OVERVIEW OF CRACK SEALING TECHNOLOGY

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Crack Treatment- Overview

- Cracking in AC Pavements
- Pavement Deterioration Due to Cracking
- Effects of Crack Sealing on Pavement Performance
- Required Material Properties
- Installation Configurations and Procedures
- Crack Sealing Process Design
Crack Formation

Cracking occurs when the AC mix can no longer flow to accommodate stresses/strains from traffic loadings and temperature changes.
Crack Types

• Thermal – Transverse, Longitudinal
• Fatigue
• Block
• Reflective
• Construction
• Other
Crack type- thermal
Crack type- longitudinal
Crack Movements

Horizontal- Temperature changes, spacing

Vertical- Traffic loadings
## Horizontal Movements

<table>
<thead>
<tr>
<th></th>
<th>Seasonal</th>
<th>Daily</th>
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<tbody>
<tr>
<td>Rate, mm/min</td>
<td>0- 0.004</td>
<td>0- 0.01</td>
</tr>
<tr>
<td>Amount, mm</td>
<td>0-25</td>
<td>0-2</td>
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Cracks can open as much as 100%+ of original width as the pavement contracts from summer to winter temperature extremes.
Vertical Movements

- Due to traffic loadings
- Deflection at the crack under load is many times greater than before cracking
Crack Growth

- Cracks widen as they age
- Crack face deterioration, ravelling
- Mixture shrinkage
- Incompressible intrusion
- Widening of approx 10% of annual movement per year
Incompressible intrusion
Pavement Deterioration Resulting From Cracking

- Local water intrusion weakens subgrade
  - 2% w/c increase, 100% strength reduction
- AC mix damage, 50% thickness reduction
  - Damage approx 1m each side of crack
- Increased deflections from traffic loads
  - Potholes, depressions, secondary cracking
Water intrusion
Pavement Condition Curve

PCI Points Lost per Year
Model for Pavement Life of 30 years

Loss of 2-4 PCI Points per Year
Loss of 8-12 PCI Points per Year
Loss of 1-6 PCI Points per Year

Multnomah County, Oregon
DBCS/Transportation Division
Pavement Deterioration

An Analogy

Process is continuous and inevitable

The rate of water flow increases as condition decreases

The effort to pump water increases with decreasing condition

Seal = $0.50 / sq yd
Overlay = $5 / sq yd
Reconstruct = $15 / sq yd
Crack Sealing Function and Effects

- Reduce water penetration into underlying pavement layers, maintain base strength near the crack
- Reduce incompressibles, reduce crack growth
- Seals crack surfaces, reduces ravelling and crack growth
Crack Sealing Effects on Pavement Condition

- Slows pavement deterioration
- Slows roughness increases
- Reduces pothole and depression formation
- Slows crack spalling
- Extends pavement life, 2-5 years
Slow Down Pavement Deterioration

Performance Curves: control vs Treated --
Highway 11 (Ontario)

Pavement Condition Index

Years of Service
Crack Sealing in Pavement Management

• Typically incorporated in PCI determinations by reducing severity ratings for sealed cracks
• Sealed cracks are rated as low severity, while unsealed may be moderate or high severity
• Slows roughness increases
Crack Sealing in Preventive Maintenance and Pavement Preservation

- Crack sealing is one of the typical preventive maintenance procedures
  - Chip seals, Slurry /Micro surfacing
  - Thin Overlays
  - Recycling
  - Crack Sealing
- Crack Sealing is used extensively in conjunction with other preservation processes, usually as a pretreatment
Crack Sealing Life Expectancy

- Up to 10 years at a 75% effectiveness (FHWA RD-99-147)
- With proper timing, materials and installation methods for the project, crack sealing is a cost effective process
Crack Sealing Treatments Need to Resist

- Temperature extremes
- Traffic loadings
- Horizontal and Vertical Movements
- Aging
- Water
- Abrasion

WITHOUT

- Debonding, Cracking, or Tracking
Crack Treatment Basic Elements

• Pavement
• Crack Seal Material
• Installation Geometry
Asphalt Concrete Pavement

- Varying overall condition
- Varying crack types
- Varying crack spacings
- Varying crack conditions
- Varying other distresses
- Varying mixture designs
- Varying surfacing materials
Crack Sealing Material Characteristics

- Application Consistency
- Adhesion
- High Temperature Stiffness
- Low Temperature Extensibility
- Elasticity
- Application Life
- Weathering Resistance
- Compatibility with Asphalt Concrete
- Curing time
- Relaxation
Crack Sealing Material Types

- Asphalt Cements
- Asphalt Emulsions, Cold Applied
- Asphalt Cutbacks, Cold Applied
- Modified Asphalts, Hot Applied
  - Fiber, rubber, polymers
- Polymeric
  - Urethanes, silicone, epoxy
Hot Applied Modified Asphalts

- ASTM Specs -- D5078, D6690, I-IV
- AASHTO Specs—M324, I-IV
- Variety of State, local Specs
- Manufacturer Specifications
Installation Configurations

• Overband-- 1/8 in. max thickness by approx 4 in wide

• Reservoir--- ½ to 1 ½ in wide, ½ to 1 in deep
Crack Seal Treatment Design Process

• Pavement Evaluation
• Process Selection
• Temperature Ranges
• Material Selection
• Installation Geometry
• Installation
Pavement Evaluation

- Determine Cracking type and extent
- Consider overall pavement condition
- Generally applicable at PCI approx 50-80, but can vary depending on climate, traffic, and other factors
- Pavement condition can be too bad for crack sealing
Forget it!!
General Pavement Guidelines

- Intact, defined crack faces
- Maximum crack width of 1.5 in.
- Not significant base damage
Process Selection

• Working or Non–Working cracks
• Working->1/8 in thermal movement, typically transverse spaced at over 20 ft.
  – Use Crack Seal Process
• Non-Working- < 1/8 in thermal movement, Typically longitudinal, transverse or other types spaced at less than 20 ft.
  – Use Crack Fill Process
Crack Seal Process

- Flexible, extensible materials that can accommodate the expected annual temperature changes and movements
- Installed in widened reservoirs, designed to take the expected movement
  - Widened reservoirs reduce sealant extension percentages as the pavement contracts from summer to winter
Crack Fill Process

- Stiffer, yet flexible, more traffic resistant materials
- Installed in cleaned existing cracks, or in routed reservoirs for improved life
- Typically installed in a fill and overband configuration
Temperature Ranges

- Determine temperature extremes
- LTPPBIND, at surface level
- Ranges from 76-10 to 64-40
- FHWA Application Note- RD-03-080

Using LTPPBIND V2.1 to Improve Crack Sealing in Asphalt Concrete Pavements
Available from FHWA

- On the Web
- On CD
- By Mail
LTPPBIND
Materials Selection--Low Temperature Property Evaluation

- Bond Test -18C, -29C, 50-200% extension
- Mandrel Bend/ Flexibility- 0C to -40C
- Penetration at -18C
- Stiffness at low temperatures
- Relaxation at Low temperatures
- Experience
BBR Stiffness Measurements

• For good performing material in MN in transverse cracks, when PAV aged, and tested at -34C,
  – S = 11.0 mpa
  – M value = 0.463

• Approximately 1/50 the stiffness of -34 grade asphalt cement
High Temperature Property Evaluation

- Softening Point
- Flow at 60 or 70C
- Penetration at 25, 58, 64, 70, 76, 82C
- DSR
- Experience
General Specification Applicability

-34,-40 areas: D6690 Type IV
-22,-28 areas: D6690 Type II,III
-16 areas: D6690 Type I
-10 areas: State, local specs
Sealant Properties/Performance

- Sealant material performance is controlled by the relationships and interactions of low temperature, high temperature, adhesive and elastic properties over the entire range of temperatures and strains experienced.
Installation Configurations-Working Cracks

- Reservoir width based on temperature range and crack spacing.

<table>
<thead>
<tr>
<th>Temp Range</th>
<th>Min Width</th>
<th>Depth</th>
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<tbody>
<tr>
<td>&lt;80C</td>
<td>½ in</td>
<td>¾ in</td>
</tr>
<tr>
<td>86C</td>
<td>¾ in</td>
<td>¾ in</td>
</tr>
<tr>
<td>92C</td>
<td>1 1/8 in</td>
<td>½ in</td>
</tr>
<tr>
<td>96C+</td>
<td>1 ½ in</td>
<td>½ in</td>
</tr>
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</table>

If crack spacing is over 50 -60 ft, consider next wider size.
Reservoir Types/Sizes

Configuration A
Standard Reservoir-and-Flush

Configuration B
Standard Recessed Band-Aid

Configuration C
Shallow Recessed Band-Aid
Installation Configuration- Non Working Cracks

- Fill existing cleaned crack, or
- Use overband, 1/8 in max by 4 in wide, or
- Can also use reservoir for longer life, typically 1/2 in by ¾ in.
Recommend Overband Appearance (Non-Rout/Clean & Fill)
Not recommended
Reservoir Cutting

- Cut with router or crack saw
- Remove at least 1/8 in of mix from each side of crack
- Center reservoir over the crack
- The cut faces should be intact without spalling from the cutting operation
Routing

• Rout at least 1/8” from each crack face

• Keep centered over crack

• Reduce spalling by using as many cutters as possible
Sealant Installation--Cleaning and Drying

• Dry Compressed Air, 100 psi min
• Vacuum system, for reduce dust
• Heat Lance

• Objective—clean, dry, intact crack face surfaces
Clean cracks:

[Image: Not Clean - left side]
[Image: Clean - right side]
Vacuum

- Reduces dust
- No post job clean up
- Healthier work environment
- Safer work environment
- PM 10 air regulation compliant
Sealant Heating

• Appropriate Melters- Heat to specified required temperatures
  – Indirectly heated
  – Thermostatic Heating controls
  – Effective, continuous agitation
  – Over heating prevention
  – Correct size for production rate desired
  – Several versions and sizes available
Sealant Heating

- Sealant must be heated to and installed within specified temperature ranges
- Overheating can degrade material—polymer breakdown, crosslinking, reduce application life
- Underheating can result in not achieving material properties and adhesion
Weather Conditions

• Minimum 40 F pavement temperature
• Dry pavement and cracks
• Rain not imminent
Finishing

- Recessed Fill- leave approx ¼ inch low in the crack
- Flush Fill– fill to flush with the pavement surface
- Slight overlap- slight overfill with approx ¼-1/2 inch overlap on each side of crack
- Overband- 1/8 in by approx 4 in wide band centered over top of crack
Failure Modes

• Adhesion loss- cleaning, moisture, install temperatures, weak mix, wrong sealant
• Cohesive Fracture-wrong sealant or geometry
• Pullouts-wrong sealant, cleaning, moisture, excess application
• Tracking-wrong sealant, excess application
• Installation Errors
Missed Crack During Installation
## Process Comparison to Hot Mix AC

<table>
<thead>
<tr>
<th>Hot Mix</th>
<th>Crack Seal</th>
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<tbody>
<tr>
<td>Pavement Design</td>
<td>Evaluation, Seal, Fill</td>
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<tr>
<td>Ac/Agg Specs</td>
<td>Sealant Type/Prop.</td>
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<tr>
<td>Mix Design</td>
<td>Install Geometry</td>
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<tr>
<td>Construction</td>
<td>Installation</td>
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<tr>
<td>Temps, compaction</td>
<td>Temps, cleaning</td>
</tr>
<tr>
<td>Quality Control</td>
<td>Quality Control</td>
</tr>
</tbody>
</table>
Elements of Successful Crack Sealing

- Right Pavement
- Right Time
- Right Sealant
- Right Geometry
- Right Installation
- Right Temperatures
Potential Research Topics

- Crack Movement Determination Procedure
  - Determine movements to better select the treatment process and reservoir size

- Crack Treatment Design Process
  - Guide to select pavements, process type, sealant type, installation geometry

- Sealant Materials Properties
  - Properties determined/ measured considering standard temperature ranges, installation geometries, and expected movements
Summary

• Asphalt pavements crack
• Sealing cracks extends pavement life
• Crack seal process must be designed for the pavement conditions
• Sealant performance is the result of the balance of properties over the entire temperature range experienced
• Correct installation geometry is required for appropriate performance