Impact of Joint Sealing Effectiveness on Concrete Pavement Performance

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International Grooving and Grinding Association
Why Concrete Pavement Preservation

Bellefontaine, Ohio  1925

2016= 125th Anniversary
Presentation Outline

- Why do we seal?
- Field Performance Issues
- Sealant Life and When to Reseal
- Design of Joint Sealant Installation
- Sealant Selection and Installation
- Can We Seal Joints?
- How Does Sealing Impact Pavement Performance
Reasons for Joint Resealing

- Minimizes water & incompressibles into pavement system
- Reduces subgrade softening, pumping and erosion of fines and spalling
- Prevents Joint Associated Distress?
- Reduces Noise (Joint Slap)
Field Performance?
Why Seal Joints and Cracks

Prevents Incompressible from Lodging in the Joint — Slab Growth and Blow Ups
States With Examples and Studies
Why Seal Joints and Cracks

Prevents Water from Entering the Subgrade:

- Prevents subgrade erosion
- Voids beneath the slab
Water Damage to Pavements
The Top Doesn’t Always Tell the Story
Joint Associated Distress
When to Reseal & Sealant Longevity

- Adhesive Failures
- Cohesive Failures
- % Damaged or Missing

When the Sealant is No Longer Serving its Intended Function
Reseal or Original Seal?
Crafco 221 = 5.4 – 9.8 yrs
Crafco 231 = 6.4 – 9.5 yrs
Dow 888 SL = 12.8 yrs
Dow 888 = 13.9

232% to 348% Increase for Silicone
20 Year Old Sealant In Airfield
Same Airfield - One Year Old Sealant Installation

Old Concrete

New Concrete
Same 20 Year Old Airfield Sealant Installation
Design of Sealant Installation
Design of Sealant Installation

Sealant Performance Depends On:

- Design Factors (See ACPA App Website)
  - Anticipated Movement
  - Construction Schedule and Installation Conditions
  - Required Performance Period
  - Noise Considerations

- Sealant Selection---Proper Design and Specification for Application

- Joint Preparation---Clean, Dry, and Bondable

- Sealant installation
  - Silicone & Compression Seal Should be Recessed
  - Hot Pour Should be Flush Filled
  - Backer Rods Appropriate for Sealant Type
  - Primer?
Allowable Joint Opening Movements (Compression/Extension)

- Hot Pour Sealants: 25% Extension
- Silicone Sealants: 50% Compression to 100% Extension
- Compression Seals: 15% min Compression to 50% Extension
Guidelines for Joint Design

- A = ¼” to 3/8”
- B = < 3/8”
- C = Min of ¼”
- D/B ≥ 2
- D ≥ ¼”
## Manufacturer Design Tables
### Silicone and Compression Seal

<table>
<thead>
<tr>
<th><em>Joint Width</em></th>
<th>1/4&quot;</th>
<th>3/8&quot;</th>
<th>1/2&quot;</th>
<th>5/8&quot;</th>
<th>3/4&quot;</th>
<th>7/8&quot;</th>
<th>1&quot;</th>
<th>1 1/8&quot;</th>
<th>1 1/4&quot;</th>
<th>1 1/2&quot;</th>
<th>1 3/8&quot;</th>
<th>1 1/2&quot;</th>
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<tbody>
<tr>
<td><strong>Minimum Sealant Recess</strong></td>
<td>1/4&quot;</td>
<td>1/4&quot;</td>
<td>5/16&quot;</td>
<td>5/16&quot;</td>
<td>3/8&quot;</td>
<td>3/8&quot;</td>
<td>3/8&quot;</td>
<td>1/2&quot;</td>
<td>1/2&quot;</td>
<td>1/2&quot;</td>
<td>1/2&quot;</td>
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<tr>
<td><strong>Backer Rod Diameter</strong></td>
<td>3/8&quot;</td>
<td>1/2&quot;</td>
<td>5/8&quot;</td>
<td>3/4&quot;</td>
<td></td>
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<tr>
<td><strong>Sealant Bead Thickness</strong></td>
<td>1/4&quot;</td>
<td>1/4&quot;</td>
<td>1/4&quot;</td>
<td>5/16&quot;</td>
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<td></td>
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<td></td>
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<tr>
<td><strong>Minimum Joint Saw/Reservoir Depth</strong></td>
<td>1 1/8&quot;</td>
<td>1 1/4&quot;</td>
<td>1 1/2&quot;</td>
<td>1 3/4&quot;</td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Minimum Backer Rod Depth</strong></td>
<td>1/2&quot;</td>
<td>1/2&quot;</td>
<td>5/8&quot;</td>
<td>11/16&quot;</td>
<td></td>
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<tr>
<td><strong>Estimated Usage Non-Sag</strong></td>
<td>245</td>
<td>149</td>
<td>112</td>
<td>70</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td><strong>Estimated Usage Self-leveling(ft./gal)</strong></td>
<td>273</td>
<td>172</td>
<td>130</td>
<td>82</td>
<td></td>
<td></td>
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</tbody>
</table>

### Meeting Specifications

Delastic® Preformed Pavement Seals meet ASTM standard specifications. They are also recognized by the FHWA, U.S. Army Corps of Engineers, the U.S. Air Force, the FAA, consulting engineers and other agencies as an effective, long-lasting concrete pavement joint seal solution.

Delastic® Preformed Pavement Seals have been successfully used on high performance concrete pavements throughout the U.S. Many of these installations have protected pavements located in extreme hot and cold climates in excess of 20 years.

### Delastic® Preformed Pavement Seal Characteristics

<table>
<thead>
<tr>
<th>Delastic® Seal Catalog No.</th>
<th>Nominal Width (In)</th>
<th>Nominal Height (In)</th>
<th>Max. Movement *</th>
<th>Narrowest Opening *</th>
<th>Widest Opening *</th>
<th>Minimum Depth (In)</th>
<th>Typical Installed Width (In)</th>
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<tbody>
<tr>
<td>E-437</td>
<td>0.437 (11.11)</td>
<td>0.937 (23.31)</td>
<td>0.153 (3.90)</td>
<td>0.319 (8.15)</td>
<td>0.372 (9.45)</td>
<td>1.006 (25.50)</td>
<td>0.290 (7.35)</td>
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<tr>
<td>E-563</td>
<td>0.563 (14.30)</td>
<td>0.625 (15.88)</td>
<td>0.184 (4.70)</td>
<td>0.390 (9.95)</td>
<td>0.478 (12.20)</td>
<td>1.063 (27.00)</td>
<td>0.315 (7.98)</td>
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<tr>
<td>E-486</td>
<td>0.687 (17.46)</td>
<td>0.687 (17.46)</td>
<td>0.259 (6.59)</td>
<td>0.335 (8.50)</td>
<td>0.584 (14.80)</td>
<td>1.188 (30.60)</td>
<td>0.375 (9.53)</td>
</tr>
<tr>
<td>E-816</td>
<td>0.812 (21.64)</td>
<td>0.830 (21.10)</td>
<td>0.313 (7.95)</td>
<td>0.378 (9.60)</td>
<td>0.691 (17.55)</td>
<td>1.438 (36.55)</td>
<td>0.500 (12.70)</td>
</tr>
<tr>
<td>E-1000</td>
<td>1.000 (25.40)</td>
<td>1.000 (25.40)</td>
<td>0.480 (12.13)</td>
<td>0.400 (10.16)</td>
<td>0.850 (21.50)</td>
<td>1.625 (41.20)</td>
<td>0.500-0.503 (12.70-12.90)</td>
</tr>
<tr>
<td>E-1256</td>
<td>1.250 (31.75)</td>
<td>1.000 (25.40)</td>
<td>0.563 (14.30)</td>
<td>0.500 (12.60)</td>
<td>1.063 (26.90)</td>
<td>1.975 (50.20)</td>
<td>0.790 (20.05)</td>
</tr>
<tr>
<td>E-1625</td>
<td>1.625 (41.28)</td>
<td>1.125 (28.57)</td>
<td>0.623 (16.30)</td>
<td>0.790 (19.98)</td>
<td>1.381 (35.00)</td>
<td>2.268 (57.60)</td>
<td>0.875 (22.22)</td>
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<tr>
<td>E-2000</td>
<td>2.000 (50.80)</td>
<td>1.500 (38.10)</td>
<td>0.980 (24.80)</td>
<td>0.750 (19.05)</td>
<td>1.700 (43.18)</td>
<td>2.500 (63.50)</td>
<td>1.125 (28.58)</td>
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<tr>
<td>E-2500</td>
<td>2.500 (63.50)</td>
<td>2.500 (63.50)</td>
<td>1.125 (28.58)</td>
<td>1.000 (25.40)</td>
<td>2.125 (53.98)</td>
<td>3.375 (85.73)</td>
<td>1.375 (34.92)</td>
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<tr>
<td>E-3000</td>
<td>3.000 (76.20)</td>
<td>2.500 (63.50)</td>
<td>1.550 (39.37)</td>
<td>1.000 (25.40)</td>
<td>2.550 (64.77)</td>
<td>4.000 (101.60)</td>
<td>1.750 (44.45)</td>
</tr>
</tbody>
</table>

*Estimated Usage Self-Leveling(ft./gal)*

- **E-437**: 273
- **E-563**: 182
- **E-486**: 172
- **E-816**: 130
- **E-1000**: 112
- **E-1256**: 72
- **E-1625**: 62
- **E-2000**: 49
- **E-2500**: 49
- **E-3000**: 49
### JOINT AND SEALANT MOVEMENT ESTIMATOR

#### Location Details
- **State:** Arizona
- **Location:** Phoenix

#### Concrete Material Details
- **Cement Type:** Type I/II
- **Cementitious Materials Content (lb/yp³):** 600.0
- **Coefficient of Thermal Expansion (10⁶/F):** 5.00

#### Concrete Pavement Structure Details
- **Concrete Pavement Thickness (in.):** 10.00
- **Transverse Joint Spacing (ft):** 15.00

#### Construction Details
- **Month of Construction:** June
- **Curing Procedure:** Curing Compound

[Calculate] [Save Inputs]
Crack Opening Width based on Time of Year of Placement

- Phoenix, AZ
- Bismarck, ND
- San Diego, CA

Crack Movement (in)

Month of Construction
Joint Slap Adds 5 dBA to Overall Pavement Noise at 70 MPH

For passenger cars, 70% to 90% of the traffic generated noise is produced by the tire-pavement interaction. Thus, additional traffic generated noise due to such vehicles is well characterized through evaluation of just the tire-pavement interaction. In the U.S., this is accomplished with the use of On-Board Sound Intensity (OBSI; see image on the right in the header) per AASHTO TP-76.

As a vehicle travels over joints in a jointed concrete pavement, there is a joint slap noise that contributes to the overall tire-pavement noise. When evaluating pavements using OBSI techniques, it is generally only convenient to determine the overall pavement noise levels. These levels are a function of both the joint slap effect and the pavement texture effect.

This tool, based on the work of Dr. Paul Donavan, was developed to allow designers to estimate the impact of various joint geometries and condition on the overall tire-pavement noise level and to provide guidance to maintenance efforts in terms of the noise benefit attainable through sealing joints.

### Concrete Pavement Details

- **Joint Spacing (ft):** 15
- **Joints Sealed:** No

### Traffic and Pavement Texture Details

- **Vehicle Speed (mph):** 70

### Concrete Pavement Details

- **Joint Width (in.):** 0.625
- **Joint Depth (in.):** 1.5
Sealant Material Selection
Sealant Types

- **Silicone**
  - Non Sag
  - Self Leveling
  - Rapid Cure

- **Hot Pour**
  - Standard Modulus
  - Low Modulus

- **Compression Seal**
NON-SAG SILICONE

- Light Gray
- Horizontal or Vertical Application
- Low Modulus
- Requires Tooling
- Rehab or New Pavements
- Seals Small Spalled areas in Joint Walls
- Tack Free in 25 to 90 mins.
- Full Cure through in 14 days
SELF-LEVELING SILICONE

- Dark Grey
- Horizontal Application Only
- Ultra Low Modulus
- Neat Seal-No Tooling
- Rehab or New Pavements
- Tack Free in 3 hours max
- Full Cure through in 21 days
- 6% maximum grade
- AC/PC Joints ???
Asphalt Hot Pour Joint/crack Sealants

- **ASTM D-6690:**
  - Type I - ASTM D1190
  - Type II - ASTM D 3405
  - Type III - Low Modulus
  - Type IV - Fed Spec SS-S-1401C

FAA P 605-ASTM D-6690

State Specifications
Compression Seal

- Extruded from compounds of neoprene (polychloroprene) which meet or exceed current ASTM standard specifications
- Uses adhesive/lubricant for installation
- Requires proper installation equipment
Cleaning Joints
Percent of Total Cost For Each Operation of Sealing a Joint*

- Non Sag Silicone
- Self Leveling Silicone
- Hot Pour
- Compression

Legend:
- Furnish and Install
- Cleaning
- Reservoir Cut
- Initial Cut

* ACPA Relative Cost Study
Clean Isn’t an Option

Finger Test
Power Washing After Green Sawing
Intersecting Joints After Power Washing
Media Blasting
Media Blasting
Keeping Joints Cleaned and Protected After You’ve Cleaned Them.....
Do You Know Where Your Oil is?
Keep the Joints Clean During Construction
Early Traffic Damage
Installing Sealant Systems
Inserting and Rolling Backer Rod

- 25% Larger than Joint
- Cold Rod/Hot Rod
- Closed Cell Backer Rod
- Do Not Puncture Backer Rod-bubbling
- Do Not Stretch Backer Rod
Inserting and Rolling Backer Rod
Installing Backer Rod
Hot Pour Joint Sealant Configuration

40° F Minimum Pavement Temperatures
Flush Fill, Recessed or Over-band

Flush Filled  Recessed  Flush Filled
Installing Hot Pour Sealants
1. Recess min 1/8”- 1/2” Below Surface
2. 2 to 1 Ratio
3. Tooling Required
Silicone Sealing Application

40° F Minimum Pavement Temperatures
1/8” Minimum Recess
Requires Tooling
Silicone Sealant Installed at Joint Intersection
1. Make a knife cut horizontally across the silicone

2. Make a vertical cut approximately 3 inches long on each side of the joint

3. Hold the piece of silicone firmly and slowly pull at a 90° angle. If adhesion is proper, the silicone will not pull out of the joint, but will eventually tear cohesively
Compression Seal Installation

- Lubricant-Adhesive shall meet ASTM D2835
- Installation Above 32 F
- Install Sealant in Longitudinal Joint First
- Cut Longitudinal Joint in Center of Each Transverse Joint
- Install Transverse Joint Continuously Across
- Sealant Stretch Should be Less than 4%
- Recess Sealant 3/16”
Properly Installing Compression Seal
Compression Seal at Joint Intersection
Single Saw Cut Sealant Extrusion
Can We Seal a Joint?

20 Years Old

1 Year Old
WJE Pull Off Test

Bond Strength test Area

Pull Off test No. 1

Pull Off test No. 2

1 in

2 in

3 in

1 in

Wipe Test Area

1

2
Comparison of Tape Pull off Test to Tensile Bond Test

Dry v. Wet

Tape Pulloff Test (psi)

Sealant Tensile Test (psi)

- Dry (D)
- Wet (W)
Performance of Sealed and Unsealed Concrete Pavement Joints

This TechBrief presents the results of a nationwide study of the effects of transverse joint sealing on performance of jointed plain concrete pavements (JPCP). This study was conducted to assess whether JPCP designs with unsealed transverse joints performed differently from JPCP designs with sealed transverse joints. Distress and deflection data were collected from 117 test sections at 26 experimental joint sealing projects located in 11 states. Performance of the pavement test sections with unsealed joints was compared with the performance of pavement test sections with one or more types of sealed joints.

**BACKGROUND**

The sealing of transverse contraction joints in JPCP has been standard practice throughout most of the United States for many years. Its widespread use is due to the common belief that sealing joints improves concrete pavement performance two ways: reducing water infiltration into the pavement structure, thereby reducing the occurrence of moisture-related distresses such as joint spalling and blowouts.

Transverse jointed concrete pavement (JCP) are typically created by making an initial saw cut to form a cut for the joint sealant material. This traditional approach of sawing and sealing transverse contraction joints is estimated to account for between 2 and 7 percent of the initial construction cost of a JCP. Moreover, these sealed transverse joints require rescaling one or more times over the service life of the pavement, leading to additional costs in terms of labor, materials, operations, and lane closures.

Recently, several state departments of transportation (DOTs) have been questioning conventional transverse joint sawing and sealing practices. These agencies contend that the benefits derived from sealing do not offset the costs associated with the placement and continued upkeep of the sealant over the life of the pavement. As a result, they have been experimenting with different sawing and sealing alternatives, for example:

- Narrow unsealed joints, consisting of single saw cuts that are left unsealed.
- Narrow filled joints, consisting of single saw cuts that are filled with sealant that adheres to the sides and bottom of the saw cut.
- Narrow sealed joints, consisting of single saw cuts that contain a narrow backer rod and sealant material.
Is Sealant Cost Effective

### Guidelines for the Preservation of High-Traffic-Volume Roadways

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Expected Performance</th>
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<tbody>
<tr>
<td></td>
<td>Treatment Life (yr)</td>
</tr>
<tr>
<td>Concrete joint resealing</td>
<td>2–8</td>
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<tr>
<td>Concrete crack sealing</td>
<td>4–7</td>
</tr>
<tr>
<td>Diamond grinding</td>
<td>8–15</td>
</tr>
<tr>
<td>Diamond grooving</td>
<td>10–15</td>
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<tr>
<td>Partial-depth concrete patching</td>
<td>5–15</td>
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<tr>
<td>Full-depth concrete patching</td>
<td>5–15</td>
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<tr>
<td>Dowel bar retrofitting</td>
<td>10–15</td>
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<tr>
<td>Ultra-thin bonded wearing course</td>
<td>6–10</td>
</tr>
<tr>
<td>Thin HMA overlay</td>
<td>6–10</td>
</tr>
</tbody>
</table>
A key outcome of this project is advancement of a mechanistic tool for analysis of specific combinations of traffic, climate, base materials, and sealant condition on subbase erosion and pavement performance.
Figure D.1 Erosion Test Using Hamburg Wheel-Tracking Device.
Summary

- Design Joint Sealant System for the Expected Joint Movements
- Select a Joint Sealant Material and Backer Rod Appropriate for the Intended Purpose
- Ensure Proper Cleaning and Preparation—Clean, Dry and Bondable
- Inspect the Work and Verify its Acceptability
The Seal/No Seal Group was formed to respond to the age-old industry question about the value of sealing concrete pavement joints. Its mission is to develop a committed membership that takes responsibility for determining the long-term effectiveness of sealants in concrete pavements.

As cost pressures continue, there is increased interest in eliminating transverse joint sealants as a means of lowering the cost of concrete pavements. However, there is a lack of data in the industry to help guide owners about sealant effectiveness and the long-term impact of using or not using such sealants.
Questions
Place Sealant That Only Covers Joint
Seal Joint Without Cleaning
Overband Hot Pour Sealant
What Not to Do