Concrete Pavement Joint Sealing

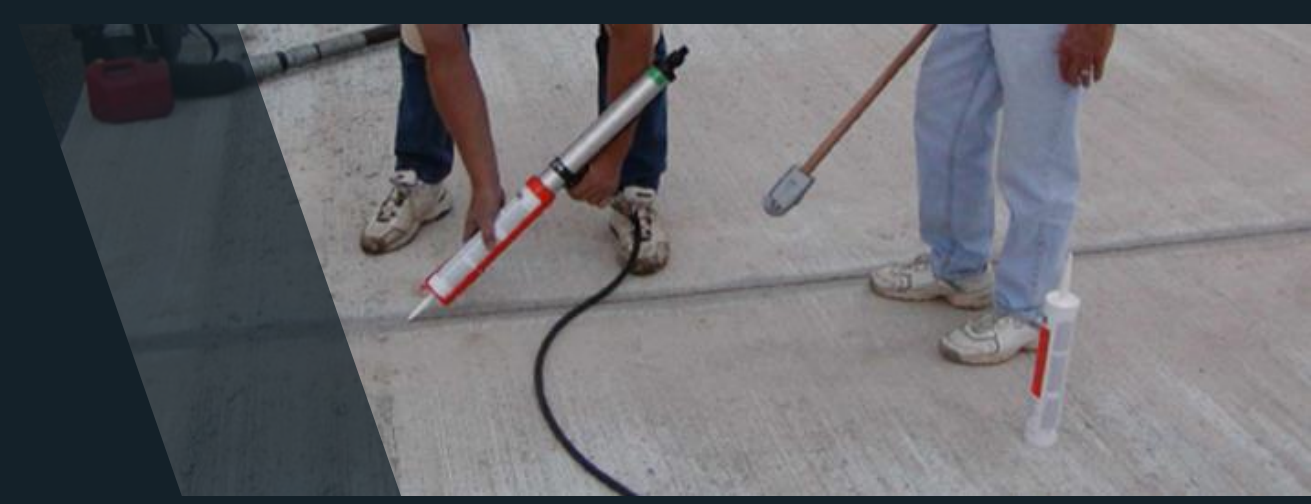
19th Arizona Pavements/ Materials Conference

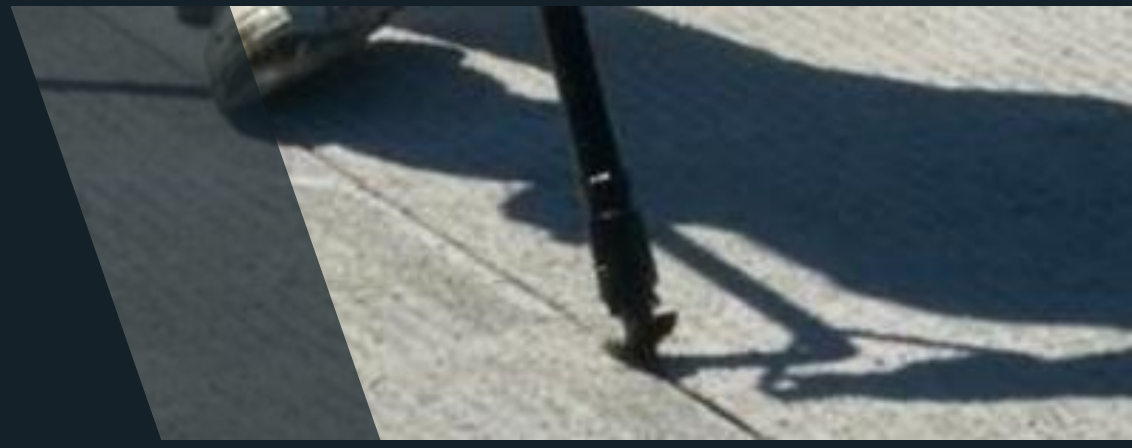
ASU Ira A. Fulton Schools of Engineering
Arizona State University

ADOT

November 16, 2022

Kurt Smith
Applied Pavement Technology, Inc.





Outline

- Joint Sealing Description
- ADOT Frame of Reference
- What Have We Learned?
- Closure

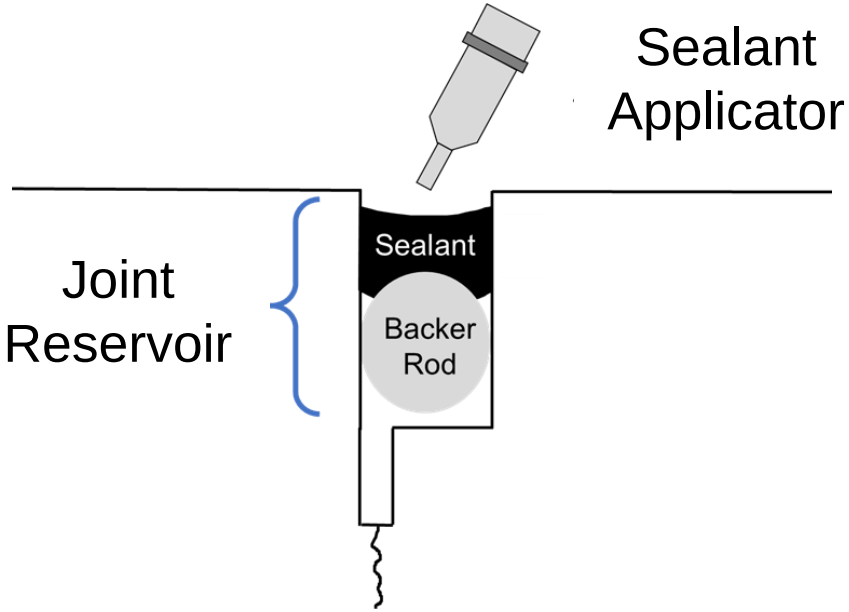
Courtesy Larry Scofield

applied pavement TECHNOLOGY

Joint Sealing Description

What Is It?

- Placement of an approved sealant material in an existing joint (transverse or longitudinal)

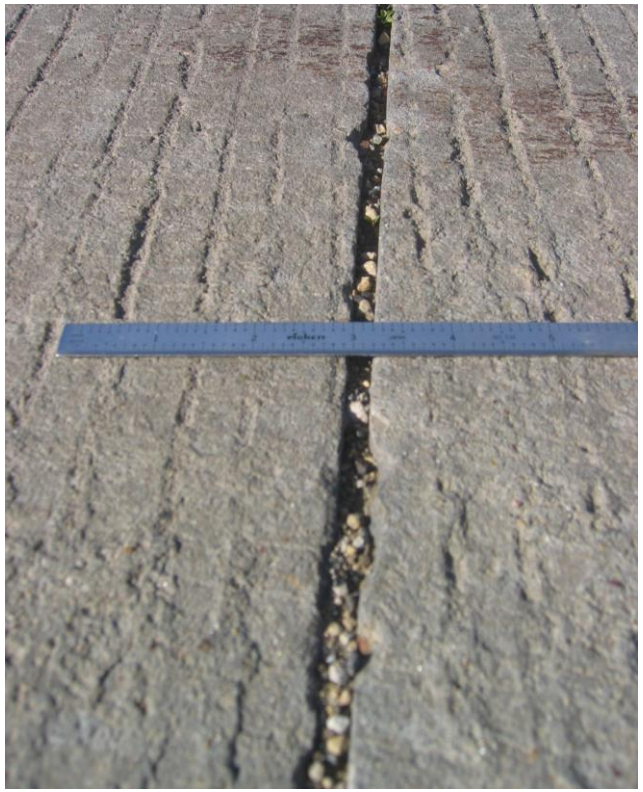


Why Do We Seal Joints?

- Minimize moisture infiltration

Why Do We Seal Joints?

- Reduce incompressibles



What Do We Expect?

- 2019 FHWA Tech Brief
  - Hot-Poured Sealants: 3 to 8 years
  - Silicone Sealants: 8 to 10+ years
- Longer performance also documented
- Factors affecting performance:
  - Movement (slab size, base, climate, loading)
  - Joint installation/preparation
  - Sealant properties and design

Silicone (AZ)

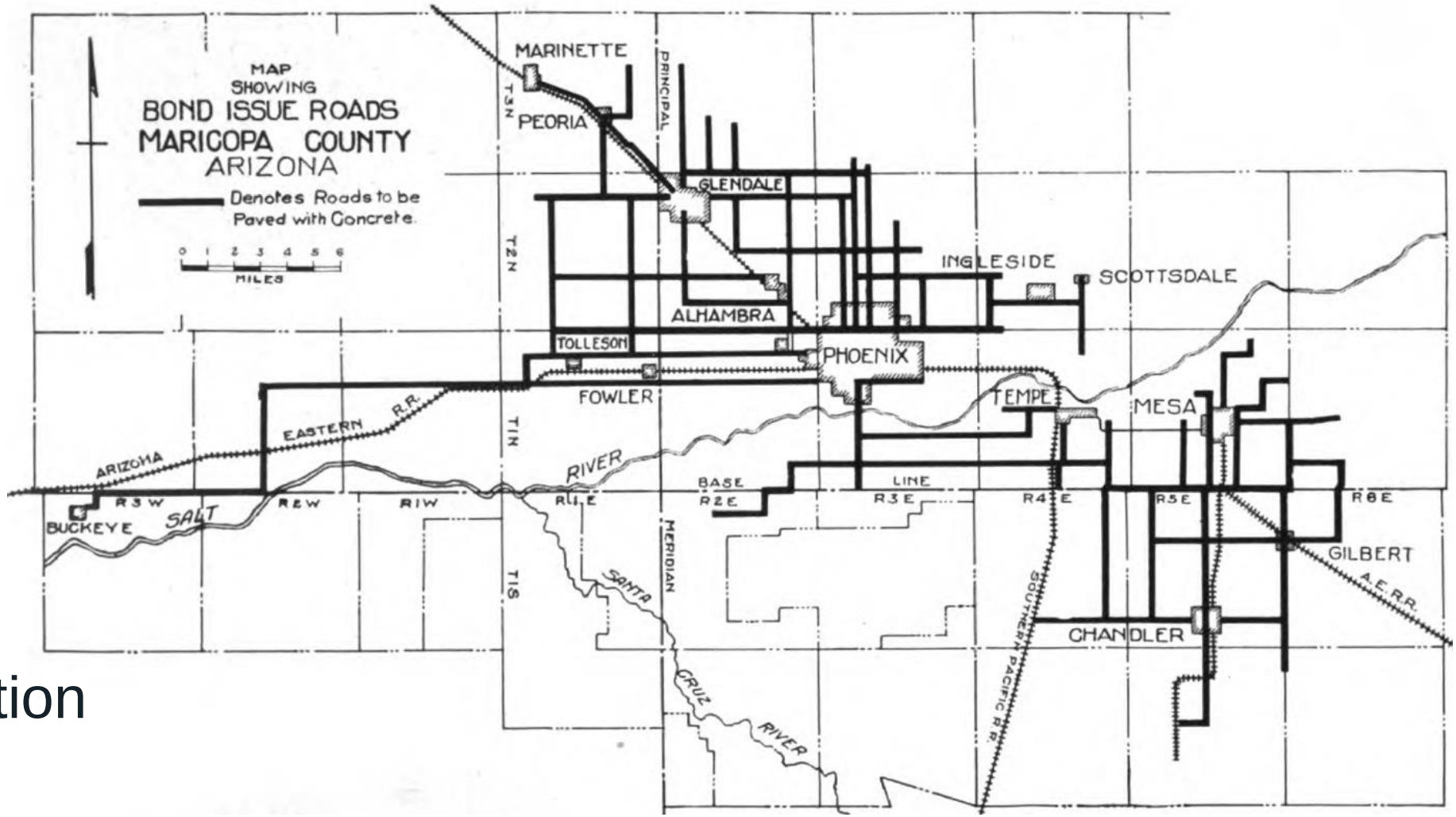
Hot-Poured (WA)

Courtesy Larry Scofield

ADOT Frame of Reference

First Concrete Pavements in Arizona

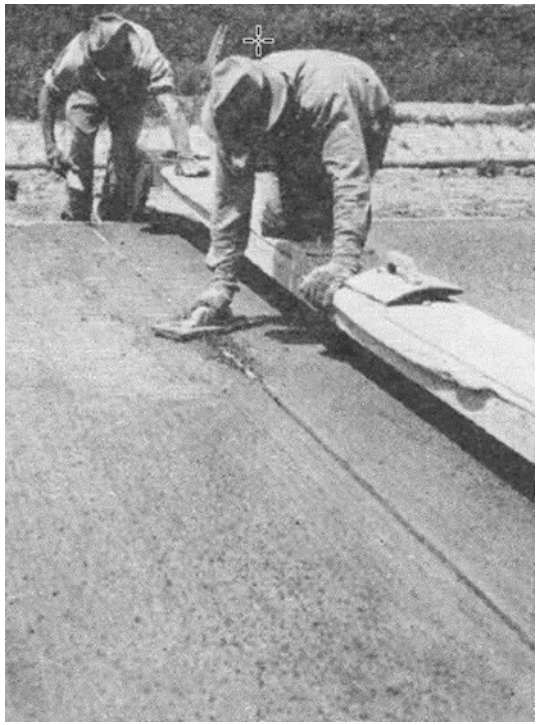
- 1919/1920: $4M & $4.5M bond programs in Maricopa Co.
- Paved 277 miles by 1927
- “Saved” users money in terms of maintenance and increased gas/oil consumption



applied pavement TECHNOLOGY

Early Concrete Pavement Joint Maintenance

- Common early “sealants:” tar paper, tar, coal tar, Tarvia, bitumen, rubber, sand, wood
- Limited effectiveness in accommodating slab movements and keeping incompressibles out
  - Expansion joints
- General movement to bituminous materials
  - Unmodified asphalt cement
  - Some ductility



Arizona Sealant Studies

ARIZONA DEPARTMENT OF TRANSPORTATION

REPORT NUMBER: FHWA-AZ-7904

PERFORMANCE OF CONCRETE JOINT SEALANTS IN HOT CLIMATES

Final Report

Prepared by:
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October 1987

Prepared for:
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Phoenix, Arizona 85
in cooperation with
U.S. Department of T
Federal Highway Ad

ARIZONA DEPARTMENT OF TRANSPORTATION

REPORT NUMBER: FHWA-AZ91-264-I

EVALUATION OF CONCRETE PAVEMENTS IN THE PHOENIX URBAN CORRIDOR

Volume I
Final Report

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LTPP Pavement Maintenance Materials: SPS-4 Supplemental Joint Seal Experiment, Final Report

PUBLICATION NO. FHWA-RD-99-151 OCTOBER 1999

ATRC Technical Memorandum:
Pavement and Seal Performance at the Mesa SPS-4 Test Site

Project Overview
The Arizona Department of Transportation (ADOT) constructed a 6-lane test pavement on eastbound US 60 in Mesa between Power Road and Ellsworth Road in 1991 to evaluate the effect of sealing transverse and longitudinal joints in jointed plain concrete pavements (JPCP) on pavement performance. The test site was designed to provide comparisons of the performance of pavements with sealed or unsealed joints and to rank the performance of the several combinations of sealant material types and placement configurations included in the experiment.

The test pavement consisted of a 13-in Portland cement concrete (PCC) slab, placed on 4 inches of compacted aggregate base over a compacted subgrade. Joint spacing was random (i.e., varied at intervals of 13-, 15-, 17-, and 15-ft). Reinforcing tie bars were used at the longitudinal lane to shoulder joints. The travel lanes were 12-ft-wide while the PCC shoulders were 8.5- to 11-ft wide. No dowels were used in either the transverse or longitudinal joints.

This pavement was designed for a 20-year life and has carried an estimated 9.0 million equivalent single axle loads (ESALs) through February 2006. Average annual precipitation at the site is about 7 in, and the average monthly temperature ranges from 50 to 91 °F.

The 2.15-mi test site was divided into two 12-section replicates (east and west) that are about 375 ft long. As of February 2006, fifteen years after original construction, only the joint seals of the outer driving lane of the west replicate were still in service (note that the outer lane was being widened as of February 2006). Nearly the entire original pavement of the east replicate had been removed and replaced or overlaid. Figure 1 shows the layout of the west replicate of the original test pavement.

04A451 04A452 04A453 04A454 04A455 04A456 04A457 04A458 04A459 04A460 04A461 04A462

117 m | 115 m | 114 m | 114 m | 114 m | 113 m | 114 m | 114 m | 115 m | 114 m | 114 m | 110 m

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2022

Arizona US 93 NB Silicone Joint Sealant Evaluation (040160)

On January 20, 2022, a cursory field evaluation of the 29-year-old LTPP concrete pavement test section was conducted. The evaluation consisted of taking pictures of 17 consecutive transverse joints sealed with silicone and estimating the percent of missing sealant from the photos in the office. The results indicated that almost 100% of the joint seal still existed in the joints although it was not always bonded to both joint faces. It appears that the concrete may be experiencing joint associated distress resulting in concrete disintegrating at the joint. The sealant continues to survive, but the concrete is now missing at some joint locations.

IGGA/ACPA
/ Scofield, P.E.
6/2/2022

ARIZONA DEPARTMENT OF TRANSPORTATION

REPORT NUMBER: FHWA-AZ-9403

PERFORMANCE EVALUATION OF PORTLAND CEMENT CONCRETE PAVEMENT JOINT SEALANTS

Final Report

Prepared by:
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November 1994

Prepared for:
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in cooperation with
U.S. Department of Transportation
Federal Highway Administration

ARIZONA DEPARTMENT OF TRANSPORTATION

REPORT NUMBER: AZ92-377-I

CONSTRUCTION REPORT FOR ARIZONA'S SHRP SPS-4 EXPERIMENT

Construction Report

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Federal Highway Administration

LTPP Pavement Maintenance Materials: SHRP Joint Reseal Experiment, Final Report

PUBLICATION NO. FHWA-RD-99-142 SEPTEMBER 1999

U.S.Department of Transportation
Federal Highway Administration

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LTPP

Technical Memorandum

Arizona SPS-2 PCC Joint Seal Performance

Overview
The Arizona Special Pavement Studies (SPS) 2 jointed concrete pavement test site, located on eastbound I-10 between mileposts 106 and 109 was constructed in 1993 with 12 LTPP and 9 ADOT test sections. Each test section includes about 33 transverse joints, spaced at 15 ft, which were reportedly sealed using Crafco 34902 non-sag RoadSaver Silicone sealant. Various combinations of base type, concrete strength, slab width, and slab thickness, as shown below, were designed to allow statistical analysis of the contributions of each factor. A March 2013 evaluation of the condition of the joints and seals indicates correlations of base type and Portland cement concrete (PCC) strength with adhesion and sliver spall failures.

Section	Base*	PCC Strength, psi	Slab width, ft	Thickness, in
213	DGAB	550	14	8
214	DGAB	900	12	8
215	DGAB	900	12	11
216	DGAB	900	14	11
217	LCB	550	14	8
218	LCB	900	12	8
219	LCB	550	12	11
220	LCB	900	14	11
221	PB/DG	550	14	8
222	PB/DG	900	12	8
223	PB/DG	550	12	11
224	PB/DG	900	14	11
262	DGAB	550	14	8
263	PB/DG	550	14	11
264	PB/DG	550	12	11

*6-in dense graded aggregate (DGAB); 4-in PBTB/4-in DGAB (PB/DG); 6-in Lean Concrete (LCB)

Transverse Seal Findings
Overall performance of the SPS-2 joint seal systems is extraordinarily good, considering the seals have been in place for 20 years and the truck lane has carried about 31 million Equivalent Single Axle Loads (ESALs). As figure 1 illustrates, no section exhibits more than 35 percent overall seal failure with six sections remaining below ten percent. Five randomly-selected transverse joints were evaluated in each section.

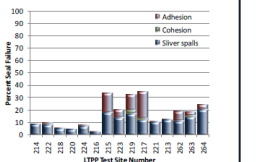


Figure 1. Overall failure rates on transverse joints

Primary modes of failure include sliver spalls and loss of adhesion with the joint walls. Additionally, slight cohesive failure was identified when the installed seal thickness (less than 0.125 in) fell below the design thickness (0.25 in). Full depth sliver spalls, shown in figure 2, typically progress around or through the aggregate adjacent to the joint wall.

These sliver spalls accounted for more than 65 percent of the seal system failures with 2.4 times more failure noted in 550 psi than the 900 psi compressive strength

ARA

1

Factors Evaluated

- Various sealant material types and installation procedures
- Various sealant configurations (widths, depths)
- Concrete pavement designs
- Some joint sealant study locations
  - I-17, Flagstaff
  - Phoenix Urban Corridor pavements (SR 360, I-10, I-17)
  - US 60, Mesa
  - I-10, Buckeye
  - US 93, Santa Claus

Historical Arizona Joint Sealing Practices

Year	Joint	Sealing Material
1928	Expansion (0.75 inch)	Wood Filler + Bituminous
1947	Contraction (formed)	Fed Spec SSF-336 (HP)
1956	Contraction (formed) (+1 experimental sawed project)	Fed Spec SS-S-164 (HP); SS-S-159 (CP), SS-S-156 (CP)
1963	Contraction (sawed 0.19 inch, 0.37 inch reservoir) Contraction (metal insert)	Fed Spec SS-S-164 (HP) (AASHTO M173); SS-S-159 (CP)
1982	Contraction (sawed 0.13 inch, 0.37 to 0.5 inch reservoir)	Fed Spec SS-S-164 (AASHTO M173); ASTM D3406
c.2003	Contraction (sawed 0.13 inch, 0.13 to 0.19 inch reservoir)	ASTM D5893 (silicone); ASTM D3406 or ASTM D3569 (HP)
2021	Contraction (sawed 0.13 inch, 0.13 to 0.19 inch reservoir)	ASTM D5893 (silicone) ASTM D6690 (II/III)

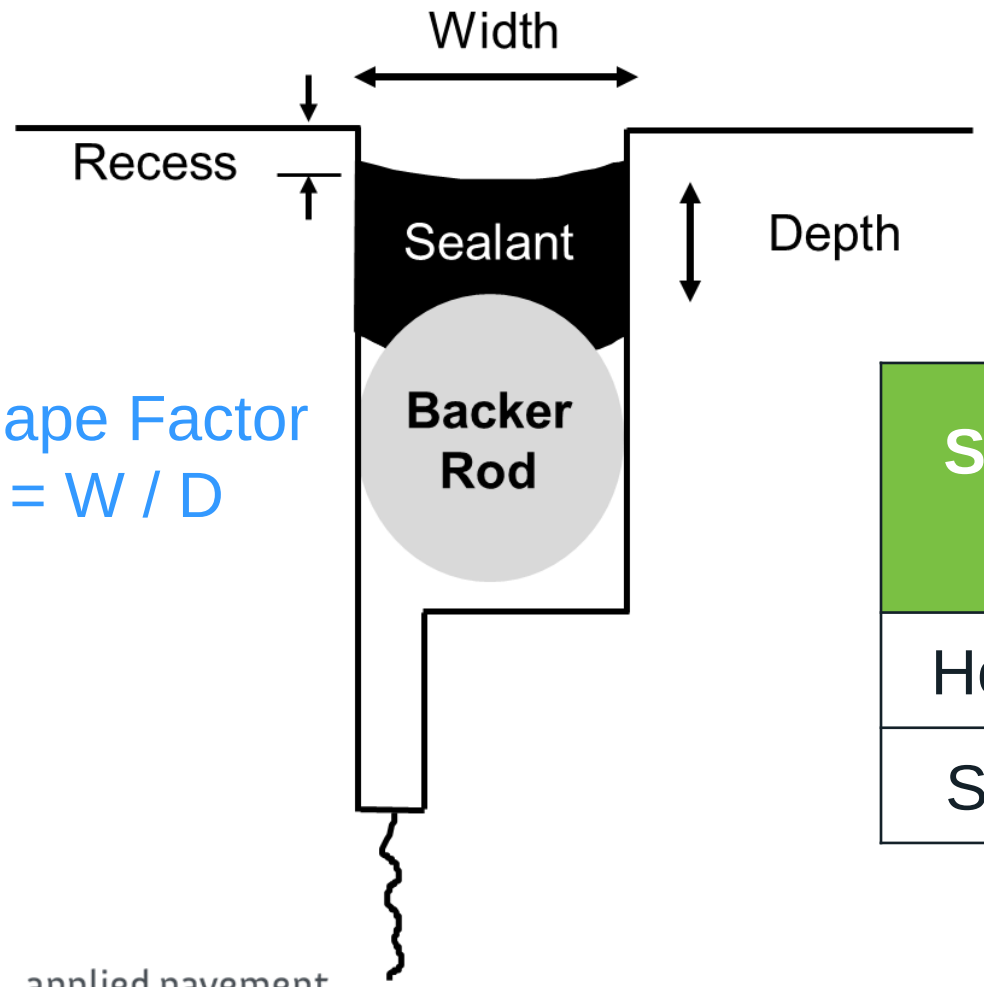
2021 ADOT Joint Sealant Specification

- Materials, Section 1011
  - 1011-3, Joint Sealant (Hot-Applied) (ASTM D6690, Type II or III)
    - When PCC is to be overlaid with ARFC
  - 1011-8 Silicone Joint Sealant (ASTM D5893)
    - When PCC is not to be overlaid
- Installation
  - Section 401-3.06 Joint Construction
  - Section 402-6, Joint and Crack Repair

Courtesy Larry Scofield

What Have We Learned?

What Have We Learned:
Joint Shape Factor



Shape Factor
= W / D

Sealant Type	Recommended Shape Factor (W:D)	Recommended Recess
Hot Pour	1:1	Flush Fill
Silicone	1:1 to 2:1	1/4 to 3/8 inch

applied pavement TECHNOLOGY

What Have We Learned:
Narrow is Better

- Advantages:
  - Allows for future resealing
  - Reduces noise/wheel slap
  - Uses less material
- Narrow joint accommodations
  - 3/16 to 1/4 inch joint for cleaning and to better accept sealant
  - Special fixtures for media blasting and filling joints
  - Consider anticipated movements for required widths

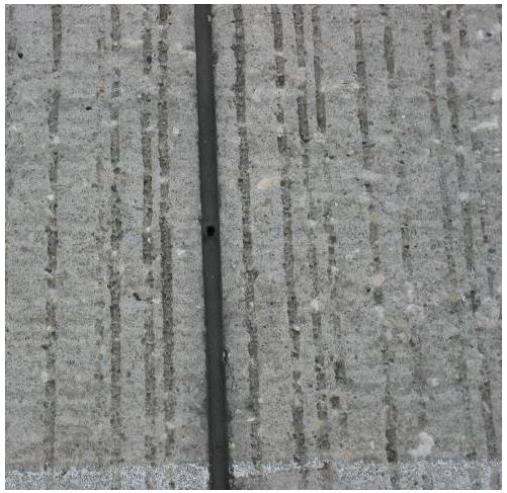
Courtesy Seal/No Seal Group

What Have We Learned:
Materials—Sealants

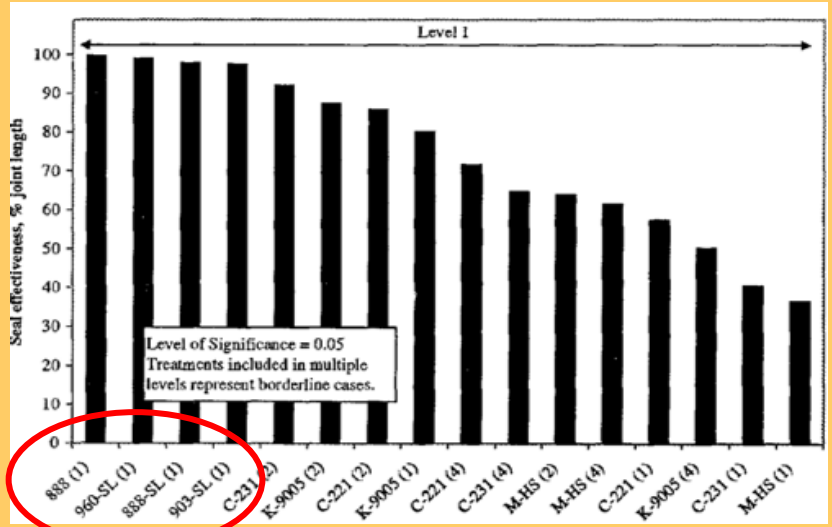
- Use quality materials meeting project needs
- Silicone (ASTM D5893)
  - » Non sag or self leveling
  - » Long-term performance in several ADOT studies (e.g., I-17, US 60, I-10)
- Hot-Poured (ASTM D6690, types I-IV)
  - » Standard or Low Modulus
  - » ADOT specifies Type II/III
  - » Moderate/mid-term performance

Silicone

Hot-Poured

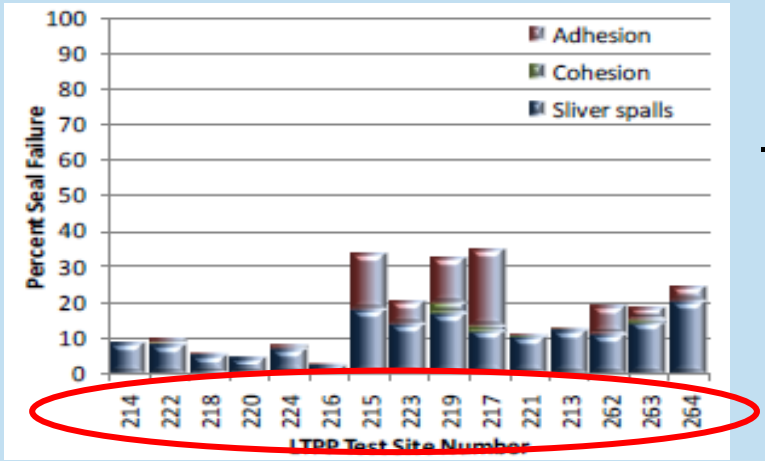


What Have We Learned:
Materials—Silicone



I-17, Phoenix
-1991 reseal
~82 months

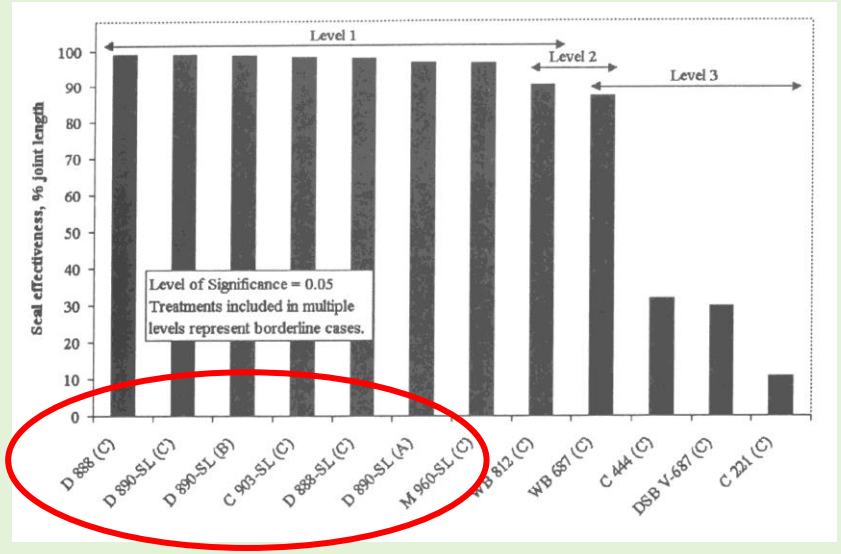
Courtesy FHWA



I-10, Buckeye
-1993 new constr.
~240 months
(20 years)

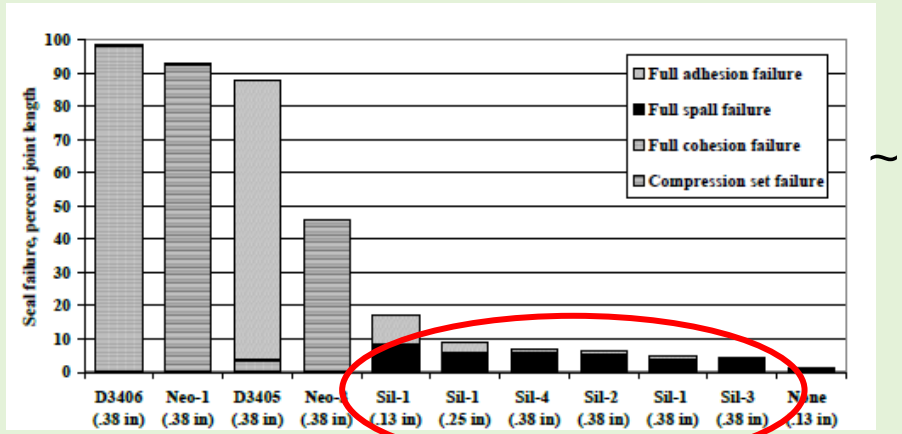
Courtesy ARA

US 60 Mesa (1992 new construction)



~83 months

Courtesy FHWA

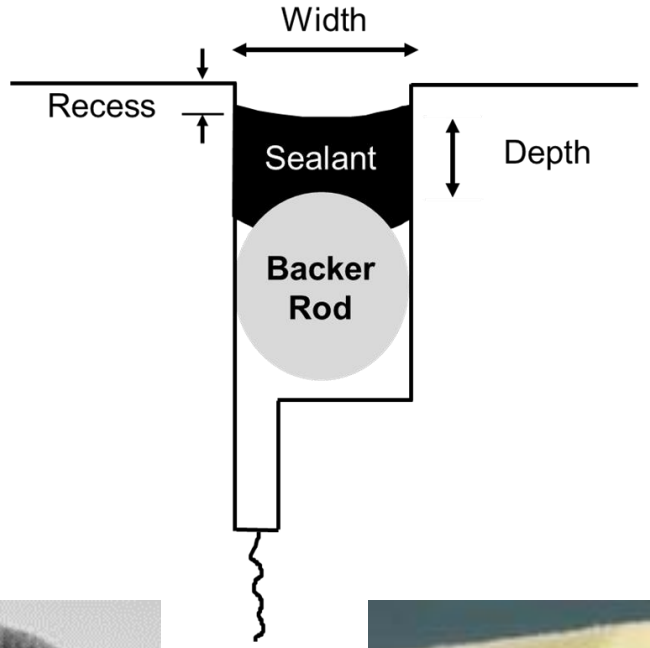


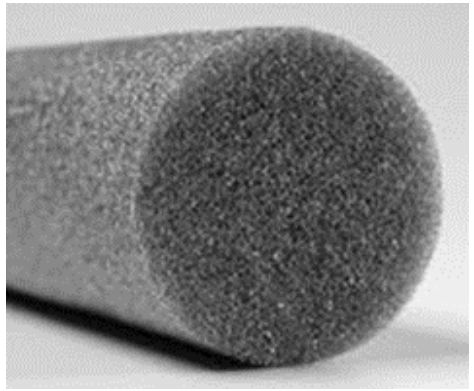
~180 months
(15 years)

Courtesy ATRC

What Have We Learned:
Materials—Backer Rod

- Helps establish proper joint shape factor
- Use closed-cell products (ASTM D5249)
  - » Open cell not recommended
- Compatible with sealant
- 25% larger than joint width
- Do not stretch or puncture backer rod





Closed Cell
(recommended)

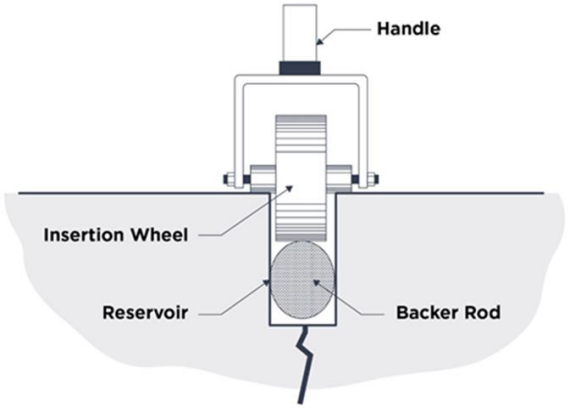
Courtesy ACPA

Open Cell
(not recommended)

applied pavement TECHNOLOGY

What Have We Learned:
Proper Preparation

- Joint preparation/cleaning
  - Media blast to remove slurry from sidewalls (both sides of joint)
  - Airblasting to remove any final debris
- Backer rod installation
  - Fit snugly in joint



Courtesy ACPA

Courtesy Scott Eilken

Courtesy Scott Eilken

Media blasting

Courtesy Steve Tritsch

Airblasting

What Have We Learned:
Proper Installation

- New concrete cured 7 days
- Joints “clean and dry”
- Weather conditions
  - Ambient temperature (typ. 40 ºF & rising)
  - No precipitation
- Monitor HP sealant temperatures
- Fill from bottom up (limit air pockets)
- Proper tooling for silicone (non-sag)
- Proper recess
  - Hot-poured: flush fill
  - Silicone: 1/4 to 3/8 inch

Courtesy IGGA

Hot-Poured

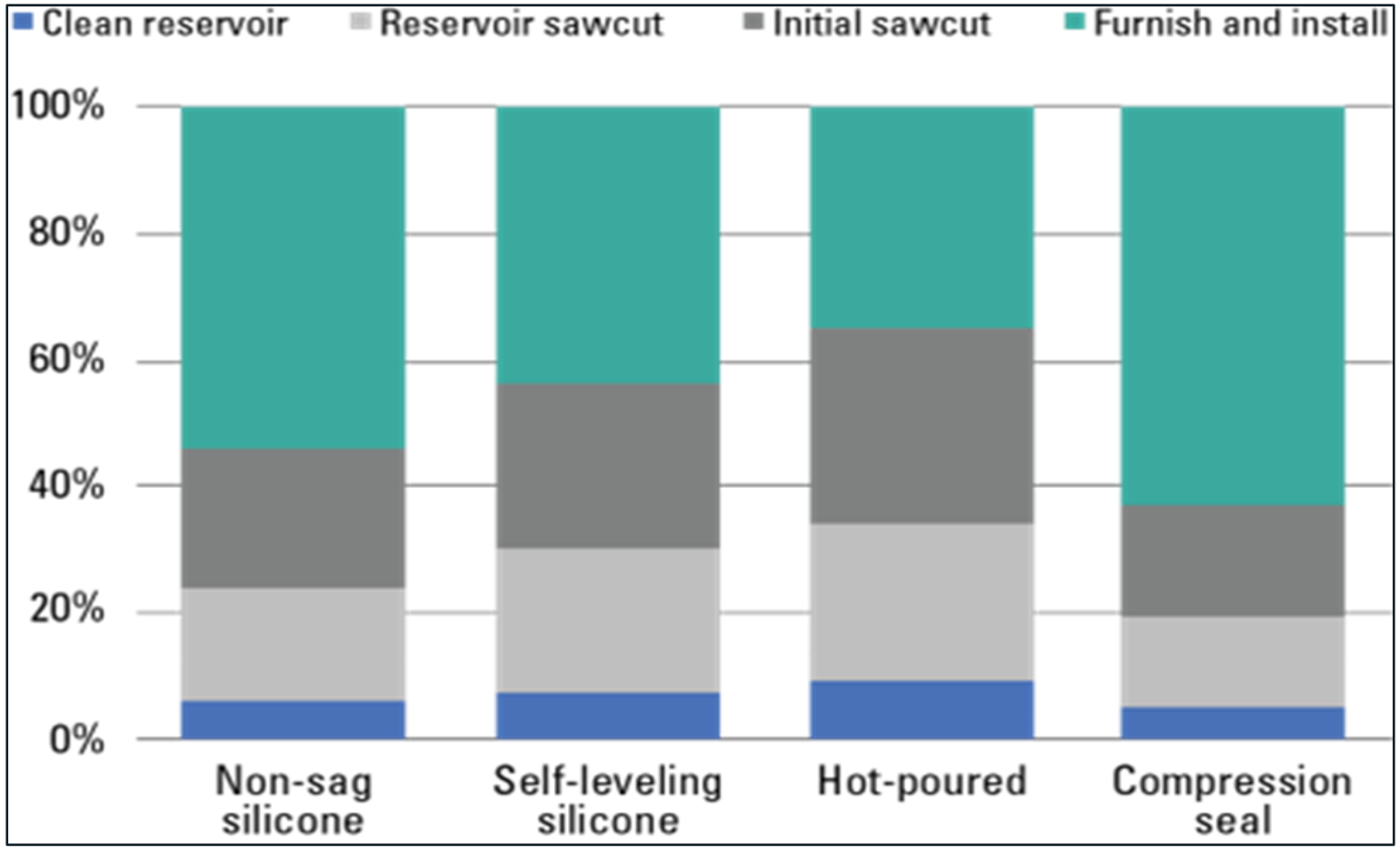
Silicone

What Have We Learned:
Bonding

- Effective sealant bonding to joint sidewalls is critical
- What inhibits bond?
  - Concrete not cured out
  - Joint faces not properly cleaned (sawing residue, dirt, dust, debris, old sealant, etc.)
  - Moisture in joint
  - Damage to concrete substrate
  - Sealant/concrete incompatibility
  - Oil/moisture in compressed air

Courtesy Scott Eilken

What Have We Learned:
Relative Cost of Sealant Installation



Courtesy ACPA

applied pavement TECHNOLOGY

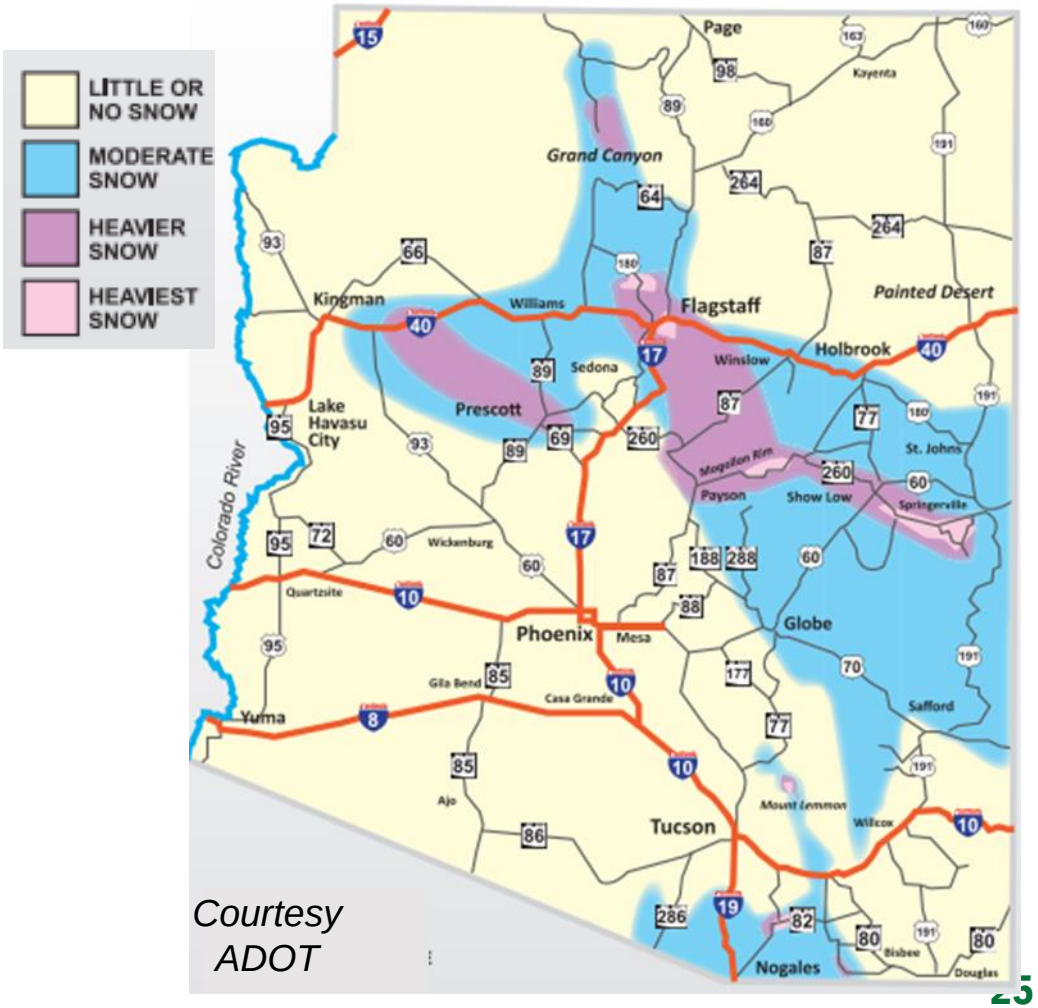
What Have We Learned:
Impacts of Chemical Deicers

- Detrimental impacts of certain deicing chemicals

Courtesy CPTech Center

- Maintaining effective seal can help minimize effects

Where does it snow in Arizona?



Courtesy ADOT

applied pavement TECHNOLOGY

What Have We Learned:
Joint Resealing

- Reseal when existing sealant no longer functional
- Pavement not severely deteriorated
- In conjunction with other preservation activities

If joints were originally sealed, continue to keep those joints sealed

applied pavement TECHNOLOGY

Closure

Closure

- Concrete pavement joint sealing has advanced in 100+ years
- Arizona has contributed to the state of the practice
- Some closing thoughts:
  - Select sealant materials to meet specific project needs
  - Keep joints as narrow as possible
  - Joint reservoir configurations (width, depth, recess) impact sealant performance
  - Effective preparation and installation critical to performance
  - Reseal in-service pavements when existing sealant no longer functional

Questions?

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applied pavement TECHNOLOGY