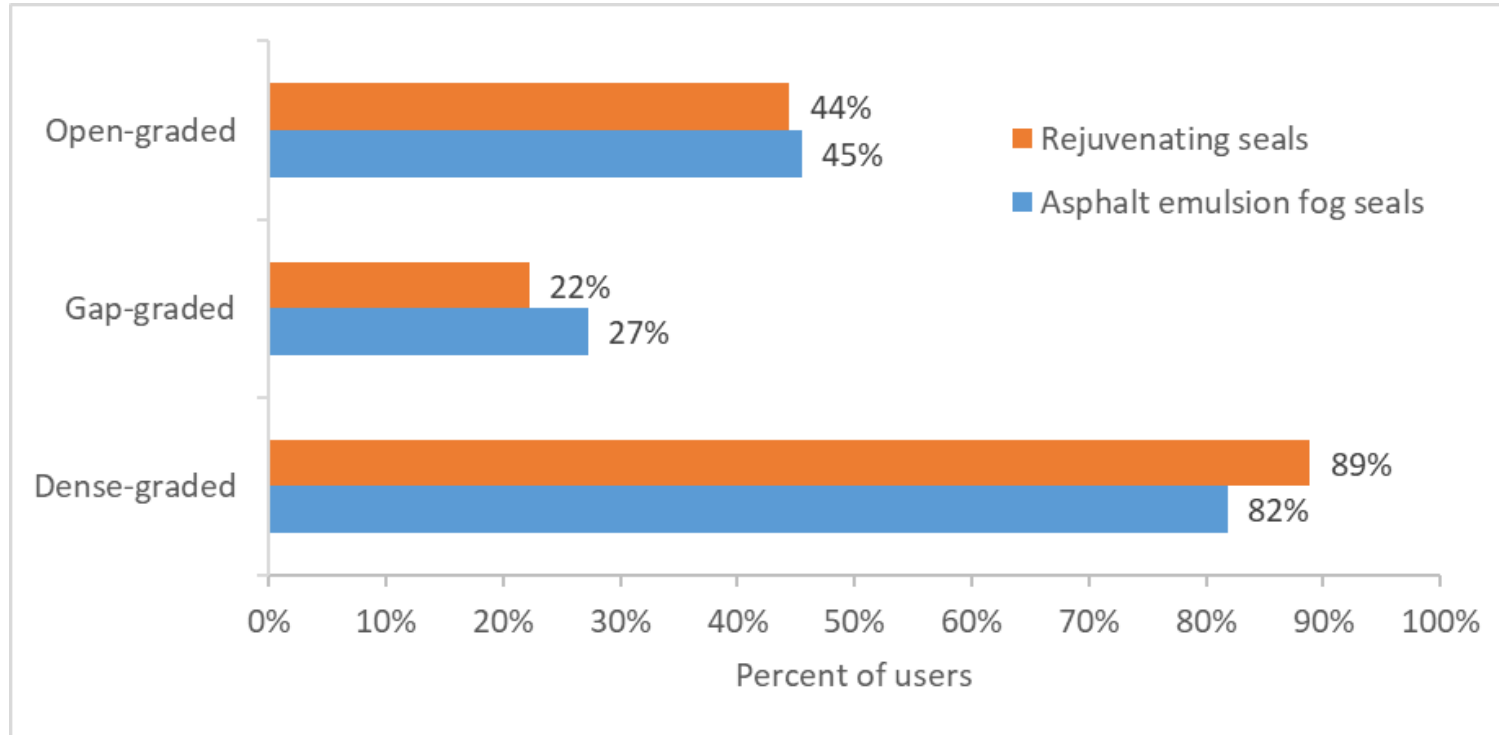


Percent of Survey Respondents with Specifications/Special Provisions in Place

- 56% require testing or other documentation to accept spray-applied treatments
 - Viscosity
 - Penetration
 - Residual and emulsion verification testing
- Products must meet the specifications or be on the approved products list

Survey Responses

Surface type

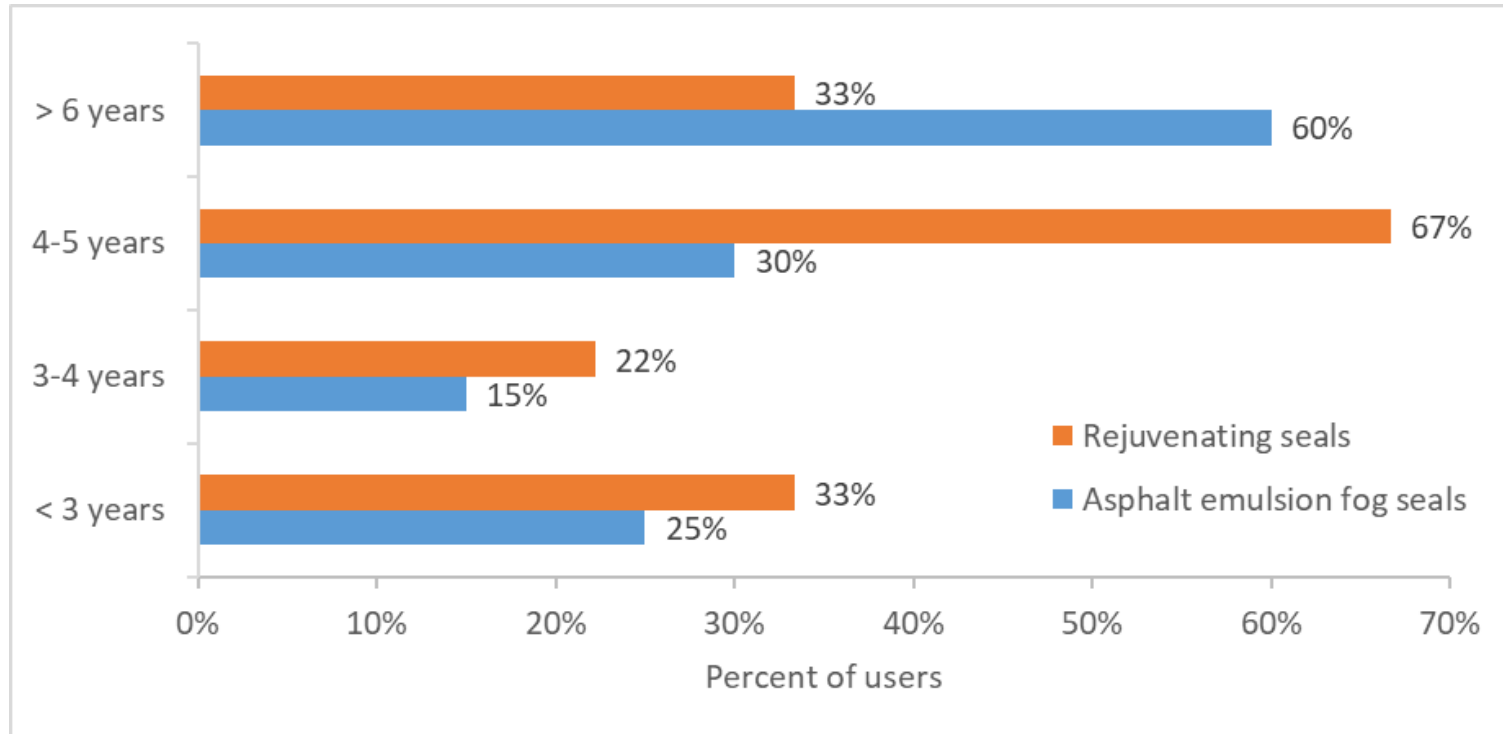


Treatment Use by Surface Type

- Both treatments are primarily used on dense-graded asphalt surfaces

Survey Responses

Age of pavement at the time of treatment

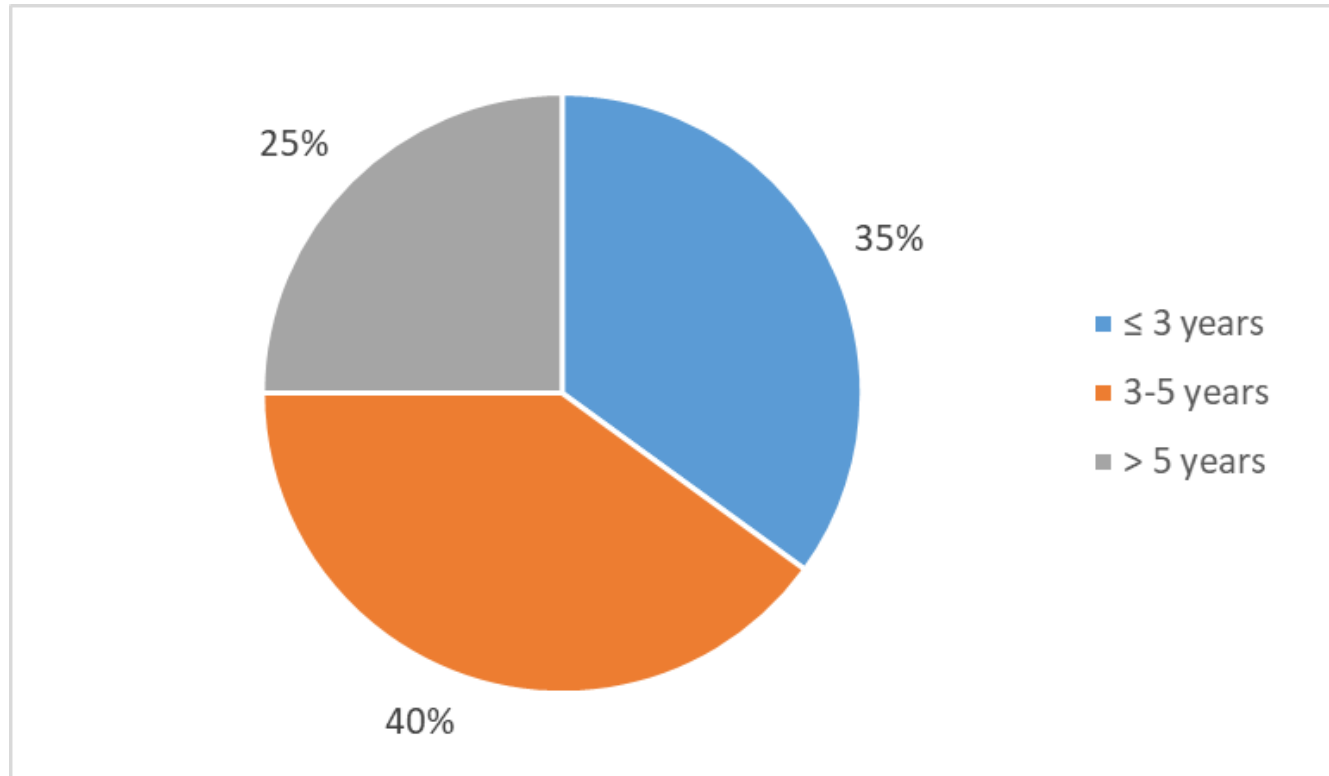


Average Age of Pavement Surface at the Time of Treatment

- **Fog seals:** pavement surfaces older than six years.
- **Rejuvenating seals:** pavement surface age between four and five years.

Survey Responses

Expected life extension



Expected Life Extension of Spray-Applied
Surface Treatments

- 40% estimated between 3 and 5 years of life extension
- 35% estimated life extension of ≤ 3 years

Survey Responses

Field testing

- **For project selection**
 - Few details provided
 - 7 agencies use locked wheel skid trailer (LWST) test for network-level friction
 - 2 use distress and ride quality data as inputs for project selection
 - Friction and macrotexture tests are not widely implemented for project selection
- **After treatment application**
 - 29% perform field testing to determine surface characteristics after treatment
 - LWST test or the dynamic friction tester (DFT)
 - Not performed routinely, only if deemed necessary
 - Friction number (FN) required before opening to traffic: between 30 and 35
 - No macrotexture requirement
 - Surface characteristics tracked for network-level condition evaluation

Tasks 1 and 2 Summary

Major knowledge gaps

- Guidance on the selection of rejuvenating seals
- Property characterization of rejuvenating seals
- Impact of rejuvenating seals on binder characteristics
- Impact on pavement surface characteristics
- Dosage selection
- Safety concerns
- Test methods employed (lab and field evaluation)
- Long-term pavement performance



Task 3. Materials Selection



- Collect up to 14 products, including both petroleum- and bio-based rejuvenators.

Category	Product Type	Producer
Bio-Based	BioMAG™	Iowa State University
	BioRestor®	BioBased Spray Systems LLC
	BioRestor® Low VOC	
	Delta Mist®	Collaborative Aggregates LLC
	Invigorate™	Iowa State University
	RPE-R	H. G. Meigs, LLC
	RePlay™	BioSpan Technologies
Petroleum-Based	ARA1 Ti	Tricor Refining, LLC
	CMS-1PF (eFog)	Ergon Asphalt & Emulsions, Inc.
	CRF®	Tricor Refining, LLC
	GSB-88®	Asphalt Systems, Inc.
	Reclamite®	Pavement Technology, Inc.
	ReGenX®	Blacklidge
	Replenify™	Flint Hills Resources

NCAT and MnROAD Field Sections

NCAT Test Track



MnROAD



Task 4. Interim Report



- **Submitted with findings of Tasks 1 and 2**
 - Over 140 literature documents
- **Description of Phase II work plan to**
 - Determine the efficacy of rejuvenating additives in rejuvenating seals
 - Determine the LEB of a rejuvenating seal
 - Determine the effect of rejuvenating seals on pavement friction, and macro texture and micro texture properties
 - Guide dosage selection



Phase II Work Plan (5 Tasks)

- 1** Determine the Efficacy of Rejuvenating Additives in Rejuvenating Seals
- 2** Determine the Life Extending Benefit (LEB) of a Rejuvenating Seal (laboratory and field)
- 3** Determine the Effect of Rejuvenating Seals on Pavement Friction, and Macrotexture and Microtexture Properties
- 4** Guide Dosage Selection
- 5** AASHTO Specification

Task 5. Determine the Efficacy of Rejuvenating Additives in Rejuvenating Seals

- Three approaches
 - **Experiment 1.** Stand-alone characterization of rejuvenating seals.
 - **Experiment 2.** Characterization of rejuvenating seals after application on the pavement surface.
 - **Experiment 3.** Evaluation of the potential interrelationship between pavements' permeability and rejuvenating seals' chemical characteristics.

Experiment 1. Stand-alone Characterization of Rejuvenating Seals

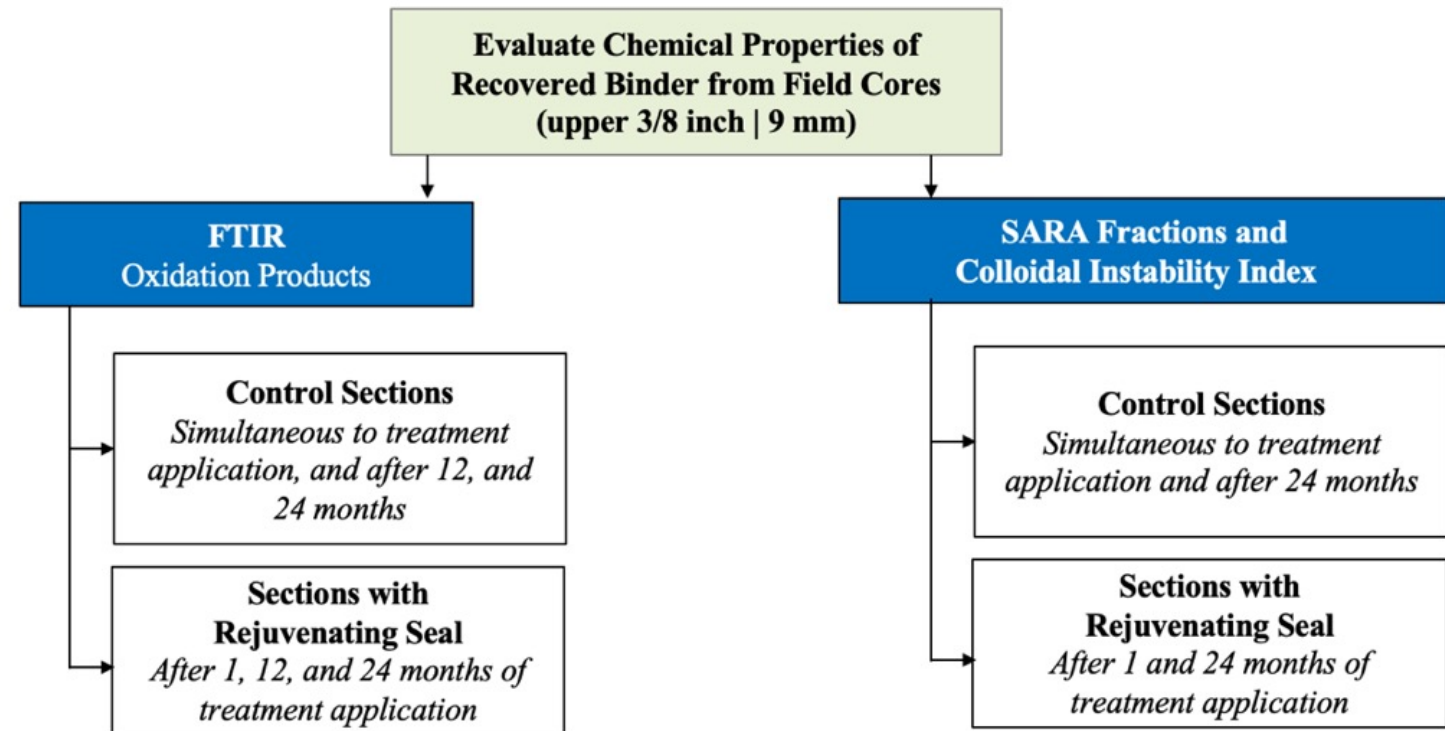
- Up to 14 rejuvenating seal products.



Experiment	Property	Test	Research Parameter
Experiment 1	Chemical Composition	Gas Chromatograph/Mass Spectrometry (GC/MS)	Fatty acids; presence of water and solvents in formulation
		SAR-AD™ Fractionation	Content of saturates and asphaltenes fractions (colloidal instability)
	Molecular Weight	Gel Permeation and Size Exclusion Chromatography (GPC/SEC)	Changes in molecular weight of binders; presence of polymer in formulation
	Wettability	Sessile Drop Method	Contact angle (wettability of an asphalt binder surface by a rejuvenating seal)
	Surface Tension	Tensiometer	Surface tension (ability of rejuvenating seals to penetrate an asphalt binder surface)
	Viscosity	Brookfield Rotational Viscometer	Viscosity (durability of rejuvenating seals)

Experiment 2. Characterization of Rejuvenating Seals after Application on Pavement Surface

- Available field sections constructed at MnROAD, a low-volume road
 - Short- and long-term effectiveness of 12 rejuvenating seal products
- Three dense-graded surface mixtures
 - Two were constructed in 2021 with 20% RAP (neat PG58S-28 binder and polymer-modified PG58H-34 binder)
 - One constructed in 2020 with 20% RAP and a polymer-modified PG58H-34 binder.



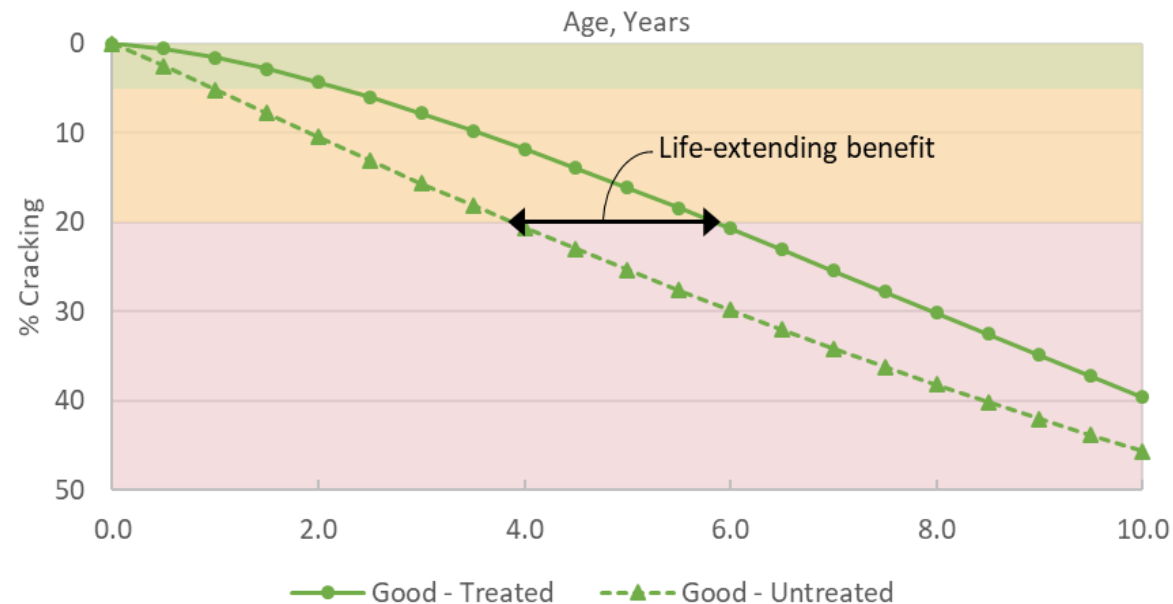
Experiment 3. Potential Interrelationship Between Permeability of Pavements and Characteristics of Rejuvenating Seals

- By utilizing the available field sections constructed at MnROAD, the in-situ permeability of up to 12 treated field sections will be collected using the NCAT field permeameter (AP-1B).
- Contact angle, surface tension and viscosity will play a role when predicting the penetration capability of rejuvenating seal.



Task 6. Determine the Life Extending Benefit (LEB) of a Rejuvenating Seal (laboratory and field)

- NCAT has experience quantifying LEB in the field.
- The methodology developed compares performance over time of treated versus untreated pavements.

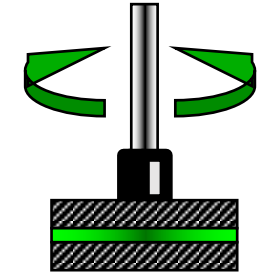
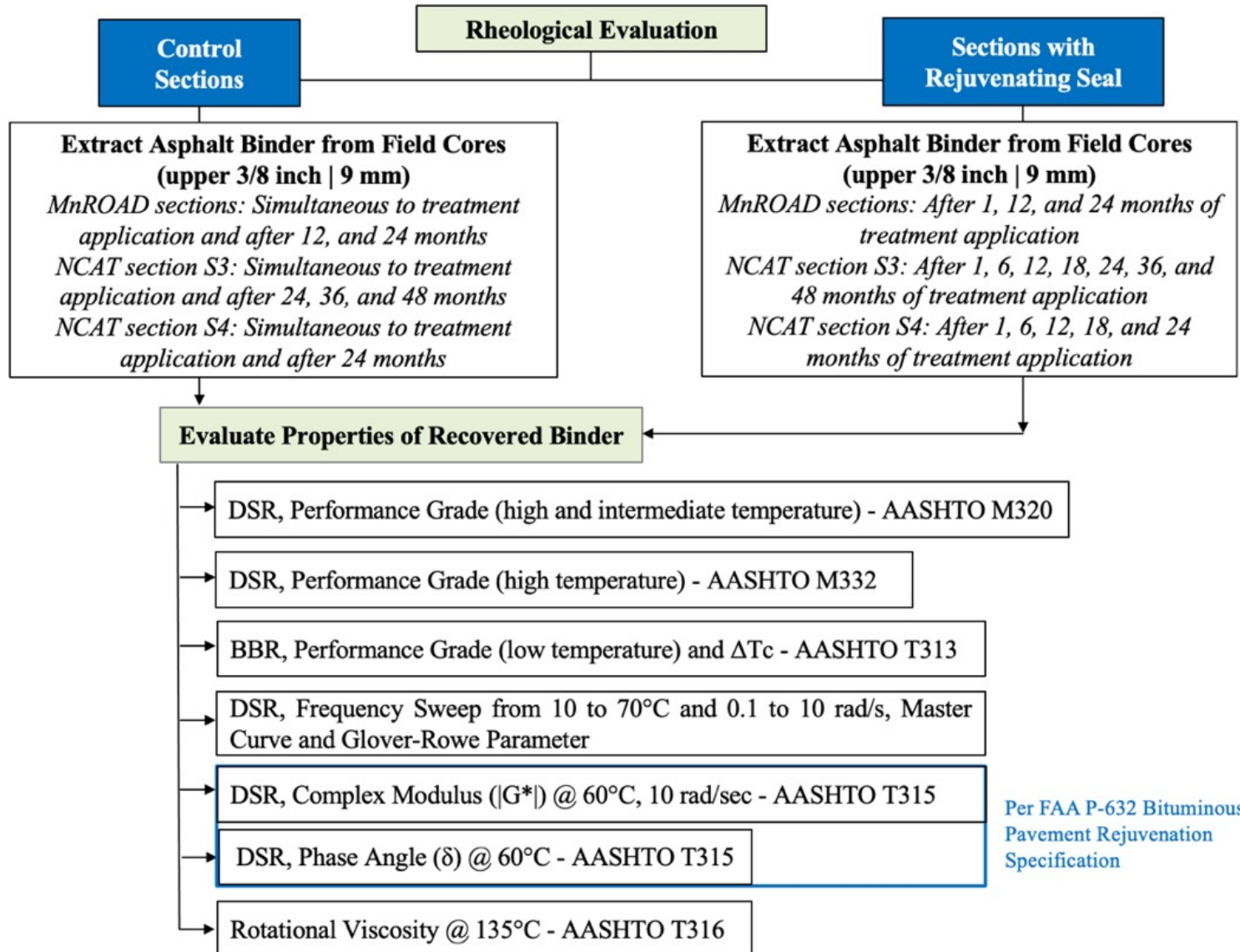


- **LEB:** difference in the time required to reach a threshold cracking value for treated and untreated sections (in this case shown as 20% of the total area).

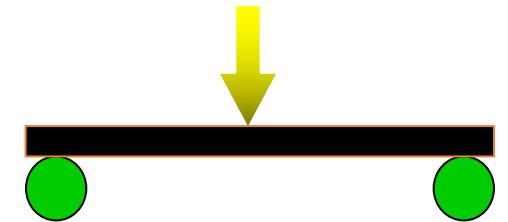
Task 6. Determine the Life Extending Benefit (LEB) of a Rejuvenating Seal (laboratory and field)

- The same approach can be applied using laboratory-measured properties
- **10-114:**
 - Existing field and laboratory data (AL, MN)
 - Rheological properties (stiffness and relaxation)
 - Time for rejuvenated sections to return to values similar to untreated
 - Binder test results will correlate directly with field performance data (focus on cracking, other parameters will also be measured)

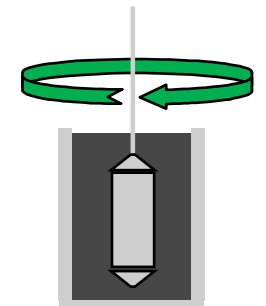
Task 6. Determine the Life Extending Benefit (LEB) of a Rejuvenating Seal (laboratory and field)



Dynamic Shear Rheometer



Bending Beam Rheometer



Rotational Viscosity

Task 7. Determine the Effect of Rejuvenating Seals on Pavement Friction, and Macro Texture and Micro Texture Properties

Field and laboratory experiments

*Pavement
micro
texture*



Locked Wheel Skid Trailer (LWST)



Dynamic Friction Tester (DFT)

*Pavement
macro
texture*



Circular Track Meter (CTM)

*Traffic
simulation*



Three-Wheel Polishing Device (TWPD)

Task 7. Determine the Effect of Rejuvenating Seals on Pavement Friction, and Macrotexture and Microtexture Properties

Field Testing: NCAT Test Track E7 and E8 (dense-graded mixtures placed 2015) (Duration: 3-6 months)

Rejuvenating Seal Treatment	Application Rate	Test Length	Friction Measure	Macro Texture Measure
A	High	100 ft	Ribbed Tire LWST (pre-treatment and monthly) Supplement with DFT	Point Laser (pre-treatment and weekly) Supplement with CTM
	Low	100 ft		
B	High	100 ft		
	Low	100 ft		

Laboratory Testing: NCAT Lab TWPD (Duration: 70,000 cycles)

Rejuvenating Seal Treatment	Application Rate	No. of Replicates	Friction Measure	Macro Texture Measure
A	High	2	DFT* (pre-treatment and every 500 TWPD cycles or adjusted as needed)	CTM (before and after treatment)
	Low	2		
B	High	2		
	Low	2		

*pavement microtexture

Task 8. Guide Dosage Selection

- Results of Tasks 1 through 7 will be used to formulate a practical approach for agencies to determine a correct rejuvenating seal dosage.
- The approach will consider:
 - (1) existing pavement surface type and age,
 - (2) climatic conditions,
 - (3) rejuvenating seal type, and
 - (4) minimum allowable post-application friction (traffic level crash risk).

Task 9. AASHTO Specification

- The Research Team will prepare a two-part AASHTO deliverable.
- **Part 1** will focus on the material specifications for petroleum- and bio-based rejuvenating seals.
 - Selection, property characterization, and dosage optimization for pavement sealing applications.
- **Part 2** will focus on the best practices for determining the impacts of rejuvenating seals on the performance and surface characteristics (friction and texture) and the life span of underlying asphalt pavements.



Task 10. Final Deliverables

- **A draft final report**
 - Documenting the results from the project, summarizing findings, drawing conclusions, and presenting the proposed AASHTO Standard Practice to implement performance-based evaluation of rejuvenating seals.
- **A virtual workshop and associated materials**
 - Describing the research results and the proposed comprehensive AASHTO Standard Practice to be given to the AASHTO Transportation System Preservation-Technical Services Program (TSP2) Emulsion Task Force (ETF).

Thank You

Questions?