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Putting Silicone Seals to the Test MDOT's Ongoing Study and Evaluation of Silicone Seals

The word sealant (in the context of concrete pavements) conjures up an image of a joint filled with a rubberlike substance providing a smooth ride to road users. The history of sealants (and silicone sealants in particular) in Michigan, however, has been far from smooth. Silicone seals were introduced in 1978. For eight years, from 1982, when they were first used in a Michigan Department of Transportation (MDOT) contract job, until 1990, they remained experimental. Engineers at the Materials and Technology (M&T) division of MDOT were never quite happy with silicone sealant performance. In 1990, significant problems with silicone sealant adhesion prompted a moratorium to be placed on their use by the Engineering Operations Committee. MDOT, thus, stopped using silicones and continued using neoprene as the standard for new concrete pavement sealing. Thereafter, silicones were used only for resealing jobs since neoprene was found impractical for filling joints with spalls of varying widths.

The failure of silicone seals was particularly frustrating for the M&T research engineers because its apparent robust performance in the lab was not being followed by equally robust performances in the field. "We wanted to know what circumstances were causing problems. Silicones which never failed in the lab were beginning to fail in the field," explained Doug Branch, Supervisor of Materials Investigation of the Materials Research Group (MRG).

The Lab Study

MRG, thus, commissioned a study to investigate the causes of the silicone sealant failures. The study of three concrete joint sealants (Dow 888 silicone, Dow

890 SL self-leveling silicone, and Sikaflex-15LM polyurethane) began in 1993. The purpose of this study was to see if there were any factors affecting the adherence of silicone and polyurethane to concrete other than those factors already known such as, proper joint design, joint cleanliness, correct size backer rod, and installation techniques.

The MRG study performed four cycles of tests on the samples. Four variables—concrete cure time, minimum sealing temperature and saturated surface dry conditions, different aggregate types, and fly ash content of the concrete as a percentage replace-



	Primer	Cure time	Aggregate	Fly ash content
Cycle I	Primer coating (1/2 the samples)	variable (3,4,5,7,9,14,28 days)	limestone	nil
Cycle II	nil	7 days	limestone	nil
Cycle III	nil	7 days	gravel and slag	nil
Cycle IV	nil	7 days	limestone	Type F

Table 1: Test cycles performed on experimental crack sealants (MRG data)

ment of cement—were used to test the sealants. (See Table 1). For example, half of the Cycle I samples were treated with a primer coating to see if this helped the adhesive properties of the sealant, cure times of the concrete were varied (3, 4, 5, 7, 9, 14, 28 days), limestone was used as the aggregate, and there was no fly ash in the concrete. Similarly, three more test cycles in which differing combinations of these variables were used to test their strength and adherence.

The samples used were two 25.4 X 50.8 X 76.2 mm concrete blocks sandwiched around a 12.7 X 12.7 X 50.8 mm seal. The sealing occurred at normal laboratory temperatures (24 °C, 50% relative humidity) for all cycles except Cycle III. The samples were tested according to modified ASTM D3583 to get a bond strength and percent elongation for each sealant. The sealants were also run through three bond test cycles at -29 °C according to ASTM C719.

The results of the study indicated that all the sealants passed most of the tests except for the Dow 888 which failed one bonding test under saturated surface-dry (SSD) conditions and the Sikaflex 15LM which failed one bonding test. Overall, though, none of the results were indicative of a major problem with any of the sealants.

The interim report provided by the Sealant Engineer, Mike Eacker, in September of 1993 throws some light on the probable causes of silicone sealant adhesion problems. The report draws the following conclusions regarding the adhesive properties of silicone sealants:

- The use of a primer does not significantly improve the adhesive properties of any of the sealants.
- Adhesive properties of all three sealants were unaffected by sealing at temperatures down to 4.4 °C.
- The type of aggregate used does not affect the sealant.
- The adhesive properties of silicone increased with the presence of fly ash in the concrete. The amount of fly

ash used was fifteen to thirty percent replacement based on the weight of the Portland Cement.

In addition to these observations the report makes the following two key recommendations regarding the use of such sealants in the field:

- The manufacturer’s recommendation of allowing the concrete to cure seven days before sealing should become a requirement.
- Joints should not be sealed with silicone even when there is the slightest amount of moisture present. It was, however, found that the presence of moisture slightly increased the adhesive properties of the polyurethane sealant.

Based on this exhaustive laboratory study, the report further recommended a complete field test and evaluation.

Putting it to the test: The field evaluation

The field study was conducted on a stretch of pavement on westbound I-94 in the Watervliet/Hartford area. The test was conducted using five different concrete pavement contraction joint sealants: three silicones—Dow 888, Dow 890 SL and Crafcro Roadsaver SL—and two polyurethanes—Sikaflex 1CSL and Sikaflex 15LM. The field study began with the sealing of the test section on September 20 and 21, 1994. Each sealant was installed in 60 contraction joints which are spaced at 8.2 m. The remainder of the pavement was sealed with 31.8 mm preformed neoprene which was (and still is) MDOT’s standard joint sealant. Recommended procedures were followed when using all the sealants with representatives of each manufacturer present on site who approved the installation.

The evaluation of the test section consisted of a visual rating of the sealant condition in the driving lane. The Pennsylvania DOT rating system was used which requires rating of the sealant in three categories: sealing,

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Important considerations before, during, and after sealant installation

Many of the problems with silicone sealants can be traced back to improper or faulty installation. Installation of sealants, therefore, is crucial in ensuring a long working life. Long sealant life, however, begins with good joint design.

Joint design. Anticipated movement is one of the key considerations while designing the joint which will ultimately hold the sealant. Coefficient of thermal expansion of the pavement, expected temperature range, and the anticipated temperature at time of sealing and time of year are also considered before sealant installation. Joint design also includes choosing the proper width and depth of the joint. The width of the joints (joint sealant reservoirs) vary from 6.35 mm to 9.525 mm. Proper joint depth is required to ensure that the sealant installed is properly recessed. (Recessing the sealant is necessary to prevent contact between vehicles and the sealant as that might lead to wear and tear of the sealant). Generally sealants are recessed to 9.525 mm.

Another essential element of good joints is the use of a backer rod (see Figure 1). The backer rod acts as a bond breaker, preventing three-sided adhesion, and also forms the desired cross-section of the sealant bead. Not installing a backer rod (or improperly installing it) will result in the sealant bonding to the bottom of the joint resulting in excessive stress on the sealant. The backer rod also ensures the proper thickness of the sealant bead.

Joint preparation. One of the first steps is to make sure that the concrete is well cured and dry, since saw-

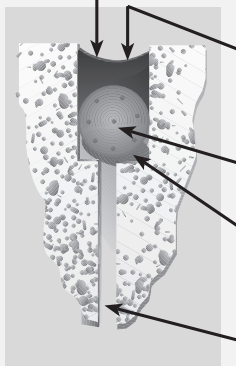
ing joints on uncured concrete might result in concrete damage. (For conventional concrete mixes, the typical concrete cure time is seven days in good drying weather).

The joint sealant reservoirs are prepared by saw-cutting the concrete to the desired depth. The joints are usually sized so that the maximum expansion and compression do not exceed +100 and -50 percent respectively.

Once the joint sealant reservoirs are prepared they are washed with high pressure water to remove saw slurry from the joint faces. Joint washing is done in any one direction to prevent recontamination. After enough time given for the joints to dry they are then sandblasted to remove residue laitance from the joint walls. Sandblasting is done in two passes, one for each face, with the nozzle held at an angle to the joint face. A high pressure air blast is then used to remove any traces of dust and dirt. This is also done only in one direction to prevent recontamination. After a final check for any residual dirt, the backer rod can be installed.

Sealant installation. Once the joint is prepared the sealant is poured in. Silicone sealants are generally pumped directly from their containers or drums into the joints by use of an air-powered pump. Certain sealants, which are not self-leveling, need tooling so that they are recessed to 9.5 mm below the pavement surface. Preferably, sealants are installed at temperatures above 4.4 °C. Depending on the ambient temperature and relative humidity, roads may be opened to traffic two to three hours after sealant installation.

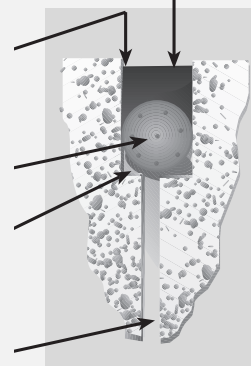
Sealant **tooled** to a minimum of 9.5mm below pavement surface.



Silicone Joint Sealant

Printed with permission from Dow Corning Corporation, Midland, Michigan

Sealant **recessed** a minimum of 9.5mm below pavement surface



**Self-leveling
Silicone Joint Sealant**

Figure 1: Joint design considerations

Category	February 1995			August 1995			February 1996		
Category	S	W	D	S	W	D	S	W	D
DOW 888	5.0	5.0	5.0	4.7	5.0	4.9	4.2	5.0	4.6
DOW 890SL	4.9	5.0	5.0	4.8	5.0	5.0	4.6	5.0	4.8
Sikaflex 15LM	4.9	5.0	5.0	4.8	5.0	4.9	4.5	5.0	4.9
Sikaflex 1CSL	4.9	5.0	5.0	4.8	5.0	5.0	4.6	5.0	5.0
Crafco RSL	4.7	5.0	4.9	4.4	4.9	4.8	3.8	4.9	4.3

Table 2: Field evaluation—average rating of sealant condition in the driving lane.

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weathering and debris intrusion. The Pennsylvania DOT rating system consists of a rating of one to five, one denoting bad sealant condition and five denoting excellent condition. (After nearly two years, the numbers should be close to five for effective sealing).

The results of the visual rating of the sealants showed, that after nearly two years, the rating numbers for the three sealants (the Dow 890 SL, Sikaflex 15LM and Sikaflex 1CSL) indicated minor adhesive losses, and even though they had less than perfect scores, the research team believed they were sealing the joints effectively (see Table 2). The Dow 888 and Crafco Roadsaver SL, however, showed values below 4.5 which were not acceptable after two years.

According to the inspection reports, after two years the DOW 888 had several minor adhesive losses among many joints. These small losses could increase as the joints open and close due to thermal movement of the pavement and hence could worsen with time. The Crafco Roadsaver SL also showed signs of sealant loss. But there was an additional problem with this sealant. Visual inspection showed a blackened section appearing over fifteen consecutive joints in the right wheel path. Representatives from

Crafco, who took samples of this blackened area, later stated that this sealant had (in those spots) been contaminated by a hydrocarbon that had made it swell, which resulted in subsequent sealant loss. However, cohesive tears and losses in other portions of the test section indicated that this sealant was not effectively sealing the joint.

The future of silicones in Michigan

With one year of the field evaluation remaining, the future of silicone sealants for new concrete paving in Michigan is still unknown. The exact reasons for the failure of some of the silicone sealants on the test site (and other sites) are not known, but there are some factors which could point to possible causes.

One cause of failure might be the use of sealants on concrete surfaces with carbonate aggregates. Minnesota DOT, for example, has stopped using silicone sealants with carbonate (limestone) aggregates because of bonding problems between the concrete and the silicone. Minnesota DOT uses silicone sealants primarily for sealing concrete pavements with gravel aggregates without any significant problems being reported.

Moisture in the joint faces could be another factor in the failure of these sealants. Any moisture in the joint, prior to sealing, will affect the bonding of the sealant to the concrete. Thus, a highly absorptive aggregate (i.e., absorptivity more than 2%) could increase the chances of sealant failure.

Current Status

As of July 1996 three of the five sealants were still effectively sealing the test joints. All five products continue to be evaluated every six months. The MRG will continue monitoring and see if the failures propagate further or if new failures occur. One more year of observation remains until MRG makes its final recommendations.

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