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To Seal or Not to Seal?

A Field Experiment to Resolve an Age-Old Dilemma

Bryan K. Hawkins, Anastasios M. Ioannides, and Issam A. Minkarah

Construction and evaluation to date of a joint sealant project in the Wet-Freeze climatic zone near Athens, Ohio, are described. Fifteen different combinations of materials and joint configurations have been used. The new pavement consists of a 250-mm (10-in.) portland cement concrete slab, placed over a 100-mm (4-in.) free-draining base layer, constructed over a 150-mm (6-in.) crushed aggregate subbase, resting over the predominantly silty clay local subgrade. The highway has a 20-year design period and a design traffic level of 11 million single-axle loads. The eastbound lanes were constructed first and have been open to traffic since the spring of 1998, and the westbound lanes have been serving traffic only since the spring of 1999. Evaluations to date indicate that with one exception, preformed compression seals have performed significantly better than liquid sealants. Unsealed sections also are performing very well, exhibiting no visible signs of distress at the joints or in the pavement slabs at this time. In contrast, after only 1 year of service, silicone and hot-pour sealants in the eastbound lanes are in fair to poor condition. The worst sections are those with narrow [3-mm (⅛-in.)] joints. Oversight and inspection provided were ineffective in averting the use of equipment and procedures that were obviously inadequate. The most significant shortcomings appear to have been the omission of sandblasting during placement and inadequate sealant recess.

Since the early 1940s, joint sealants have been an integral part of almost all jointed plain concrete pavements and jointed reinforced concrete pavements. Previous studies in Ohio and elsewhere have demonstrated that joint sealing techniques have the potential to make a significant contribution to the performance of such pavements.

Sealants are thought to provide protection to the pavement in two important ways. First, sealing the joints reduces the infiltration of moisture into the pavement base and subgrade. Such moisture would lead to softening, pumping, and erosion of these layers, resulting in joint faulting and corner breaks in the slab. Second, sealing the joints prevents incompressible materials such as small stones from entering and becoming lodged in the joints. Incompressible materials can inhibit thermal slab movement, increasing the stresses in pavement slabs and leading to joint spalling and transverse cracking.

However, serious consideration must be given to the practical aspects of joint sealing if the sealant is to work effectively. Most important, the process of sealing joints requires careful and experienced installation and inspection. The joint must be washed, sandblasted, and cleaned to prepare vertical, intact, and clean bonding surfaces that are dry and free of contaminants before the backer rod and sealant are introduced. If proper construction procedures are not followed carefully, the sealant may not form a good bond with the concrete slab and infiltrating moisture may not be effectively reduced.

Improperly installed sealants also are subject to premature deterioration from weather and traffic. If sealants are installed too far below the pavement surface, incompressible materials are likely to enter the joints. Conversely, sealants installed at or slightly above the pavement surface are likely to be damaged or destroyed by vehicle tires. Moreover, the sealant must be installed under suitable weather conditions, with virtually no moisture present in any form. Given the stringency of cleaning and installation procedures, these operations should be inspected as they proceed. Without such inspection, a great deal of effort and money could be wasted on ineffective seals.

PROJECT OBJECTIVES

A research experiment near Athens, Ohio, involved the installation of various joint sealants in the transverse joints of a newly constructed portland cement concrete (PCC) pavement. The work is documented in detail by Hawkins (*1*). The experimental design for this project was developed in 1997 by the Federal Highway Administration (FHWA) and the Ohio Department of Transportation (ODOT) to provide data for the evaluation of the performance of various joint seals and joint configurations.

Fifteen combinations of materials and joint configurations are used in the experiment, which includes unsealed control sections. The purpose of these pavement test sections, located in the Wet-Freeze climatic zone, is to complement similar sections constructed in other states under the Strategic Highway Research Program (SHRP) Specific Pavement Studies (SPS)-4 experiment. The test pavement is divided into 15 test sections, each section of which typically is 180 m (600 ft) long, but some longer sections also are included. Each test section incorporates about 30 joints. In accordance with the experimental design, two replicates of each of 15 chosen material-joint configuration combinations are provided. Two of these combinations involve unsealed joints. In each case, one replicate is in the eastbound lanes, built during the 1997–1998 construction season, and the other in the westbound lanes, placed during the 1998–1999 construction season.

In constructing the test sections, three objectives were established:

- To assess the effectiveness of various joint sealing practices used after the initial sawing of joints, and to examine their repercussions in terms of reduced construction time and life-cycle costs;
- To identify the most cost-effective materials and procedures; and
- To determine the effect of joint sealing techniques on pavement performance.

Department of Civil and Environmental Engineering, University of Cincinnati (ML-0071), P.O. Box 210071, Cincinnati, OH 45221-0071.

PROJECT LOCATION AND DESCRIPTION

The test site under investigation is a 3.3-km (2.0-mi) section of a new 10.5-km (6.5-mi) four-lane divided highway constructed along a stretch of US-50 in Athens County, Ohio. The local mean annual precipitation is 1 m (40 in.), of which 620 mm (24 in.) is in the form of snow. The mean average monthly temperature is 12°C (53°F), the low average monthly temperature is 0°C (32°F), and the high average monthly temperature is 24°C (75°F).

This new four-lane highway has a 20-year design period; current (1993) average daily traffic (ADT) is 7,820, and design year (2013) ADT is 10,950. The design traffic level is 11 million equivalent single-axle loads, and the truck percentage is 9 percent. The pavement cross section consists of a 250-mm (10-in.) plain, jointed, wire-reinforced PCC slab (ODOT Item 451) placed over a 100-mm (4-in.) crushed aggregate free-draining base layer (ODOT Item Special), constructed over a 150-mm (6-in.) crushed aggregate subbase (ODOT Item 304), resting over the predominantly silty clay local subgrade.

The new highway consists of two lanes, 3.7 m (12 ft) wide in each direction, incorporating tied PCC shoulders of variable width. The shoulders are 3 m (10 ft) wide on the outer side and 1.2 m (4 ft) wide on the inner side (adjoining the median). Transverse joints perpendicular to the direction of traffic are spaced at 6.4 m (21 ft). Epoxy-coated steel dowels 38 mm (1.5 in.) in diameter and 460 mm (18 in.) long, supported on baskets, are installed on 305-mm (12-in.) centers, beginning 150 mm (6 in.) from the longitudinal joint. The longitudinal centerline joint is tied with 16-mm (⅝-in.) round deformed bars 760 mm (30 in.) long and spaced at 760 mm (30 in.) center to center.

In addition to the sealants experiment, the pavement accommodates two other tests, all conducted under the FHWA's TE-30 High Performance Concrete Pavement Initiative. For the purposes of these tests, 25 percent of the cement in the PCC slab mix was replaced with ground granulated blast furnace slag. For freeze-thaw durability purposes, the coarse aggregate in the mix was No. 8 gravel [9.5 mm (⅜ in.) maximum size]. Some of the steel dowels in the slab were replaced with fiberglass ones or with stainless steel tubing filled with concrete.

LITERATURE SURVEY

Conventional Wisdom

Joint sealants are currently used in highway pavements to minimize the passage of surface water through joints and cracks, in conjunction with a permeable subbase designed to remove water from the pavement system (*2*). The subject of increasing controversy in the United States in recent years is whether both these lines of defense are necessary, or whether it might be more cost-effective not to seal the joints and instead to rely on the permeable subbase and other associated subsurface drainage features to remove the water.

In a survey of state highway agencies (*3*), the following philosophies on drainage were recorded. Thirty states strive to seal pavements as well as possible while attempting to control the water through use of a drainage layer, other subsurface drainage, or both. Nine states try to seal the pavement as well as possible but are not concerned with subsurface drainage. The remaining 11 states take the position that water will inevitably enter the pavement system and seek only to control it through use of a drainage layer, other subsurface drainage, or both, rather than rely on the effectiveness of joint sealants. Only 1 of these 11 states (Wisconsin) dispenses with joint sealing entirely.

Wisconsin Experience

The state of Wisconsin has been performing research on the desirability of joint sealing for the past 50 years. This problem has been investigated from various angles, considering locations in urban and rural areas as well as various traffic levels and weights, base courses and subgrades, joint spacings, load transfer means, and so on. Results of this voluminous research indicate that joint sealing did not enhance pavement performance (*4*) and that contraction joint sealing costs could not be justified (*5*). Thus, in 1990 the state of Wisconsin decided not to seal cracks or joints in PCC pavements.

The state of Wisconsin began this research by questioning the assertion that joint seals enhance pavement performance by keeping incompressible materials out of the joints and by preventing the infiltration of water. It was argued that whereas this theory might have had merit when PCC slabs were constructed above the bare subgrade, with the present use of subbase and base courses to provide drainage, it might no longer be entirely true. If an unsealed pavement remains in as good a condition as a sealed pavement, then sealing obviously is not a cost-effective procedure. In their research, Wisconsin investigators evaluated sealed and unsealed PCC pavements in terms of distress development, ride quality, bridge encroachment, and materials integrity. Their findings indicate that joint sealing has no significant effect on any of these parameters and reaffirm that pavements with shorter joint spacings perform better than pavements with longer joint spacings (*4*).

Earlier published literature from Europe suggested similar conclusions. In 1979, at the 16th World Congress of the Permanent International Association of Road Congresses—World Road Association (PIARC), the Technical Committee on Concrete Roads presented a report concluding that for joint spacings of 4 to 6 m (13 to 20 ft), there is no disadvantage in leaving narrow transverse joints unsealed when (*a*) traffic is light; (*b*) traffic is heavy, but the climate is dry; or (*c*) traffic is heavy and the climate is wet, but the pavement is doweled (*6*).

SHRP Experiment

Whether joint sealing can or does improve pavement performance remains the subject of intense debate. Many variables are at work, and myriad questions surround the issue. The SHRP SPS-4 supplemental joint seal experiment was designed to provide valuable information on the subject of joint sealing. Long-term monitoring was performed at six research sites in the western United States (*7*). An interesting trend can be observed in the data that reflect the overall performance of transverse joint seals at each site. In preparing the joints for sealant placement, water- and air-blasting were the only means of cleaning joints at three of the test sites (in Utah), whereas sandblasting was also required at the other test sites. The three Utah sites clearly exhibit performance inferior to that at other sites, suggesting that sandblasting is an important factor in ensuring high-quality, long-lasting sealed joints.

JOINT SEALANT TYPES AND CONFIGURATIONS

Table 1 lists the sealant types, test section stations, joint widths, lengths, and numbers of joints in each of the test sections. Ten different joint sealants were used in the test sections, in addition to those intentionally left unsealed. Of the 10 sealant types, 2 are

TABLE 1 Joint Sealant Treatments Used at the US-50 Test Site

Sealant Material	Begin Station	End Station	Joint Config.	Length, m (ft)	No. of Joints
Eastbound					
TechStar W-050	154+00	160+00	5	183 (600)	29
No sealant	160+00	166+00	6	183 (600)	29
Dow 890-SL self-leveling silicone	166+00	172+00	3	183 (600)	29
Crafco 444 hot pour	172+00	188+00	1	488 (1600)	76
Crafco 903-SL self-leveling silicone	188+00	194+00	1	183 (600)	29
Watson Bowman WB-687 compression seal	194+00	200+00	5	183 (600)	27
Crafco 902 non-sag silicone	200+00	206+00	1	183 (600)	29
Crafco 903-SL self-leveling silicone	206+00	213+00	4	213 (700)	33
Dow 890-SL self-leveling silicone	213+00	219+00	4	183 (600)	29
No sealant	219+00	225+00	2	183 (600)	28
Delastic V-687 compression seal	225+00	231+00	5	183 (600)	29
Crafco 221 hot pour	260+00	266+00	1	183 (600)	29
Dow 890-SL self-leveling silicone	266+00	272+00	1	183 (600)	28
Dow 888 non-sag silicone	272+00	284+00	1	366 (1200)	57
Dow 888 non-sag silicone	284+00	290+00	1	183 (600)	29
Westbound					
TechStar W-050	133+60	139+60	5	183 (600)	29
No sealant	139+60	166+00	2	805 (2640)	126
Dow 890-SL self-leveling silicone	166+00	172+00	3	183 (600)	29
Crafco 221 hot pour	172+00	188+00	1	488 (1600)	76
Crafco 903-SL self-leveling silicone	188+00	194+00	1	183 (600)	29
Crafco 903-SL self-leveling silicone	194+00	200+00	1	183 (600)	29
Dow 890-SL self-leveling silicone	200+00	206+00	1	183 (600)	28
Crafco 444 hot pour	206+00	213+00	1	213 (700)	33
Dow 888 silicone	213+00	219+00	1	183 (600)	28
Delastic V-687 compression seal	219+00	225+00	5	183 (600)	29
Watson Bowman WB-812	225+00	231+00	5	183 (600)	28
Dow 888 silicone	260+00	266+00	1	183 (600)	29
Crafco 903-SL self-leveling silicone	266+00	272+00	4	183 (600)	28
Dow 890-SL self-leveling silicone	272+00	284+00	4	366 (1200)	57
No sealant	284+00	290+00	6	183 (600)	29

Note: Nominal joint width varies by joint configuration, as follows:
1 and 5: 9.53 mm (3/8 in.); 2 and 4: 3.18 mm (1/8 in.); 3 and 6: 6.35 mm (1/4 in.).

single-component, hot-applied sealants; 4 are silicone sealants; and 3 are preformed compression seals.

Hot-Applied Sealants

The two hot-applied sealants are manufactured by Crafco, Inc. (Chandler, Arizona). Crafco Superseal 444/777 is a fuel-resistant sealant specifically intended for sealing PCC pavements in moderate to hot climates. Initially liquid, it is poured into a melter application unit, which heats the sealant to the application temperature. The product data sheet advises that this sealant should be applied only when ambient air temperature is between 10°C and 32°C (50°F and 90°F).

Crafco Roadsaver 221 is a petroleum-based, hot-applied pavement crack-and-joint sealant intended for use in moderate to cool climates. Initially a solid block, it is heated before application by using a pressure-feed melter applicator unit or a pour pot. The product data sheet recommends that application should be at pavement temperatures of 4°C (40°F) or higher and that the joint should be shaped so that the sealant reservoir depth-to-width ratio does not exceed 2:1.

Silicone Sealants

Of the four silicone sealants used, two are also manufactured by Crafco, Inc. Roadsaver Silicone SL (also designated as Crafco 903-SL) is a self-leveling, jet blast–resistant silicone sealant that can be used in all climates. It is applied using a bulk dispensing system unit and requires neither tooling nor the use of primers.

Roadsaver Silicone Sealant (also called Crafco 902) is a low-modulus, non-sag silicone sealant intended for use in PCC pavements. It has the same qualities as the Crafco 903-SL except that it is not self-leveling and must be tooled to ensure adequate contact and adhesion with the joint walls.

The remaining two silicone sealants used are manufactured by Dow Corning Corporation (Midland, Michigan). Dow 888 is a one-part, cold-applied silicone joint sealant that requires no primer and is virtually unaffected by extremes of sunlight, rain, snow, ozone, or temperature. The product data sheet recommends that the sealant should not be applied to damp concrete or installed in inclement weather. Because it is a non-sag silicone sealant, it must be tooled to ensure adequate contact and adhesion to an appropriate depth. It is applied directly from a bulk container into the joint by a hand- or an air-powered pump.

The self-leveling, one-part, cold-applied Dow 890-SL requires no primers and is resistant to climatic extremes. It has the same restriction as the Dow 888 (i.e., it should not be applied if moisture is present in any form). Because it is self-leveling, it requires no tooling and is applied using a hand- or air-powered pump.

Preformed Compression Seals

Four compression seals were used in this experiment. The Delastic V-687 compression seal, manufactured by D.S. Brown Company (North Baltimore, Ohio), is 17.5 mm ($^{11}/_{16}$ in.) wide. This preformed neoprene compression seal is installed with the help of an adhesive lubricant, by hand or with an installation machine. The data sheet advises that the seal must be installed with 3 percent or less stretch to prevent premature failure.

The TechStar W-050 W-Seal is manufactured by TechStar, Inc. (Findlay, Ohio). It is made of Santoprene thermoplastic and is installed after a TechStar adhesive has been applied to the joint. The seal is initially flat but is folded as it is fed into an installation tool, which inserts the seal into the adhesive-lined joint. Information provided by the manufacturer claims that this seal is stretch-proof and requires less recess from the pavement surface than other seals.

Two compression seal types used are manufactured by Watson Bowman Acme (Amherst, New York). The WB-687 compression seal was installed in the eastbound lanes, and the WB-812 was used in the westbound lanes. These preformed neoprene compression seals are distinguished mainly in their width and height dimensions: the WB-687 is 17 mm ($^{11}/_{16}$ in.) wide × 17 mm ($^{11}/_{16}$ in.) high, whereas the WB-812 is 21 mm ($^{13}/_{16}$ in.) wide × 22 mm ($^{7}/_{8}$ in.) high. According to the product data sheet, the recommended installation procedures include cleaning the joint with compressed air and applying BonLastic adhesive to the inner faces of the joint. The sealant is then placed along the joint and compressed into place to the desired depth.

PAVEMENT CONSTRUCTION OPERATIONS

Pavement Layers

The test site is located on the floodplain of the Hocking River in an area of unglaciated uplands. Bedrock (which in this area typically consists of shales, sandstones, and limestones of the Conemaugh and Monongahela formations, Pennsylvanian) was not encountered in any of the borings made in the vicinity of the test site. The subgrade material consists predominantly of reddish brown and gray silty clays and clays in the A-6(11) and A-7-6(15) AASHTO classifications, with some sand and gravel. The upper 0.3 m (1 ft) of subgrade was compacted and brought to grade. The minimum compaction requirement was 100 percent of the standard Proctor maximum dry unit weight. Any soft soil encountered was removed and replaced with more desirable material. Compaction of the subgrade was performed using sheepsfoot vibratory rollers.

The subbase consisted of a single 150-mm (6-in.) lift of crushed, well-graded aggregate (ODOT Item 304) purchased from a local coal strip mine. The minimum compaction requirement was set at 98 percent of the maximum density value obtained from an in situ test that involved the compaction of a test section 30 m (100 ft) long × 2.5 m (8 ft) wide. The material was delivered in dump trucks, then spread to grade using a self-propelled spreader. The subbase was compacted by using a single smooth-drum vibratory roller with a static weight of 3.6 metric tons (4 tons). To prevent the migration of fines into the overlying base layer, a bituminous prime coat (ODOT Item 408) was applied to the top of the compacted subbase. A 100-mm (4-in.) pipe underdrain was installed through the subbase layer.

The base for the eastbound lanes consists of a "New Jersey"-type nonstabilized drainable base, constructed in a single 100-mm (4-in.) lift. For the westbound lanes, a similar lift of "Iowa"-type nonstabilized drainable base was used. The procedure was similar to that used for the subbase, involving the construction of a test section to determine maximum density and optimum moisture content. A 100-mm (4-in.) shallow pipe underdrain with filter fabric was installed through this layer. The material was delivered by dump trucks, placed using an asphalt paver with automatic grade control to minimize segregation, and compacted to the level specified by ODOT by using a smooth-drum roller without vibration.

The mix design for the PCC slab, developed by the contractor, called for the following material quantities: 245 kg/m^3 (412 lb/yd^3) of Type I cement, 82 kg/m^3 (138 lb/yd^3) of ground granulated blast furnace slag, 848 kg/m^3 (1428 lb/yd^3) of river sand with a bulk specific gravity (BSG) of 2.61, and 810 kg/m^3 (1,365 lb/yd^3) of No. 8 gravel with a BSG of 2.57. The water-to-cement ratio was 0.44 (*8*). No. 8 gravel was used because the No. 57 gravel originally considered did not pass the freeze/thaw test for this area.

The concrete was delivered by dump trucks, and the slab was cast by a three-paver slipform train in an operation that involved a crew of about 25 people. Dowel bars on baskets, wire mesh reinforcement, and longitudinal and shoulder tie bars were provided. Artificial turf was dragged over the slab to give texture to the pavement surface, which was subsequently grooved transversely by a self-propelled grooving machine. Finally, a curing compound was sprayed on to the slab to seal its surface.

The concrete was tested by ODOT technicians. Testing consisted of slump and air tests performed in the field as well as laboratory tests on beams cast in the field. The specified strength of these beams was a modulus of rupture of 4.2 MPa (600 psi) from a third-point loading test. A random sample of ten 5-day breaks on these beams yielded an average modulus of rupture of 5.4 MPa (789 psi) with a standard deviation of 0.6 MPa (87 psi).

Pavement Joints

Initial saw cutting took place a few hours after the paving operations, as soon as the concrete had developed enough strength to support the saws. Typically, two saws were used, with one operator per saw. Because of prevailing cold temperatures and the mix design adopted, it was sometimes found that the concrete had not set up uniformly through the slab thickness by the time the original joint cut was made, which resulted in considerable joint spalling. It appeared that the concrete was setting from the bottom up, because the underside of the slab was warmer than its top, and some shrinkage cracks were initiated before the initial cut. Subsequently, a lighter Soff-Cut saw was used, which enabled the crew to make the cuts as specified. Several short sections in which premature shrinkage cracks had formed before the first saw cut, or in which excessive joint spalling had developed, were removed and replaced after the concrete had cured.

The widening cut was made with a 65-HP Core Cut saw, typically 1 day before sealant installation. Usually, two saws were used, with one operator per saw. After widening, the joints were cleaned with pressurized water and air. They were flushed with water at 14 MPa

(2,000 psi), air-blasted at 0.7 MPa (100 psi), and then allowed to dry, typically overnight. Sandblasting was not deemed necessary in the interest of practical expediency, because the joints had already been thoroughly cleaned of all residue. Manufacturer specifications for some of the materials used are silent regarding the need for sandblasting, whereas others suggest it as an option or even require it. This variability is probably explained by the logistical cost sandblasting will inevitably add to the use of any particular product.

After the cleaned joints that were to be sealed with silicone or hot-applied sealants had dried, backer rod was installed. Backer rod sizes of 6, 8, and 13 mm (¼, 5⁄16, and ½ in.) were used, depending on the joint configuration. Typically, the backer rod was 3 mm (⅛ in.) larger than the joint opening. The backer rod was laid out across the pavement surface and rolled into place using a special hand tool.

To verify compliance with specifications pertaining to joint width and depth to backer rod, several series of measurements were made at randomly selected locations of the test section on 3 separate days during the second construction phase (1998–1999 season). Most of the joint widths were within the specified tolerance, but two sections were outside of the specified tolerance, both exceeding the specified dimensions. The average measured depth to backer rod was within the specified dimensions for each of the four sections in which this measurement was made.

JOINT SEALING OPERATIONS

Installation of Silicone Joint Sealants

Dow 890-SL

This self-leveling silicone sealant was used in joints of three test sections differing with regard to joint width and backer rod diameter, in both directions. The general installation routine started a few days before sealing, when joints were widened (if needed) and then cleaned by water- and air-blasting. After the joints were dry, the backer rod was installed. Immediately before the installation of the sealant, the joints were air-blasted clean again. Placement of this sealant typically involved three laborers. One drove a truck to which the sealant pump was mounted and which towed an air compressor. Another air-blasted joints in front of the truck, and the third sealed joints behind the truck. A supervisor monitored the operation periodically.

Crafco 903-SL

This self-leveling silicone sealant was installed in three test sections in the westbound lanes that differed with regard to joint width and backer rod diameter, but in only two sections in the eastbound lanes. Joints in a third test section in the eastbound lanes were filled with Crafco 902 non-sag silicone sealant instead. The general installation routine for the Crafco 903-SL and the personnel involved were identical to those for Dow 890-SL installation, described above.

Dow 888

Because of changes in the experimental plan precipitated by the unavailability of certain specified materials, this non-sag silicone sealant was installed in two identical test sections in both directions. The general installation routine began with widening and then water- and air-blasting the joints, usually several days before sealing. Backer rod was placed in clean and dry joints, usually on the day of sealing. Joints were air-blasted again immediately before the sealing operation, which generally involved four laborers. The first drove the truck carrying the sealant pump and towing the air compressor. The second worker air-blasted joints in front of the truck, and the third sealed joints behind the truck. A fourth laborer tooled the sealant in the joint with a piece of rubber tubing. A supervisor monitored the operation periodically.

Crafco 902

This non-sag silicone sealant was installed only in one eastbound section (Sta 200+00 to 206+00). The installation procedure was identical to that used for the Dow 888.

Installation of Hot-Pour Sealants

Crafco 444

This hot-pour, self-leveling sealant was installed in one section in both directions. Joints were widened and cleaned several days before sealing, and the backer rod was inserted shortly before sealing. The sealant was supplied in liquid form and heated to between 132°C (270°F) and 143°C (290°F) in the melter applicator unit. Two laborers were involved in the installation. One drove the truck, which towed the melter applicator unit, and the other applied the sealant from a hose fitted with a special metal tip.

Crafco 221

The second hot-pour, self-leveling sealant included in this experiment was used in joints of one section in both directions. The typical installation procedure was almost identical to that of the Crafco 444 except that Crafco 221 is supplied in solid block form and must be heated to between 193°C (380°F) and 210°C (410°F) at installation.

Installation of Preformed Compression Seals

Watson Bowman WB-812 and WB-687

The Watson Bowman WB-812 was installed in one section of the westbound lanes, and the WB-687 was installed in one section of the eastbound lanes. The only difference between the two seals is that WB-812 has a slightly larger cross-section than WB-687. The typical installation procedure began with joint widening, followed by cleaning with water- and air-blasting. After the joints were clean and dry, an installation machine was used to apply the adhesive to the preformed seal and insert it into the joint. Three laborers were required. One operated the installation machine and guided it along the joint while another held the seal as it was drawn into the machine and cut off the excess seal length. The third laborer passed over the seal with a roller device designed to set the seal to the desired depth.

Occasionally, problems with the machine were encountered, and seal installation was performed manually. In such a case, one laborer used his hands to coat the seal with adhesive, another squeezed the seal into the joint, and the last used the roller device to set the seal to the appropriate depth.

Delastic V-687

This compression seal was installed in one section in both directions. The typical installation procedure was identical to that for the Watson Bowman seals.

TechStar W-050

This compression seal was installed in one section in both directions. The joints were widened and cleaned using water- and air-blasting 1 or 2 days before sealing, and they were air-blasted again on the day of seal installation. A special adhesive from the seal manufacturer was used to hold the seals in place. The procedure involved two or three laborers, monitored by a supervisor.

PERFORMANCE OF TEST SECTIONS TO DATE

The condition of the joint sealants in the test sections was visually inspected on two occasions. The first was in October 1998, when the University of Cincinnati research team, accompanied by Mr. Lynn Evans of ERES Consultants, Inc., surveyed the newly constructed eastbound lanes from Sta 154+00 to Sta 290+00. Because both lanes served traffic at the time (one in each direction), the inspection was conducted from the shoulder adjacent to the outer (driving) lane. The air temperature was 21°C (70°F), and weather conditions were partly cloudy.

A second visual inspection, which included both the eastbound and westbound lanes, occurred over 2 days in May 1999. Both days were hot and dry. The pavement temperature on the first day was recorded as 41°C (105°F) at 4 p.m., whereas on the second day it was 21°C (69°F) at 9 a.m. and 27°C (80°F) at 12 noon. The eastbound lanes had been open to traffic for more than a year by the time of the second inspection, whereas the westbound lanes had been operational for about 2 weeks. Because of continuing striping operations, only one lane was open to traffic in each direction, and the evaluations were again conducted from the shoulder. It is anticipated that in the future both lanes will be available, allowing for more detailed evaluations and measurements of observed distress indicators in accordance with a statistical plan similar to that followed in the SHRP SPS-4 studies.

The observations at the time of the second visual inspection (May 1999), concerning the condition of the eastbound lanes only, are summarized below.

Crafco 903-SL (Sta 188+00 to 194+00)

The sealant in this section was in fair condition, exhibiting loss of adhesion or sunken seal over about 20 percent of the joint length. The typical recess was approximately 3 mm (⅛ in.), and intermittent sections of sealant were exposed at the surface.

Crafco 903-SL (Sta 206+00 to 213+00)

The sealant in this section was in poor condition. It was estimated that over about 30 percent of the joint length, the sealant had developed full-depth adhesion loss and had been pulled away by traffic or had sunk into the joint. Much of the remaining sealant was exposed at the pavement surface, exhibiting no recess. The narrow joint design [3 mm (⅛ in.)] seems to have hindered proper sealant installation with the conventional sealing devices used, which was reflected in unsatisfactory sealant condition.

Dow 890-SL (Sta 166+00 to 172+00)

The sealant in this section was in fair condition. It was recessed to less than 3 mm (⅛ in.) over more than 50 percent of the joint length, and intermittent sections were exposed at the surface of the pavement. Full-depth adhesion loss was evident over about 10 percent of the joint length, over which the sealant had sunk into the joint.

Dow 890-SL (Sta 213+00 to 219+00)

The sealant in this section was observed to be in poor condition. Some of it had been pulled away by traffic or had sunk completely into the joint. The sealant was exposed at the pavement surface over approximately 50 percent of the joint length, and the remainder showed a recess of less than 3 mm (⅛ in.). Once again, the narrow design of the joints [3 mm (⅛ in.)] appeared to have hampered effective sealant installation, resulting in the poor condition observed.

Dow 890-SL (Sta 266+00 to 272+00)

The sealant in this section was in poor condition. Inadequate recess [3 mm (⅛ in.) or less] was typically noted, and the sealant was exposed to traffic wear over approximately 50 percent of the joint length. Full-depth adhesion failures also were quite common, typically over 40 percent of the joint length.

Crafco 902 (Sta 200+00 to 206+00)

This sealant was observed to be in fair condition, reflecting somewhat better sealant installation in the 10-mm (⅜-in.) joints, yet exhibiting many of the same distresses as the previous silicone sealant sections. The sealant had sunk over approximately 20 percent of the joint length. Elsewhere, the sealant material showed uneven recess, sometimes less than 3 mm (⅛ in.), and intermittent sections were exposed at the slab surface.

Dow 888 (Sta 272+00 to 284+00)

Whereas the design of the two Dow 888 sections is identical, this sealant appeared to be in worse condition. Full-depth adhesion failure was observed for at least 30 percent of the joint length, much more in some sections. Inadequate recess was common, and the sealant sometimes was exposed to traffic wear.

Dow 888 (Sta 284+00 to 290+00)

The sealant in this section was in fair condition. It had experienced full-depth adhesion failure and had sunk over approximately 20 percent of the joint length, and the remainder typically was recessed about 3 mm (⅛ in.).

Crafco 444 (Sta 172+00 to 188+00)

This hot-pour sealant section was in fair condition. Full-depth adhesion loss was estimated at about 20 percent of the joint length, and small bubbles were evident in the surface of the sealant. The typical recess was approximately 3 mm (⅛ in.), and the sealant was exposed at the pavement surface over approximately 10 percent of the joint length.

Crafco 221 (Sta 260+00 to 266+00)

The hot-pour sealant in this section was in poor condition. Over a considerable length (occasionally in excess of 50 percent) the joint exhibited adhesive failure, and the sealant did not even touch the joint walls in some sections. In several places (typically about 20 percent of the joint length), the sealant had sunk into the joint. Bubbles were evident in the sealant surface.

Watson Bowman WB-687 (Sta 194+00 to 200+00)

In contrast to the preceding silicone sealant sections, the compression seal in this section was in very good condition. No signs of compression set were observed, and the seal remained tight and untwisted against the joint walls. The seal was typically recessed 3 to 6 mm (⅛ to ¼ in.), and a minimal amount of debris had accumulated above the seal.

Delastic V-687 (Sta 225+00 to 231+00)

The compression seal in this section was in very good condition, with no obvious distresses or signs of compression set. The sealant appeared to be adequately recessed to approximately 3 to 6 mm (⅛ to ¼ in.) and remained tight and untwisted against the joint walls. Some debris accumulation, consisting of sand and organic matter from nearby trees, was found in most joints.

TechStar W-050 (Sta 154+00 to 160+00)

The condition of the compression seal in these joints was poor. Loss of adhesion between the seal and the joint walls was evident over about 30 percent of the joint length, and the seal was sunk deep into the joint. In many locations, the hardened adhesive that used to hold the seal was still visible close to the pavement surface. Where the seal was visible, it exhibited a typical recess of 3 mm (⅛ in.).

No Sealant (Sta 219+00 to 225+00)

The joints were observed to be in very good condition with no signs of spalling or joint-related distresses. Only a limited amount of debris had accumulated, but the joints still remained open, possibly because of the narrow design of the joint. [The joints in this section were originally cut to 3 mm (⅛ in.) using a Soff-Cut sawing system and received no additional cut.]

No Sealant (Sta 160+00 to 166+00)

The unsealed joints in this section were in very good condition, with no spalling or other distresses observed. In the driving lanes, the joints appeared open and clean with no major infiltration of incompressible materials. Over the shoulder width, however, the joints were almost full of sand and other debris.

CONCLUSIONS AND RECOMMENDATIONS

Because this project is currently at its midpoint and the westbound lanes have only recently been opened to traffic, a complete analysis of pavement and sealant performance is not possible at this time. The deteriorating condition of the sealants in the eastbound lanes, however, which have been open to traffic for just over a year, provides the opportunity for drawing some general conclusions and for formulating some preliminary recommendations.

Consider, for example, the condition of the silicone and hot-pour sealants in the eastbound lanes. After only 1 year of service, these sealants are in fair to poor condition. Many of these sections have already experienced significant full-depth adhesion failure, with the sealant either sinking completely into the joint or being pulled away by traffic. Consequently, serious consideration needs to be given to the joint cleaning and sealant placement operations used. The two most significant shortcomings appear to have been the omission of sandblasting during placement and inadequate sealant recess.

The worst of the sealed sections were those with narrow 3-mm (⅛-in.) joints. In these joints, the sealant material had overflowed and run onto the pavement surface, where it was exposed to tire traffic. Oversight and inspection provided were ineffective in averting the use of equipment and procedures that were obviously inadequate. Special nozzles or applicators must be used so that the sealant will be placed from the bottom up at a slow rate, so that the joints are not overfilled. Moreover, because even some of the wider joints exhibited overfilling, more than just the equipment used needs to be reconsidered. The backer rod should be placed with care, subject to stringent inspection, so that the proper depth and continuity are maintained.

Two other extremely important considerations are joint cleaning and joint condition at the time of placement. The joints in this experiment were cleaned only by water- and air-blasting, even when the sealant manufacturer recommended or required sandblasting. It is possible that the extensive adhesion loss is related to the joint cleaning procedures. Sandblasting provides a rough surface for the sealant to bond to, but even it may not be enough. The surfaces of the joints need to be inspected before sealing to ensure that they are clean and free of moisture, because this detail is important in obtaining effective, long-lasting sealed joints. If the equipment and procedures used in placing silicone and hot-pour sealants during this experiment represent the conditions on a typical highway construction site, it appears probable at this time that not sealing would have been a preferable alternative, in terms of convenience as well as cost.

With the exception of the TechStar W-050, the preformed compression seals have exhibited significantly better performance to date than liquid sealants. Both the Watson Bowman and Delastic seals were performing very well, with no visible signs of adhesion loss or other distress, at the time of the second visual analysis. The adhesive used with these seals appears to result in a more durable bond between the seal and joint walls. The TechStar seal did not perform as had been anticipated, if only by its much higher cost, and had developed significant adhesive failure by the time of the second visual inspection. The seal had simply broken free of the proprietary adhesive and had sunk into the joint, leaving the dried-out adhesive visible on the joint walls near the pavement surface. Although it is not possible to verify the causes of such adhesion failure at this time, incompatibility between the adhesive and the seal cannot be excluded.

The unsealed sections also were performing very well, exhibiting no visible signs of distress at the joints (e.g., spalling) or in the pavement slabs. Small debris had entered the shoulder joints, but the traffic lane joints were still fairly open and clean. No blowups or loss of subbase support had occurred. Interestingly, no mention has been made of any distresses or problems with the unsealed sections in the SHRP SPS-4 supplemental joint seal experiment (*7*), either. It is worthwhile to continue monitoring unsealed sections and to compare their performance with that of sealed sections. If no significant differences in performance can be found, leaving PCC pavement joints unsealed should be considered a cost-effective design feature.

This project will undergo several more years of evaluation; conclusions reached thus far are based only on relatively early observations. It is hoped that future evaluation of both the westbound and eastbound lanes will provide significant feedback regarding the effectiveness of current joint sealing procedures.

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