Spray-Applied Rejuvenators and Sealers for Effective Pavement Preservation

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Outline

• Pavement Aging and Tools

• Rejuvenators
  • What, why, and how are they used?
  • Research and Projects

• Spray-Applied Asphalt-Based Treatments
  • Fog Seals
  • Rapid Penetrating Emulsion
Why Do Pavements Age?

• Asphalt binder oxidizes with time
  • Becomes stiffer, brittle, prone to cracking
  • Referred to as aging in pavement industry

• 2 approaches to address aging
  • **Physical**: Limit exposures by covering/sealing pavement, reducing permeability
    • Ex. Fog seal, chip seal
  • **Physiological**: Directly affect asphalt binder
    • Ex. Rejuvenators
When Should A Pavement Be Treated?

Early is better!

“Most of oxidative aging in the upper stratum of an asphalt concrete pavement occurs during the first 4 years after construction. After this period, the asphalt aging rate decreases significantly... *(a surface seal) must be placed during the first 2 years* (approximately) of the pavement’s life.”

- Permeability of Asphalt Surface Seals and Their Effect on Aging of the Underlying Asphalt Concrete – Joe Button, Transportation Research Record Journal, 1996
Proactive Approach

- Early treatments extend life, save money, safer for workers and motorists
- Surface treatments are most effective early in life
History Of Rejuvenators

• First applications recorded around 1970
  • Reclamite and Koppers BPR most notably
• Asphalt-derived products to balance maltene to asphaltenes ratio
• Proposed specifications involved extracting and recovering asphalt binder in top 3/8”
  • Viscosity decrease by minimum 40%
  • Penetration increase by minimum 20%
• Currently no universal specifications (AASHTO)
  • Local specs, FAA, etc. can vary
• Push towards bio-oil and plant-based materials in recent years
  • Same function as asphalt-based maltene materials
• Increase in usage in past decade, but not new concepts

Source: Boyer, “Asphalt Rejuvenators – Fact or Fable”
What Is A Rejuvenator?

• Materials or additives that offset, maintain, or restore properties of asphalt that degrade with aging
• Low-to-medium viscosity oils at ambient temperature soluble in asphalt binder
• Three broad categories
  • **Petroleum-based:** derived from petroleum products
  • **Bio-based:** derived from plants
  • **Hybrid:** blended with asphalt binder or residue
• Aging is not “reversible”, but can be offset or mitigated with these products
How Can Rejuvenators Be Used?

- **Spray-applied to pavement surface**
  - Post-construction for preventative maintenance
- **Added into asphalt binder or RAP/RAS during HMA production**
  - Increase amount of RAP/RAS
- **Cold Recycling Additive**
  - Added to RAP/RAS at ambient/near-ambient temperatures

- **Rejuvenator chemistry is often designed for a specific application (Not all created equal)**

Source: RoadResource.org, CALTRANS
Why Use A Rejuvenating Emulsion?

- Offset aging gradient near surface of the pavement
  - Where most of oxidative aging occurs
- Improve Performance Grade of binder = better crack resistance
- Reduces pavement permeability
- Extends preservation timeline when applied **EARLY**
  - Less effective later in pavement life
Rejuvenator Performance: Industry Opinion

- Historical applications show improvement in cracking resistance, life extension
- Michigan 3R guideline good resource for different treatments
- Effective rejuvenator applications can expect to give 2-4 years of life extension (RoadResource.org)
Rejuvenator Performance: Residue Penetration

Penetration of Residue, 25 °C

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<th>Oil B Penetration (dmm)</th>
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<td>Next 1/2&quot;</td>
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Treated: oil treated, Control: oil control
Rejuvenator Performance: Residue Delta Tc

<table>
<thead>
<tr>
<th></th>
<th>Oil A Top 1/2&quot;</th>
<th>Oil A Next 1/2&quot;</th>
<th>Oil B Top 1/2&quot;</th>
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<td>Control</td>
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ΔTc of Residue, °C
**Other Performance Tests**

- Extraction and binder recovery tests:
  - DSR (G*, phase angle)
  - High temp Critical PG
  - Low Temp Critical PG
  - Viscosity
- Ideal CT – ASTM D8225
  - Known to be sensitive to aging, additives
National Research Initiatives

- MNDOT National Road Research Alliance (NRRA) – Spray on Rejuvenator Test Section
  - 12 rejuvenator products applied on sections of MnROAD and 15th St NE in St. Michael, MN
  - Research funded through 2023
- NCAT Test Track study on rejuvenators
  - 7 different surface treatments applied in 2012
  - Reports available on NCAT site
  - Currently in RFP
  - Determine performance impact, life extension, optimization of rates, and suggested practices
**Project Selection**

**Ideal:** surface films intact, no raveling

**Satisfactory** surface films >50% intact, minimal raveling; may require sanding

**Exercise Caution:** Films ~50%, minor raveling, consider hybrid treatment
Project Selection: Permeability And Texture

• Permeability: measuring rate of water flow through pavement
  • Higher permeability = better penetration into pavement
  • Adjust application rate
• Mean Texture Depth – Use Circular Track Meter (CTM) or Sand Patch
  • Texture loss = residue did not penetrate (more typical for asphalt-based materials)
• Testing before and after application
• Test patches are common
  • Sample material on squares at pre-weighed rates
Application Of Rejuvenating Emulsions

• Easy to apply using conventional spray equipment and/or distributors
  • Storage stable, minor mixing only
  • Generally, no heating required
  • Rates 0.035 gal/sy to 0.10 gal/sy
  • Full-width or longitudinal

• Dosage easily adjusted with application rates

Full Width Application
Application Of 
Rejuvenating Emulsions

- Formulation can be adjusted to be project-specific
  - Addition of asphalt-based emulsions (50/50)
  - Designed with penetrating capabilities
- Dry time dependent on ambient conditions
  - Good conditions = traffic release < 1hr
  - “Sanding” requirement project and material specific
  - Penetrating emulsions may not require or require less
  - Depend on existing permeability, friction, texture
Typical Application
Sanding Process

• Usually ~0.25-0.5 lb/sy for fat areas and to provide early frictional resistance
• Projects with film loss or areas of concern
• Sand is swept or allowed to wear away

River sand on county highway

Pickup-mounted spreader with boiler slag
Application Of Penetrating Rejuvenators
Full Width Treatment

• New pavement, for effective penetrating capability
• Reduce or omit the need for sanding
Hybrid Rejuvenators And Sealers

- Asphalt-based hybrid
  - Asphalt emulsion blended with rejuvenating emulsion
- Gilsonite-based
  - Additive to seal pavement and give longer-lasting dark color
- **Existing guideline in MI**
  - Better contrast with new striping
  - Lower permeability
  - Better aesthetics
  - Existing pavement markings will need replaced

~45 minute post application

~2 minutes post-application
Asphalt-Based Sealers

- Physical means to seal surface with asphalt residue
  - Reduce permeability
- Fog seals
  - Inexpensive, large permeability reduction
  - Can cause texture/friction loss, may be worn away easier
- Rapid Penetrating Emulsions (RPE)
  - Penetrate surface to fill voids, materials remains below surface even after surface residue worn away
  - Minimal effect on texture and friction
Rejuvenator vs RPE

- Oil-based slow-setting emulsion (25-30% solids)
  - Rate ≤ 0.1 gal/yd² (0.03 gal/SY res.)
  - Restore properties of the asphalt binder and reduce permeability
  - Recommend PCR > 70
  - 2 to 4 years added life claimed
  - $1/yd² to $3/yd² applied cost with sanding

- Low viscosity asphalt emulsion (35-40% solids)
  - Rate ~0.15 gal/yd² (0.06 gal/SY res.)
  - Reduce permeability and maintain texture
  - Best if applied within the first 2 years
  - Not enough data on added life yet
  - ~ $0.75/yd² applied cost, usually not sanded

- Penetrate pavement surface ~ ¼” to ½” depending on voids and texture
- Reduce permeability but not impermeable
What Is A Rapid Penetrating Emulsion?

Designated As RPE

- Asphalt emulsion ~30 - 40% AC
- Designed to penetrate voids of bituminous pavement
- Reduces air and water intrusion while maintaining pavement texture
- "In" the pavement instead of "on" the pavement
- Quick resistance to water
- Most effective when applied in first year of pavement life
RPE Penetrating Capability

Laboratory Compacted Slab

**ONE** RPE Application vs **ONE** Diluted SS-1H Application
0.15 gal/sy 0.15gal/sy
RPE Effect On Permeability And Texture

Hendricks County, IN 2016

- New pvmt 0.14 gal/yd² 47% AC
- 3 yr old pvmt 0.1 gal/yd² 47% AC
- New pvmt 0.22 gal/yd² 44% AC

CR 700S: 85.4% reduction in texture, 12.1% reduction in perm
CR 400E: 94.6% reduction in texture, 41.8% reduction in perm
CR 200E: 95.0% reduction in texture, 3.9% reduction in perm
Where Is RPE Used?

Project Selection

- New Hot Mix Asphalt Pavement
  - Centerline
  - Full Width

- Recycled Pavements
  - Full Width

- Low density areas
  - Spot Repair

At Application

5 Minutes After Application
RPE Centerline Treatment Effect

Reduced permeability allows the treated centerline to dry faster than other parts of the pavement.
Recycled Pavement Application
Cold Central Plant Recycling

1st Application 0.20 gsy
2nd Application 0.15 gsy
30 Minutes After Final Application
6-month Review After One Winter

- RPE allows placement of more asphalt residue into mix after construction
- Typical treatment would be a double chip seal or 2” HMA overlay
- Creates uniformity in permeability: better tack for HMA or only single chip seal necessary
- Chip seal or overlay delayed past 1st season of construction
Complimentary Treatments

• Surface treatments are complementary with other preventative and reactive maintenance products/methods
• Combining with a product such as VRAM can protect top and bottom = bulletproof joint

VRAM – Beneath The Joint

Emulsion/Rejuvenator Products – Over The Joint

BULLETPROOF JOINT!!!
Conclusion

• Are rejuvenators effective?
  • Area of ongoing research nationally
  • Appear to be, but success needs to be defined by user expectations

• What is the expected life/cost in terms of EAC/ROI?

• What steps can I take to have success and what should I look for?
  • Do the research and testing up front – Not all pavements are ideal

• What other product options are available?
  • Hybrid rejuvenators
  • Rapid Penetrating Emulsions
Questions?

Thank You!

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