Field Performance of a Low-Modulus Silicone Highway Joint Sealant

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ABSTRACT

A field study undertaken to evaluate the performance of Dow Corning 888 silicone highway joint sealant in various climates and pavement conditions indicates that sealant performance remains high for 6 years and beyond. Nine-year-old joints in Georgia and Michigan are performing well. Pavement seals in Connecticut, Georgia, Illinois, Indiana, Iowa, New Mexico, Michigan, Minnesota, and South Dakota, covering four major climatic zones (wet, freeze; no freeze; dry, freeze; and dry, no freeze) were inspected and evaluated. The study also identified factors that affect performance. Of these, installation procedures and shape of the actual seal are the most influential and also the most controllable. The inspections revealed that Dow Corning 888 silicone highway joint sealant can overcome inadequacies in field installation procedures and provide a reasonable seal life.

There are more than 200 low-modulus silicone highway joint sealant installations across the country. Project sizes vary from 3 joints to 30 miles of jointed pavement. Many projects have been installed by state agencies to evaluate these new sealants. Others are part of demonstration projects. There are several installations where the sealant was installed on regular construction projects.

The sites for this nine-state field study were selected to evaluate Dow Corning 888 low-modulus silicone highway joint sealant with various seal ages, climatic zones, traffic levels, and joint conditions. The study revealed that Dow Corning 888 silicone sealant offers excellent seal integrity and longevity. Performance variations between installations primarily reflect differences in joint design and care taken during installation.

UNIQUE SEALANT PROPERTIES

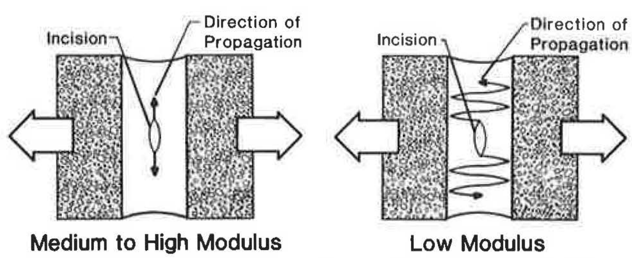
Silicone sealants are widely used in concrete construction. They are one-part materials consisting of long chain silicone polymers, curing agents, and fillers. The applied sealant cures to an elastomer on exposure to water vapor in air, and forms a continuous silicone-oxygen-silicone network. This silicone-oxygen linkage is transparent to ultraviolet radiation and is responsible for the superior weatherability of silicone sealants.

Silicone sealants can be differentiated from one another by their modulus (i.e., their ability to stretch and recover their original shape). The lower the modulus value, the greater is their ability to elongate and recover and thus withstand the cyclic movement of concrete pavement joints. The modulus, ultimate elongation, and joint movements for typical high-, medium-, and low-modulus silicone sealants are given in the following table (1):

Type	Modulus (psi)	Ultimate Elongation (%)	Cyclic Joint Movement (%)
High	>100	<500	±25
Medium	40-100	500-1,200	±40
Low	<40	>1,200	±50

Silicone sealants, in general, are set apart from other sealants by their ability to resist compression set. This allows them to withstand repeated movement caused by climatic changes. Typical recovery values after compression for low-modulus silicone sealants are 90 to 100 percent compared with recovery values of 80 to 90 percent for urethane and 70 to 80 percent for polysulfide sealants. This combination of resistance to compression set and low-modulus characteristics enables the sealant to expand when the joint opens. Recovery from compression is a key feature that distinguishes silicones from other sealants (1).

Another property of Dow Corning 888 silicone sealant is its resistance to tear propagation. Usually sealant tears propagate perpendicular to the direction of stress (1). In contrast, the low-modulus silicone has a very ragged tear that propagates slowly back and forth almost parallel to the direction of stress (Figure 1).



Note: Blocks of concrete are shown pulling on the sealant with an incision to initiate a tear.

FIGURE 1 Difference in tear propagation between low-modulus and higher-modulus silicone sealants.

Joints filled with the low-modulus silicone sealant can be repaired by patching with new sealant. New silicone will form a strong bond with the cured sealant. Thus small failures can be repaired without replacing the entire joint seal.

FACTORS AFFECTING SEAL PERFORMANCE

Although many factors influence sealant performance, the most important factors are shape of the applied sealant, joint spacing, sealant physical properties, joint condition, and proper seal installation. Of these, proper installation and the shape of the applied sealant are the most influential, and also the most controllable.

The smaller the ratio of applied sealant thickness to width, the lower is the stress applied to the silicone rubber [Figure 2 (2)]. A thickness-to-width ratio, or shape factor, of 0.5 to 1.0 with a thickness range of 0.25 to 0.5 in. is recommended. This produces a thinner seal than recommended for other sealants, but it is acceptable because of the ability of the silicone sealant to bond to the joint walls and because of its excellent cohesion.

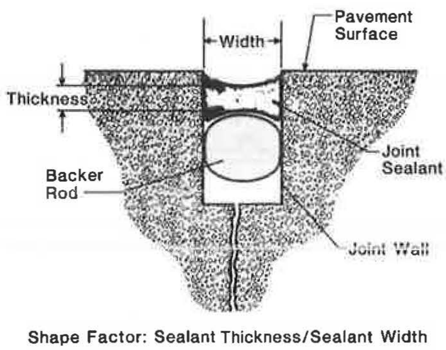


FIGURE 2 Joint terminology and shape factor (2).

Proper installation procedures are necessary to ensure that the physical properties can be maximized. The joint must be clean and dry, free of sawing debris, and free of any particles or film of old sealant. The backer rod, which controls sealant depth, must be correctly placed. The sealant must be tooled immediately after application to recess it beneath the pavement surface and to apply sufficient pressure to force the sealant against joint walls to ensure a good bond.

STRESSES AFFECTING SEALANTS

Adhesive stress is the tensile stress between the sealant and the joint wall. Factors that can cause the sealant to separate from the joint wall include weak sealants, wet or dirty joint walls, inadequate tooling, high stress brought on because of an improper shape factor, and sealant hardening.

Cohesive stress is developed within the sealant when the joint opens. If the sealant is insufficiently elastic or has weak interparticle bonds, it will split. Also, if the thickness-to-width ratio is too great, high cohesive stress will cause an otherwise acceptable sealant to fail.

Peeling stress develops at corners of the sealant where it bonds to joint walls. It is caused by joint movement and can be accentuated by improper installation or tooling.

Compressive stress is caused by joint closing. If the sealant is too fluid, or if the joint closes too far, the sealant will extrude from the joint.

Figure 3 (2) shows the effect of these stresses on the sealant and the sealant-joint wall interface. Anything that reduces stress or strain on the sealant or increases the bond strength between the sealant and the joint wall without reducing sealant elasticity will improve sealant performance.

ASSESSING SEALANT PERFORMANCE

The function of a highway joint sealant is to prevent water and foreign matter from entering the joint. Consequences of sealant failure include sub-

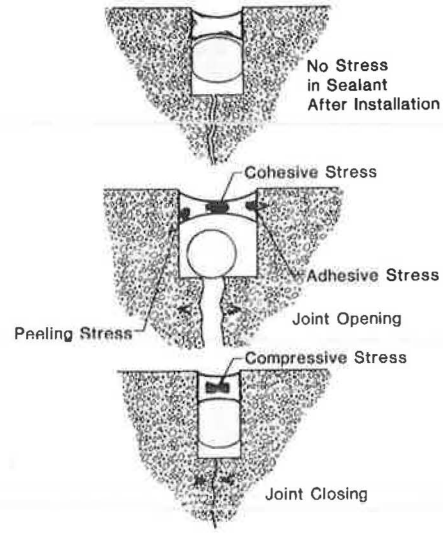


FIGURE 3 Stresses in field-poured sealants (2).

grade weakening, pumping, faulting, accelerated D-cracking, blow-ups, and joint spalling.

In evaluating the low-modulus silicone highway joint sealant, four performance properties were examined: (a) adhesion, (b) cohesion, (c) surface defects, and (d) spalling or the presence of foreign material in the joint.

Adhesive failure is a common failure with any sealant. With silicone sealant, such a failure may be caused by lack of an initial bond or by the loss of bond. Also, a large shape factor, especially in the narrow joint (where the sealant is extended more than 100 percent), is a common cause of a loss of bond. When failure occurs in such cases, the joint wall usually has residue on it.

An adhesive failure with no sealant residue on the joint wall indicates a firm bond was never established because of improper cleaning before sealant installation. Insufficient tooling or contamination of joint walls with dirt, sawing residue, old sealant, or moisture can prevent a good bond. Figure 4 shows the results of common installation problems.

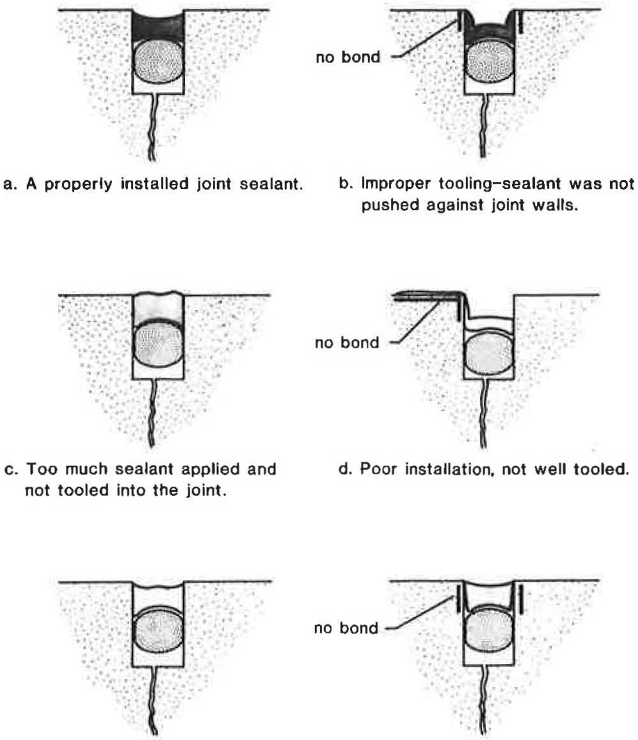
Cohesive failure is purely material failure. The sealant is unable to stand the internal tensile stress caused by the joint opening. Significant amounts of sealant usually remain on the joint wall.

If failure is near the joint wall it may be difficult to distinguish between adhesive and cohesive failure. Examination of the joint wall is the key. Adhesive failure leaves little sealant on the joint wall. Cohesive failure leaves more sealant on the wall, and it will still be firmly bonded. Cohesive failure of low-modulus silicone sealant is uncommon, except when the seal is too thin (usually less than 0.125 in.).

Joints were also checked for damage due to spalling caused by incompressibles. Spalling caused by incompressibles is distinguished from chipping of the leave slab by the size and shape of the particles. Close inspection usually reveals that chipping caused by snowplows is distinguishable from spalling by many small, thin pieces of concrete broken away from the slab at a 45-degree angle.

MEASURING SEALANT PERFORMANCE

A severe test was developed to identify and measure adhesive and cohesive failures. The end of a thin,



a. A properly installed joint sealant.

b. Improper tooling–sealant was not pushed against joint walls.

c. Too much sealant applied and not tooled into the joint.

d. Poor installation, not well tooled.

e. Sealant installed well but was in compression before completely cured.

f. Sealant applied in wet joint, bond is at top of joint wall.

FIGURE 4 Joint cross section illustrating installation problems.

0.75-in.-wide metal ruler is pushed into the sealant at intervals of 3 to 6 in. along the joint. Cohesive failure is apparent when the ruler is pushed into the sealant. Twisting the ruler pulls the sealant away from the joint wall (Figure 5) and severely tests the bond between them. Any adhesive failure is noted and measured in inches. This test permits year-round inspection, not just in winter when joints are open for visual inspection.

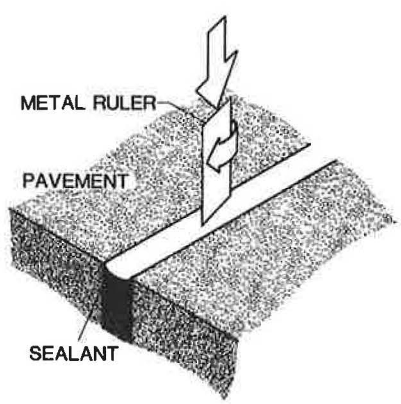


FIGURE 5 Graphic representation of test procedure for adhesive/cohesive failures.

An adhesion/elongation test evaluates sealant strength and the sealant-joint wall bond. Three cuts are made in the sealant: 2-in. cuts along each wall and a cut across the sealant at one end of the 2-in. cuts. The 2-in. tab thus formed is lifted out of the joint at a right angle to the surface. A mark is drawn across the tab at a height of 1 in. Then, with the ruler held along it, the tab is pulled up at a steady rate. The location of the mark along the ruler when the sealant begins to fail is noted, as is the type of failure: adhesive or cohesive. This test can also be conducted at any time of year because silicone sealant properties are not especially temperature sensitive.

In this test, an inch change in length equals 100 percent elongation. Typical values recorded in the field ranged from 200 to 500 percent. However, the amount of elongation is insufficient to describe the results because elongation is a function of sealant cross-sectional area.

Adhesive failure is the sign of a weak bond. Cohesive failure indicates that the sealant has sufficient bond strength to withstand joint movement.

PERFORMANCE SUMMARY

Locations for sealant performance evaluation were selected to represent different climatic zones: wet, no freeze (Georgia); wet, freeze (Connecticut, Illinois, Indiana, Iowa, Michigan, and Minnesota); dry, freeze (South Dakota); and dry, no freeze (New Mexico). Sealant age was also a consideration. A complete list of test sites is given in Table 1.

TABLE 1 Sites Inspected

Location	Climatic Zone	No. of Sites	Sealant Age (years)
Georgia			
I-75	Wet, no freeze	1	6
I-16	Wet, no freeze	1	5
I-85	Wet, no freeze	2	6
I-20	Wet, no freeze	2	4
Connecticut, I-84	Wet, freeze	1	2
Indiana, US-31	Wet, freeze	1	4
Illinois, IL-5	Wet, freeze	1	1
New Mexico, I-94	Dry, no freeze	1	2
Minnesota, I-94	Wet, freeze	1	5
Iowa, R-30	Wet, freeze	1	5
South Dakota, I-29	Dry, freeze	2	4
Michigan, I-69	Wet, freeze	1	1

Georgia

Georgia was selected for the first inspections because, since 1974, the state has sealed many miles of pavement with Dow Corning 888 low-modulus silicone sealant. Six sites were inspected in detail in May 1983, and others were examined visually (see Table 2).

Georgia's use of low-modulus silicone pavement joint sealant has received considerable attention. Published reports indicate the sealant is performing well, and detailed inspections verify this (3). Numerous pavement and bridge deck sealing projects were observed while traveling with Georgia Department of Transportation (DOT) engineers.

The oldest silicone sealant installation in Georgia, located on the northbound lane of I-75 at milepost 189 near Forsyth, was installed in 1974. Heavy traffic prevented detailed inspection. Cursory examination showed that the sealant was still performing well.

All of the joints inspected were resealing projects covered by Georgia DOT specifications. Joints were sawed and cleaned by sandblasting, although occasionally a wire brush was used.

Ten joints (240 linear feet of sealant) were inspected at each site. The results are summarized in Table 2. At several sites it was noted that the

TABLE 2 Georgia Inspection Summary

Location	Pavement[a]	Installation Date	Age (years)	Pavement Distress	Sealant Failure	Comments
I-85						
Northbound lane, milepost 17	9-in. PCC over 1 in. of AC sand; JPCP at 20-ft spacing with dowels	Summer 1977	6	Old spalls filled with silicone	3 percent, adhesive	Insufficient tooling
Northbound lane, milepost 22	9-in. PCC over 1 in. of AC sand over 12-in CTB; JPCP at 20-ft spacing	Summer 1977	6	None	0.5 percent, adhesive	Insufficient tooling
I-75, northbound lane, milepost 204	9-in. PCC over 3 in. of AC sand over 8-in. CTB; JPCP at 20-ft spacing	May 1977	6	Localized chipping	None	
I-20						
Eastbound lane, milepost 116	9-in. PCC over 12-in. CS; JPCP at 30-ft spacing with skewed joints	June 1979	4	Minor faulting	None	
Westbound lane, milepost 129	9-in. PCC over 12-in. CS; JPCP at 30-ft spacing with skewed joints	June 1979	4	Minor faulting	<1 percent, cohesive	Sealant too thin, <0.0625 in.
I-16, southbound lane, milepost 4	9-in. PCC over 4 in. of AC sand over 8-in. CTB; JPCP at 30-ft spacing	Fall 1978	5	None	0.5 percent, adhesive	

[a]Note that PCC = portland cement concrete, AC = asphalt concrete, JPCP = jointed plain concrete pavement, CTB = cement-treated base, and CS = crushed stone.

asphalt shoulder sealant and paint stripe at the pavement edge acts as a dam, trapping water, sand, and small stones in the joint recess. In time, this could accelerate joint and sealant damage.

The most sealant failure was found on the northbound lane of I-85, at milepost 17. Here sealant on the pavement surface and along the joint wall above the recess indicates incomplete tooling. The same condition was also noted in the southbound lanes of I-85, but resulted in only 0.5 percent adhesive failure.

Connecticut

The Connecticut test site is on the eastbound lanes of I-84 south of Manchester at the end of the Wyllyss exit turn off. The four-lane pavement is on a long uphill grade. Three lanes are long-jointed portland cement concrete (PCC) pavement. An asphalt shoulder serves as a truck lane. This pavement is subjected to as much as 0.5-in. of vertical movement caused by differential frost heave. Seven transverse joints (originally 0.875 to 1.25 in. wide) and the corresponding longitudinal joint (0.5 to 0.75 in. wide) were sealed with silicone sealant in September 1981.

This installation was satisfactorily done. The sealant is well tooled against the joint walls, and the average recess is 0.375 in. Except for two large adhesive failures 2 and 4 ft long, only small failures were found in the remaining joints. The 2-ft failure appeared to be caused by too thin an initial bond area. The joint with the 4-ft failure did not appear to have been throughly cleaned. Old asphalt sealant was found under the backer rod, and the joint wall of the leave slab contained some residue.

Adhesive failures totaled 87 in., or 3 percent of joint length, and the two large failures accounted for 72 in. of this. Overall, the sealant is still performing well.

Indiana

The Indiana test site is on US-31 northwest of South Bend. The silicone sealant was installed as a demonstration in May 1979. Twenty-five joints from station 209+30 north to station 218+90 were inspected.

The sealant was installed in new pavement with 40-ft joint spacing. Joints were sawed 0.25 to 0.375 in. wide and cleaned with an airblast. Using a roller, 0.375-in.-diameter closed backer rods were installed 0.5 in. deep in the joint. Silicone was pumped into the joint and tooled to a 0.25-in. depth with a tooling foot, a device attached to the applicator that produces the intended sealant recess.

This site is typical of most test installations. Because of inexperience or experimentation, sealant application is uneven in the first few joints. Joints sealed later look neater and correctly installed.

Of 240 linear feet inspected, there was no bond for 48 ft, or 20 percent of the total length. This adhesive failure is classified as lack of bond development caused by contamination of joint walls with sawing residue. Airblasting alone cleans unevenly, and adhesive failures can be expected. This pavement is also heavily tined, making joint walls prone to damage from snow removal equipment. Most joints have a foot or more of chipping.

Illinois

In the summer of 1982, low-modulus silicone sealant was used to seal joints in 5 miles of PCC overlay in the eastbound lanes of the East-West Tollway between Naperville Road and IL-59. The 8-in. overlay was laid over 10 in. of original concrete pavement on a crushed stone base. Random joint spacing ranges from 12 to 18 ft.

According to engineers interviewed at the site, the contractor used the following installation procedure. Joints were sawed within 24 hr of construction and again 2 weeks later. A sealing crew followed immediately with a high pressure waterblast. Sealant was pumped into wet joints for the first 2 miles of the project. Informed of the proper cleaning technique, the contractor switched to wire brush cleaning for the last 3 miles.

The sealant was inspected approximately 1 week after installation by pulling up on the ends. Few joints failed; those that did were resealed.

Inspection of 10 seals placed in wet joints revealed lack of bond in 9. About one-third of total sealant length failed adhesively. Most had bonded at one time, but only to the top 0.125 in. of the joint wall that had time to dry before the sealant was applied. The appearance of the sealant also indicates that tooling was insufficient to create intimate contact between the sealant and the joint wall.

Despite these problems, the silicone sealant is still in place and functioning on this heavily traveled road where bond is only 0.125 in. An average recess of nearly 0.5 in. contributes to this performance by preventing tires from pulling the sealant out of the joint.

New Mexico

In September 1981 about 7,200 linear feet of silicone sealant was installed on I-25 south of Albuquerque. The site begins 300 joints south of milepost 219 in the northbound lane. Joints are skewed on 18-ft spacing in plain jointed concrete.

No failures, either adhesive or cohesive, were found in 10 joints inspected in December 1983. This site illustrates the importance of the shape factor and the sealant thickness-to-width ratio. Joints range from 0.5 to 0.625 in. wide and sealant thickness ranges from 0.375 to 0.5 in. Thus the shape factor varies from 0.6 to 1.0, the correct range. Sealant recess averages 0.1875 in.

Cursory inspection of the other 290 joints revealed only 3 with any visible distress. All three are in the outer wheelpath where the sealant was used to fill spalls. A total length of 56 in. (0.6 percent of the total) has been replaced with asphalt.

The silicone sealed joints have a neat appearance and performance has been satisfactory. There are essentially no failures in 7,200 linear feet of silicone sealant.

Minnesota

Twenty-five joints on the eastbound lane of I-94, previously sealed with hot-poured asphalt, were resealed with low-modulus silicone on October 24, 1978. The joints, spaced 20 ft apart, are located just east of the first service crossover west of the Sauk Center interchange.

The joints were sawed with a diamond blade to a width of from 0.625 to 0.75 in., then sandblasted and airblasted. A 0.75-in. Ethafoam backer rod was rolled into the joint to a 0.75-in. depth. A tooling foot on the sealant applicator tooled the sealant to a depth of 0.25 in. The right lane was sealed first and opened to traffic within 30 min of sealant application.

This site was inspected by Dow Corning representatives in April 1979. Joint appearance was reported good, with the left lane looking better than the right. This is understandable because of traffic volume. As the work progressed, the applicators became more adept. Some adhesive failure occurred at the centerline, where the sealant had been used to fill large corner spalls. Overall, the silicone sealant looked good after its first winter.

In 1983 the overall seal condition was very good to excellent. The corner spalls had been replaced by asphalt concrete as a part of a maintenance program for the entire pavement. The silicone was removed from the spall area before patching, and the spall repair crew somewhat damaged adjacent sealant. Approximately 60 in. of chipping by snow removal equipment was observed, but the silicone sealant held the chips firmly in place.

There is less than 1 ft of adhesive failure in the total joint length of 240 ft. After 5 years the sealant is still performing well.

Iowa

The Iowa test site is an excellent example of the importance of proper joint cleaning and sealant application. The site is located on country road R-30 between F-31 and IA-44 northwest of Des Moines. Forty joints are north and five joints are south of the first gravel crossroad south of F-31. The 6-in. concrete pavement was constructed in the summer of 1978, and the joints, spaced every 40 ft, were sealed in September.

The joints were divided into nine sections of five each. Each section was sawed to different widths, and three different cleaning methods were used (Table 3). Both sandblasting and waterblasting were followed by an airblast. Waterblasted joints were allowed to dry for 4 hr before applying the sealant.

TABLE 3 Combinations Used for Joint Sealing, Iowa Site

Section	Joint Width (in.)	Cleaning Method	Backing Material
1	0.25	Waterblasting	Ethafoam
2	0.25	Airblasting	Ethafoam
3	0.5	Airblasting	Ethafoam
4	0.5	Airblasting	Tape
5	0.375	Airblasting	Ethafoam
6	0.375	Airblasting	Tape
7	0.25	Sandblasting	Ethafoam
8	0.5	Sandblasting	Ethafoam
9	0.5	Sandblasting	Tape

Various tooling methods produced variable sealant recesses. An immediate inspection stated that the installation was only fair because of overall sloppiness. Uniformity of joint width was poor, and a rough surface hindered installation.

An inspection in April 1979 revealed no evidence of adhesive failure but did discover areas where not enough sealant had been applied to "wet" the joint. As a result, no bond had developed.

Twenty joints, 10 cleaned by sandblasting, and 5 cleaned by each of the other methods, were inspected in August 1983. The airblasted-only joints have an average of 50 percent adhesive failure. Four of the waterblasted joints averaged 16.5 percent adhesive failure. In the fifth, the sealant was less than 0.09375 in. thick, and the joint was full of small gravel from the road intersecting at this point; it failed totally. Only 1 percent of the joints that had been sandblasted and airblasted failed adhesively, and that failure is attributed to not enough sealant being applied. Nine feet of cohesive failure was noted in one sandblasted joint where the sealant was only 0.03125 in. thick.

It should be noted that proper sealant shape, proper thickness-to-width ratio, and proper sealant recess below the pavement surface would have improved performance at this site, regardless of the cleaning method.

South Dakota

Low-modulus silicone sealant was installed in a 30-mile pavement rehabilitation project on I-29 in South Dakota. In the fall of 1979 the sealant was installed in 13 miles of the northbound lanes extending north from the Iowa line. The next year the sealant was installed in the northern 17 miles of the project in the southbound lanes. The rehabilitation consisted of partial depth patches to repair spalls caused by deteriorating Unitube joint formers. About 75 percent of each joint was patched, so much of the sealant was applied in new joints. Joints were sawed and cleaned with a waterblast followed by an airblast.

At this site the sealant is subject to three different joint conditions: (a) joints previously sealed with hot asphalt, (b) new joints sawed from patches, and (c) a patch on one side and old concrete on the other. Performance of the silicone sealant in these joints is influenced by how well the joints were formed after patching and how well asphalt sealant residue was removed from old surfaces. Most of the adhesive failures noted in 1983 were in resealed joints in which an asphalt film remained on joint walls. The patched joints have much better adhesion because the waterblast process removes saw fines more effectively than old sealant.

Poorly formed joints appear to have caused problems during application and tooling. In many joints the surface of the sealant is wavy, as shown in Figure 4c, rather than concave, as in a properly tooled joint.

Joints installed in the northbound lanes in 1979 exhibited more uneven application and adhesion problems than those installed the next year. Also, adhesive failures were inversely proportional to the length of the patch. The majority of one particular joint, less than one-half of which had been patched, failed adhesively. All other joints averaged 5 percent adhesive failure, and the failures occurred almost exclusively in the unpatched portion of the joint where residual sealant remained.

The seals in the southbound lanes looked much better. Only 21 in. (1 percent) of the total joint length inspected showed any failures. Some chipping of high spots in patches was also noted.

Michigan

Low-modulus silicone sealant was installed in the eastbound lanes of I-69 between the Clark Road overpass and the Airport Road exit in 1982. Joint spacing is 40 ft and the pavement has concrete shoulders.

Both transverse and longitudinal joints in the highway and the shoulder are sealed with silicone. Joints were sawed 1 in. wide and sandblasted before installation.

Detailed inspection in 1983 found no adhesive or cohesive failure in 1,950 linear feet of transverse and longitudinal joints inspected in 1983. Joint width ranged from 0.875 to 1 in. and sealant thickness ranged from 0.375 to 0.9375 in., giving the proper shape factor. Typical sealant recess was 0.25 in. Tooling appeared adequate, although considerable excess sealant was noted on the pavement surface.

CONCLUSIONS

Among the variables influencing the performance of Dow Corning 888 sealant examined in this study were climate, age, joint cleaning methods, installation procedure, joint design, sealant shape factor, sealant recess, traffic, pavement condition, and joint spacing. Inspection of 14 highway sealant installation projects indicates that two factors are paramount: joint wall cleaning and installation techniques. The data in Table 4, which summarize the results from all 14 sites, clearly demonstrate this.

The various sites inspected included four cleaning techniques: airblasting only; wire brushing followed by airblasting; waterblasting followed by airblast; and sandblast followed by airblast.

The Iowa site vividly demonstrates the superiority of sandblasting. The South Dakota site shows the importance of removing old sealant residue from joint walls in resealing projects and indicates that high-pressure waterblasting is unable to do this effectively.

Wire brushing, as on I-16 in Georgia, is effective for removing saw residue in new or resealed joints. However, this technique is not recommended unless the joint is sawed. There is no data to indicate that it removes old sealant effectively.

Installation is very important. Sealant should never be applied to a wet or damp joint. After the sealant is pumped into the joint it must be tooled to push it against the joint walls. This can be done with a special foot on the applicator nozzle or by hand using a variety of trowel-like devices. The fewest failures were found at joints where the width of the tooling foot matched the joint width or where the sealant was carefully tooled by hand.

Joint design and sealant shape factor are also important, especially when joint cleaning and installation techniques are marginal. The correct shape factor reduces stresses in the sealant and increases its life. In the sites inspected, sealant thickness varied considerably. At a few sites very thin seals failed cohesively. However, no problems could be attributed to very thick application. Seals with shape factors of less than 0.5 and greater than 2.0 were performing well after 5 years, which indicates that Dow Corning 888 sealant is forgiving of poor joint design and some application techniques.

Other variables appear to have only a minor effect on sealant performance. Climate and age were expected to be major factors, and may prove to be so with time. However, samples taken at several sites and analyzed to determine the effect of aging indicate that the modulus (elasticity) of the sealant

TABLE 4 Inspection Summary

Location	Date	Age (years)	Cleaning Method	Tooling	Failure (%) Adhesive	Failure (%) Cohesive
Georgia						
I-75	1977	6	Sandblasting	Good	0	0
I-16	1978	5	Wire brush	Good	0.5	0
I-85	1977	6	Sandblasting	Fair	2.0	0
I-20	1979	4	Sandblasting	Good	0	0.4[a]
Connecticut, I-84	1981	2	Sandblasting	Good	3.0	0
Indiana, US-31	1979	4	Airblasting	Fair	20.0	0
Illinois, IL-5	1982	1	Waterblasting	Fair	31.0[b]	0
New Mexico, I-25	1981	2	Sandblasting	Good	0	0
Minnesota, I-94	1978	5	Sandblasting	Good	0.3	0
Iowa, R-30	1978	5	Airblasting	Poor	50.0	0
			Waterblasting	Poor	16.5	5.0[a]
			Sandblasting	Poor	3.0	4.5[a]
South Dakota, I-29	1979	4	Waterblasting	Good	3.0	0
Michigan, I-69	1982	1	Sandblasting	Good	0	0

[a]Sealant installed thinner than recommended.
[b]Installed in wet joint.

changes very little with age, as indicated by the data in the following table:

Number	Age	Modulus (psi)
1	4 years	24
2	4 years	26
3	2 years	28
4	5 years	29
5	7 days	20-25
6	27 days	25-30

Because of their excellent aging characteristics, silicone sealants appear to be capable of preventing pavement distress for much longer periods than conventional asphalt sealants.

The data developed in this study indicate that Dow Corning 888 low-modulus silicone sealant can overcome minor installation inadequacies and provide extended seal life. The data demonstrate that performance remains high for 6 years and more.

Longer-term performance has not been established because of the length of service of present installations. More study will be required over longer time periods to collect and analyze standardized performance data and illustrate long-term performance. This study is one point in time of the performance history of the installations surveyed.

RECOMMENDATIONS

Pavement joint sealant systems must be based on the calculated joint movement. After the working range of the joint is determined, the sealant shape can be selected to ensure that sealant strains will be within the manufacturer's recommendations.

Detailed specifications should include joint design, material acceptance, preparation, sealant installation including equipment, and inspection (4). Regular monitoring of the job site is necessary to assure that the specifications are followed precisely.

A long-term study should be undertaken to evaluate the performance of all types of sealants in a standardized manner. Such a study could establish life-cycle cost data for use in planning cost-effective pavement rehabilitation strategies. Joint sealing is critical to pavement life and should be addressed in a professional manner.

REFERENCES

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