Seminar on Maintenance of Asphalt Pavements

Crack Sealing

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Technology Transfer Specialist
Agenda

1. Importance of Crack Sealing
   Road Enemy #1 - ‘Water’

2. FHWA/SHRP/LTPP
   Studies & Results
   Manual of Practice
   LTPPPBind Software
Agenda

3. Crack Sealing Program
   - Materials
   - Equipment
   - Preparation
   - Sealing
   - Safety

4. Saw and Seal Program
Video

US Army Corps of Engineers
Cold Regions Research &
Engineering Laboratory (CRREL)
Hanover, NH

“Crack Sealing Flexible Asphalt
Pavement”
Importance of Crack Sealing

- One of the best early Preventive Maintenance Techniques to prolong the life of your roads
- Cost Effective!
Factors Affecting Road Life

- Traffic Loads
- Water
- Age
- Quality of Construction & Road Materials
- Maintenance Program
- Subgrade Quality

Road Life
Deterioration / Rehabilitation Relationship

- 40% Quality Drop
- 75% Time
- 17% Time
If left go, a single crack will only continue to deteriorate, resulting in more severe distress with more work to repair along with additional costs.
Crack Sealing

Types of Cracks

Block
Reflection
Edge
Longitudinal
Transverse
Caution!
Alligator/Fatigue Cracking

Recommended Treatment: Base Repair

DO NOT CRACK SEAL
Caution!

Alligator/Fatigue Cracking

Recommended Treatment: Base Repair

DO NOT CRACK SEAL
Federal Highway Administration

Strategic Highway Research Program

Long Term Pavement Performance
SHRP Studies

- H-105 Innovative Materials & Equipment for Pavement surface Repair
- H-106 Innovative Materials Development & Testing
- FHWA Long-Term Monitoring (LTM) of Pavement Maintenance Materials Test Sites


http://www.fhwa.dot.gov/pavement/pub_listing.cfm?areas=LTPP

- TechBrief: Sealing and Filling Cracks in Asphalt Pavements
Materials and Procedures for Sealing and Filling Cracks in Asphalt-Surfaced Pavements

Manual of Practice

Materials and Procedures for Sealing and Filling Cracks in Asphalt-Surfaced Pavements

Federal Highway Administration
U.S. Department of Transportation

Strategic Highway Research Program
National Research Council

FHWA Report No. FHWA-RD-99-147

http://www.fhwa.dot.gov/pavement/pub_listing.cfm?areas=LTPP
Crack Treatment

Method depends on crack density and edge deterioration

- Surface Treatment
- Repair
- Sealing
- Filling
Table 2. Guidelines for determining the type of maintenance to be performed.

<table>
<thead>
<tr>
<th>Crack Density</th>
<th>Average Level of Edge Deterioration (percentage of crack length)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low (0 to 25)</td>
<td>Moderate (26 to 50)</td>
</tr>
<tr>
<td>Low</td>
<td>Nothing</td>
<td>Nothing or Crack Treatment</td>
</tr>
<tr>
<td>Moderate</td>
<td>Crack Treatment</td>
<td>Crack Treatment</td>
</tr>
<tr>
<td>High</td>
<td>Surface Treatment</td>
<td>Surface Treatment</td>
</tr>
</tbody>
</table>
Crack Sealing vs Filling

- Crack Sealing: Placement of specialized materials above or into working cracks using unique configurations to prevent water intrusion.
- Crack Filling: Placement of ordinary treatment materials into non-working cracks to prevent water intrusion.
Working vs Non-working Cracks

- Working Cracks: Horizontal movement of 0.1 inches or greater, usually transverse
- Non-working Cracks: Horizontal movement less than 0.1 inch, usually longitudinal
Table 3. Recommended criteria for determining whether to seal or fill.

<table>
<thead>
<tr>
<th>Crack Characteristics</th>
<th>Crack Treatment Activity</th>
<th>Crack Sealing</th>
<th>Crack Filling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width, mm</td>
<td></td>
<td>5 to 19</td>
<td>5 to 25</td>
</tr>
<tr>
<td>Edge Deterioration (i.e., spalls, secondary cracks)</td>
<td>Minimal to None (&lt; 25 percent of crack length)</td>
<td>Moderate to None (&lt; 50 percent of crack length)</td>
<td></td>
</tr>
<tr>
<td>Annual Horizontal Movement, mm</td>
<td>≥ 3</td>
<td>&lt; 3</td>
<td></td>
</tr>
<tr>
<td>Type of Crack</td>
<td>Transverse Thermal Cracks Transverse Reflective Cracks Longitudinal Reflective Cracks Longitudinal Cold-Joint Cracks</td>
<td>Longitudinal Reflective Cracks Longitudinal Cold-Joint Cracks Longitudinal Edge Cracks Distantly Spaced Block Cracks</td>
<td></td>
</tr>
</tbody>
</table>
Materials for Sealing vs Filling

- Minimal movement permits use of less expensive, less specialized crack-filler materials.
- If existing cracks are both working and non-working, using a material appropriate for the most demanding crack type may be desirable.
Factors Effecting Sealants

- Climate
- Traffic
- Weather Conditions during Sealing
- Pavement Design
- Pavement Age
- Drainage Profile
Factors Effecting Sealants

- Material Preparation
- Material Type (& manufacturer)
- Material Configuration
- Crack Movement
- Crack Deterioration
- Crack Preparation
Sealant Distresses

• Adhesion Failure*
• Cohesion Failure
• Weathering/Aging
• Extrusion, Tracking, Pullouts
• Intrusion of Incompressibles
*Adhesion Failure*

- Sealant Material
- Improper Configuration
- Inadequate Crack Preparation
- Incorrect Installation Procedures
Desirable Sealant Characteristics

- Short preparation time
- Quick & easy to place
- Short cure time
- Adhesiveness
- Cohesiveness
Desirable Sealant Characteristics

- Resistance to softening & flow
- Flexibility
- Elasticity
- Resistance to aging & weathering
- Abrasion resistance
Types of Sealants

1. Cold-Applied Thermoplastic
2. Hot-Applied Thermoplastic
3. Thermosetting Chemically Cured
Types of Sealants

- Cold-Applied Thermoplastic
  - Set by release of solvents (cutbacks) or breaking of emulsions
  - Applied at ambient temps or heated to 120-140° F
Types of Sealants

• Hot-Applied Thermoplastic
  » Soft upon heating
  » Harden on cooling
  » No change in chemical composition
Types of Sealants

- Thermosetting Chemically-Cured
  - Cure through chemical reaction
  - High cost
Sealant Uses

- Non-working cracks (crack filling)
  - asphalt emulsions
  - asphalt cement
  - fiberized asphalt

- Working cracks (crack sealing)
  - polymer-modified liquid asphalt
  - asphalt rubber
  - rubberized asphalt
  - low-modulus rubberized asphalt
  - self-leveling silicone
Table 4. Summary of AC crack treatment materials.

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Applicable Specifications</th>
<th>Recommended Application</th>
<th>Cost Range, $/kg(^a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt Emulsion</td>
<td>ASTM(^b) D 977, AASHTO(^c) M 140, ASTM D 2397, AASHTO M 208</td>
<td>Filling</td>
<td>0.15 to 0.30</td>
</tr>
<tr>
<td>Asphalt Cement</td>
<td>ASTM D 3381, AASHTO M 20, AASHTO M 226</td>
<td>Filling</td>
<td>0.15 to 0.30</td>
</tr>
<tr>
<td>Fiberized Asphalt</td>
<td>Manufacturer's recommended specs</td>
<td>Filling</td>
<td>0.35 to 0.60</td>
</tr>
<tr>
<td>Polymer-Modified Emulsion</td>
<td>ASTM D 977, AASHTO M 140, ASTM D 2397, AASHTO M 208</td>
<td>Filling (possibly sealing)</td>
<td>0.80 to 1.20</td>
</tr>
<tr>
<td>Asphalt Rubber</td>
<td>State specs, ASTM D 5078</td>
<td>Sealing (possibly filling)</td>
<td>0.45 to 0.65</td>
</tr>
<tr>
<td>Rubberized Asphalt</td>
<td>ASTM D 1190, AASHTO M 173, Fed SS-S-164</td>
<td>Sealing</td>
<td>0.55 to 0.85</td>
</tr>
<tr>
<td></td>
<td>ASTM D 3405, AASHTO M 301, Fed SS-S-1401</td>
<td>Sealing</td>
<td>0.65 to 1.10</td>
</tr>
<tr>
<td>Low-Modulus Rubberized Asphalt</td>
<td>State-modified ASTM D 3405 specs</td>
<td>Sealing</td>
<td>0.75 to 1.40</td>
</tr>
<tr>
<td>Self-Leveling Silicone</td>
<td>ASTM D 5893</td>
<td>Sealing</td>
<td>5.75 to 6.75</td>
</tr>
</tbody>
</table>

\(^a\) Based on 1998 costs.
\(^b\) ASTM = American Society for Testing and Materials.
\(^c\) AASHTO = American Association of State Highway and Transportation Officials.
Table 5. Properties associated with various material types.

<table>
<thead>
<tr>
<th>Property</th>
<th>Material Type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Emulsion</td>
</tr>
<tr>
<td>Short Preparation</td>
<td></td>
</tr>
<tr>
<td>Quick &amp; Easy to Place</td>
<td></td>
</tr>
<tr>
<td>Short Cure Time</td>
<td>⋄</td>
</tr>
<tr>
<td>Adhesiveness</td>
<td>⋄</td>
</tr>
<tr>
<td>Cohesiveness</td>
<td>⋄</td>
</tr>
<tr>
<td>Resistance to Softening &amp; Flow</td>
<td>⋄</td>
</tr>
<tr>
<td>(cured state)</td>
<td></td>
</tr>
<tr>
<td>Flexibility</td>
<td>⋄</td>
</tr>
<tr>
<td>Elasticity</td>
<td>⋄</td>
</tr>
<tr>
<td>Resistance to Aging &amp; Weathering</td>
<td>⋄</td>
</tr>
<tr>
<td>Resistance to Abrasion</td>
<td>⋄</td>
</tr>
</tbody>
</table>

- Applicable
- **Very Applicable**
Configurations

- Flush Fill
- Reservoir (routed)
- Overband (band-aid)
- Combination
A. Flush-fill

B. Simple Band-Aid

- Material
- Crack
- 25 mm wide wipe zone
- 3 mm thick (typical)
- 75 to 125 mm (typical)
C. Capped

D. Standard Reservoir-and-Flush

Cap

12 to 19 mm

12 to 19 mm

Reservoir
See Figure 6: Material Placement Configurations
1. Establishing a Program
   » Assessment prior to action
     – Type & orientation of cracks
     – Climatic conditions, pavement structure, traffic, future rehabilitation plans
   » Determine crack movement expected
   » Determine appropriateness of short, medium, or long-term treatment
2. Working Cracks

- **Short-term 1-3 years**
  - Rubberized asphalt in simple band-aid configuration

- **Medium-term 3-5 years**
  - Rubberized asphalt in standard recessed band-aid configuration
  - Modified rubberized asphalt in simple band-aid configuration
2. Working Cracks (continued)

- Long-term 5-8 years
  - Modified rubberized asphalt in standard recessed band-aid configuration
  - Modified rubberized asphalt in shallow recessed band-aid configuration
3. Non-working Cracks

- Short-term 1-3 years
  - Asphalt cement in flush fill configuration

- Long-term 5-8 years
  - Asphalt rubber or rubberized asphalt in flush fill or overband configuration
  - Fiberized asphalt in overband configuration
4. Other considerations

» Use of hot-lance to clean, dry and warm cracks appears cost effective

» Self-leveling silicone looks promising, more study needed
Innovation! LTPPBind

- LTPPBind: A Software Tool for Selecting Cost-Effective Superpave Asphalt Binder Performance Grades
  - Database of high & low temps for 7,835 U.S. & Canadian weather stations
  - Allows user to select PGs based on actual temperature conditions at their site

- Product Brief in Handout

So why is this important to crack sealing??????
Using LTPPBind to Improve Crack Sealing

- Sealants with different properties are needed in different climates.
- Warm climates require stiff sealants, colder climates require softer, more flexible sealants.
- Sealants must function over the range of temperatures from summer to winter.
- Installation methods also vary by climate.
- The same pavement temperatures identified by LTPPBind can be used in selecting crack sealant materials and procedures.
Using LTPPBind to Improve Crack Sealing

- Using LTPPBind, sealant properties at anticipated high and low temperatures can be evaluated or compared.
- The LTPPBind temperature range also indicates expected crack movement aiding in reservoir-widening (routing) decisions.
- See Handout: Using LTPPBind V2.1 to Improve Crack Sealing in Asphalt Concrete Pavements FHWA-RD-03-080
Crack Sealing Program

Basic Elements of Crack Sealing

- Materials
- Equipment
- Preparation

- Sealing
- Safety
Crack Sealing Program

Materials:

- Recommend Prepackaged Materials
- Do **not** recommend field mixing
Crack Sealing Program
Materials

● If you are field mixing:

» Asphalt & PDR: 2 lbs rubber per gallon asphalt

» Asphalt & fibers: 5% fibers by weight of asphalt (10 lb bag per 25 gallons asphalt)
Crack Sealing Program
Materials

Problems with field mixing:
- Proper Kettle
- Proper proportions
- Uniform mix
Prepackaged Materials: Right proportions, uniform mix
Crack Sealing Program
Materials

- Temperature of sealant is critical
- Follow manufacturer’s recommendations
Crack Sealing Program
Materials

- Two important temperatures
  - Recommended application temperature
  - Safe Heating Temperature (generally 20°-30°F higher than application temp)
Crack Sealing Program

Equipment

- Router
- Air Compressor
- Hot Lance
- Heating Kettle with pump & agitator

(See Table 7: Types & Recommendations)
Crack Sealing Program
Equipment

Routing/Cutting
- Vertical-spindle router
- Rotary-impact router
- Random-crack saw
Routing

Caution!

Routing may NOT be suitable for:

- Older, aged asphalt pavements (above 6 yrs old)
- Thin asphalt pavements (less than 2” thick)
- Routing not needed if pavement is to be overlayed within 2 years
Routing

Advantages:
- Opens small cracks to allow greater penetration
- Provides a reservoir for sealant
- Produces uniform edges for better adhesion

Disadvantages:
- Very labor intensive, thus extra cost
- Can be difficult to follow meandering crack
- May damage older or thin asphalt pavements
- Longer exposure of workers to traffic
Crack Sealing Program

Equipment

Air Compressor

- To clean dust & debris
- Pressure: 100 psi min
- Flow: 150 cfm min
- Velocity: 3250 fps min
Crack Sealing Program
Equipment

Hot Lance
- Heats & dries crack
- Velocity: 2000 fps min
- Temperature: 2500°F min
Hot lance heats and dries crack
Crack Sealing Program

Equipment

Heating Kettle
- Direct heating
- Indirect heating (double boiler)

Type must be correct for material being used!
KETTLE TYPES

Direct Heat

Indirect Heat

Air

Oil
Indirect Heating Kettle

- Double boiler with separate temp controls & gauges for oil & melting chamber
- Mechanical full-sweep agitator
- Heating range to 450° F

60 gal. capacity

200 gal. capacity
Indirect Heat, Air-Baffled
Crack Sealing Program
Preparation

- A clean, dry crack is critical
- Dirt, dust, cold, and dampness can be disastrous
- Compressed air

or ......
Hot-Air Lance
Crack Sealing Program
Preparation

- Routed cracks also need to be clean & dry
Crack Sealing

- Cracks $\frac{1}{4}''$ to 1"
- Temperature (air & surface)
  - $40^\circ$F. min
  - $90^\circ$F. max
Crack Sealing Program

Sealing

- Temp above 40° F
- Wait 24 hours after rainfall
- Cracks 1/4” to 1”
- Material at proper temperature
Winter & Summer NOT the Right Time for Joint and Crack Sealing

Winter
Don’t Pour

Summer
Compression

Summer
Don’t Pour

Winter
Tension

Spring or Fall
Pour Joint

Summer
Compression (minimum)

Winter
Tension (minimum)
Crack Sealing Program

Sealing

- Kettle with pump & wand preferred
Crack Sealing Program

Sealing

- Pour pots & buckets
  - Higher safety risks
  - Difficult to maintain temperature
Crack Sealing Program
Sealing

- Apply the sealant INTO the cracks with the sealant wand.
- Slightly overfill to squeegee for bandaid configuration
Crack Sealing Program
Sealing

- Band-aid configurations
  - Squeegee or special nozzle head
  - Keep squeegee free of material buildup
Crack Sealing Program

Sealing

● Band-aid configurations
  » Keep squeegee or special head centered over crack
  » Operate squeegee closely behind wand
Crack Sealing Program
Sealing

- Sealant Configuration:
  - Standard Reservoir with band-aid
  - Width = 3”
  - No build-up!

A “Wipe”
Crack Sealing Program
Sealing

3 important items:

• Consistently maintaining application temperature
• Maintaining sufficient supply of heated material in kettle
• Properly dispensing right amount of material into crack
Crack Sealing Program
Sealing

• Blotting
  » Prevents tracking
  » Fine sand, limestone dust, talcum powder, **toilet paper**
  » Apply immediately after finishing
Crack Sealing Program
Safety

Safety

- Traffic - Proper work zone traffic control
- Compressed air
- Hot materials
Crack Sealing Program
Safety

- Face shield and/or goggles
- Heat resistant coveralls & gloves
- No direct heat applied to hoses
- Training for entire crew
Crack Sealing Program
Safety

Hot Asphalt First Aid

- **DO NOT** attempt to remove asphalt from the skin
- Submerge affected area in ice water
- Seek medical attention

**FIRST AID FOR MOLTEN ASPHALT CEMENT BURNS**

In the event of a MOLTEN ASPHALT CEMENT BURN: GURG, the asphalt cement and affected parts of the body immediately.

Methods of cooling in order of preference:
1. Completely submerge affected area in ice water;
2. Completely submerge affected area in tepid water;
3. Place affected area under running water.

**DO NOT DELAY**

Use ice or cold water, contain skin temperature while arranging for further cooling.

**CAUTION** DO NOT apply ice directly to affected area.

1. Allow heated asphalt cement on affected area

Prepared with the following:

MINOR ASPHALT CEMENT BURN... at first opportunity get victim to physician.

FIRST:

- Remove all sources of heat from contact
- Inhibit a small amount of body temperature

SECOND:

- Keep affected area of asphalt cement area
- Cover with clean, soft, absorbent material

TREATMENT FOR BURN:

- In the event of a serious skin burning:
  1. Keep victim calm, comforted, and quiet.
  2. Keep eviscerated with a barrier of water solution to keep heat from making contact with skin
  3. Radical scalds should not be used to promote heat away from head and chest.

DO NOT ATTEMPT TO REMOVE THE ASPHALT EXCEPT WITH WOODEN CUTTERS OR TONGS.

Photographs will be stored in about 60-70 hours.

ALG
Crack Sealing Program
Summary

Cracks Clean & Dry
Proper Material & Configuration
Correct Temperature
Proper Equipment
Safety

See Table 8: Crew requirements & production rates
SAW and SEAL
Sawing & Sealing Joints in Asphalt Pavement to Control Cracking
Saw & Seal

- An option for controlling cracks
  - New Asphalt Pavements
  - Asphalt Overlays on Jointed Concrete Pavements (JCP)
  - Asphalt Overlays on Asphalt Pavement
Saw & Seal

Should not be used:

» Overlays on JCP with high frequency of midpanel cracks or badly deteriorated cracks
» Overlays on JCP with badly deteriorated joints or joint patching
» Overlays on asphalt pavements with meandering transverse cracks
» Overlays on asphalt pavements with severe load related distress - alligator cracking, potholes, etc.
Would you rather have this, …
...or This!
Thermal Cracking

Crack will form at the surface where stress is the highest.

- Bituminous Surface
- Thermal Tensile Stress
- Granular or Bituminous Base

Temperature: Coldest to Warmest
Why Saw and Seal Works

Crack will form at the saw cut where pavement is weakest.

Bituminous Surface

Granular or Bituminous Base

Temperature
- Coldest
- Warmest
Reflective Cracking

Crack will form at points of stress concentration

Bituminous Overlay

Existing PCC Pavement or Bituminous Pavement
Why Saw and Seal Works

Bituminous Overlay

Existing PCC Pavement or Bituminous Pavement

↑↓

↔
Sample Saw Blade Configuration

Two Shallow Blades

One Deep Blade
Typical Saw Cut Dimension

- Backer Tape: 1/8"
- 1/2"
- 5/8"

Variation:
- New York: 2-1/2" for O.L. > 4"
- Varies (T/3, T/2, 2-1/2'')
Typical Problems

- Too far apart
- Not deep enough
- Poor Alignment
- Poor Alignment
Recommendations

- Joints spaced 30-50 feet apart. Most recommended is 40 feet.
- Depth of deep cut to be 1/3 asphalt thickness or 2 ½”, whichever is greater.
- Sawing done in one pass.
- Reservoir filled properly to achieve good bond & long sealant life
- Specification MnDOT 3720
Thank You!

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