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Office of Research

PCC/AC Shoulder Joint Seal Evaluation

Study SD96-10
Executive Summary

Prepared by
Office of Research
South Dakota Department of Transportation
Pierre, South Dakota 57501-2586

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This work was performed under the supervision of the SD96-10 Technical Panel:

Gary Buchele.....Aberdeen Region
Joe Feller..... Materials and Surfacing
Jon Becker.....Office of Research
Dale Russell.....Rapid City Region
Mike Young.....Operations Support
Dan Johnston .....Office of Research

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16. Abstract

This report presents the findings on the evaluation of Crafco Incorporated Roadsaver 903 SL Silicone Sealant and Dow Corning 890 SL Silicone Sealant. The Research Technical Panel had proposed to use the two self-leveling silicone joint sealants in test sections to seal longitudinal joints between Portland Cement Concrete Pavements (PCCP) and Asphalt Concrete (AC) shoulders.

The SDDOT Materials Lab conducted in-house tests on both the Crafco Incorporated Roadsaver 903 SL Silicone and Dow Corning 890 SL Silicone sealants. The results of the tests were compared to the SDDOT 1998 *Standard Specifications for Roads and Bridges*, Section 870 Concrete Joint Sealer Specifications as well as to each manufacturer's silicone sealant specifications. Military Specification S-8802E and ASTM Designation 5893-96 *Standard Specification for Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements* were reviewed to determine appropriate curing and tack free times for the silicone samples.

Neighboring states were contacted to determine if they used silicone sealants to seal longitudinal joints between PCCP and AC pavements. The results of the survey, as well as recommendations from Crafco Incorporated are contained in the report. Based on this information, the researcher recommended that the SDDOT only allow the use of approved hot-pour sealants for PCCP/AC longitudinal joints.

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Background

This report presents the findings and recommendations on the evaluation of two self-leveling silicone joint sealants which were to be used to seal longitudinal joints between Portland cement concrete pavements (PCCP) and asphalt concrete (AC) shoulders. The study was to be a follow-up of SD90-13, "*PCC/AC Shoulder Joint Seal Evaluation*". Evaluations were conducted on Crafco 903 Roadsaver Silicone SL Sealant and Dow Corning 890-SL Self-Leveling Silicone Joint Sealant.

For years 3405 Modified Joint Sealant has been used to seal the longitudinal joints between PCCP and AC pavement. Sealing longitudinal joints is important, because the intrusion of moisture can remove fine aggregates, causing faulting or settlement of the asphalt at the joints. Because the 3405M sealant has failed in many installations throughout the state, several test sections were installed using silicone joint sealants developed by Dow Corning. Dow 888 SL was evaluated in 1988, and Dow 890 SL was evaluated in 1990-1994. Dow 888 SL was developed for use on PCCP pavements only, while the Dow 890 SL was developed for use on PCCP pavements as well as for sealing joints between PCC and AC pavements. The initial evaluation of the 890 SL Silicone sealant was reported in the SD90-13 report.

As documented in the SD 90-13 research study, the Dow 890 SL Silicone sealant performed well for five years, but because of its long curing time, Dow Corning decided to reformulate the product. Following the reformulation, samples of Dow 890 SL were obtained and tested in the South Dakota Department of Transportation (SDDOT) Materials Lab. The results of those tests will be presented in this report.

Research Objectives

The technical panel overseeing Research Project SD96-10 "PCC/AC Shoulder Joint Seal Evaluation" defined the following objectives for the study:

1. To identify product(s) for use in longitudinal PCC/AC shoulder joint applications.

2. To evaluate the product(s) in laboratory and field tests and compare to 3405M.

3. To verify or recommend specifications for PCC/AC shoulder joint sealants.

Literature Review

A Transportation Research Information System (TRIS) literature search was completed to obtain background information on joint sealants, construction methods, and specifications. In addition, Dow Corning Corporation and Crafco Incorporated were contacted to request product

information and samples of silicone sealants. Neighboring states were contacted in January 1999 to determine what products they were using to seal longitudinal joints between PCCP and AC shoulders. Responses indicated that the majority of PCCP/AC longitudinal joints were sealed with hot-pour sealants.

Most of the information obtained from the TRIS search focused on the use of hot pour materials to seal shoulder joints. Several articles also identified various design approaches that can be taken to minimize the longitudinal pavement shoulder joint problem. These included providing either one or a combination of the following: a structurally adequate shoulder section; sawing and sealing the longitudinal joint; and a positive means for removal of water from the vicinity of the longitudinal joint.

Information indicated that the use of full depth asphalt concrete and Portland cement concrete shoulder sections could greatly reduce distress near the longitudinal joint. It was emphasized that the shoulder in the vicinity of the longitudinal joint should be designed to carry the anticipated truck traffic encroaching on the shoulder.

Both manufacturers provided information on joint sealing techniques and products. The Crafco Incorporated information described two types of problems that can develop when edge joints remain unsealed. The first problem is water infiltration. The water is able to enter unsealed joints and weaken the underlying sub-base material. The moisture problem is compounded by the fact that all PCC roadways are designed to drain surface moisture towards the edge joint and roadway edge. Consequently, unsealed edge joints are subject to a greater amount of moisture infiltration and pavement damage than other roadway cracks and joints.

Secondly, incompressible materials restrict natural thermal movement. During cold weather, the PCCP and AC pavement will contract, creating a wider joint opening that allows sand, rocks, and other incompressible debris to enter the joint. These incompressible materials can lead to structural failure by restricting joint movement and pavement expansion when warmer temperatures return.

Crafco Incorporated literature states that sealing the edge joints with hot pour polymer modified asphalt sealants can prevent intrusion of moisture and incompressible materials and maintain a high quality pavement. The literature also states that sealing this joint with a selected hot pour polymer modified asphalt sealant is less expensive than using silicone sealants.

Specifications

The SDDOT 1998 *Standard Specifications for Roads and Bridges,* Section 870 Concrete Joint Sealer, defines requirements for both Hot Pour Elastic Joint Sealer and Low Modulus Silicone Sealant. This research report reviews these SDDOT silicone sealant specifications along with those provided by Dow Corning Corporation, Crafco Incorporated, 1982 Military Specification MIL-S-8802E, and the American Society for Testing and Materials (ASTM) Designation D5893-

96 *Standard Specification for Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements*.

ASTM D5893-96 references the appropriate terminology and test methods for silicone sealants. Selected terms are as follows:

1. Type NS (Non-Sag) - A single component sealant that resists sagging after application in horizontal joints and requires tooling or forming into the joint to achieve the desired application configuration.

2. Type SL (Self-Leveling) - A single component sealant that is self-leveling and has sufficient flow characteristics to form a smooth and level surface in horizontal joints without tooling or forming after application.

3. Tack-Free Time - The sealant shall be tack-free, with no transfer of the sealant to the polyethylene, when tested at 5 hours + or - 10 minutes in accordance with Test Method C679.

4. Cure Evaluation - The sealant shall cure throughout a 12.7 by 12.7 mm (0.5 by 0.5 in.) cross section within 21 days when evaluated in accordance with specified testing procedures. At 21 days + or - 4 hours of curing, the sealant shall not show the presence of any uncured material, as indicated by sealant that has not changed from a liquid to a solid state.

A review of the SDDOT specification indicated that there are several sections that may have to be further evaluated due to changes in the types of silicone sealant. The current specification does not allow for Type SL (Self-Leveling) silicone. This is especially evident by the tack-free time allowed, and the 7-day cure time requirement. The tack-free time and the 7 day cure time could also impact Type NS (Non-Sag) silicone. Other possible items to be evaluated would include elongation, movement and adhesion requirements, as well as testing methods.

The SDDOT silicone tack-free time testing methods are defined in Military Specification MIL-S-8802E, Amendment 3, dated 28 August 1984. A review of Section 4.8.8 Tack-Free Time describes the procedures used to determine the tack-free time. It should be noted that this section does not differentiate between NS or SL silicone types. Furthermore, it refers to "freshly mixed sealing compounds". Both of the silicone sealants that were evaluated in this study are "Single Component".

The same section refers to section 3.3.8 to determine the tack-free time. A review of that section shows 10 hours or more for tack-free time, or "as specified". There are no other times specified in the reference. It appears that the tack-free time specified in the SDDOT Requirements (20 - 75 minutes) may have come from an older Dow Corning 888 NS manufacturer's specification.

Table 1 identifies several sets of specifications dealing with silicone sealants. Each category has one or more items that are different from the SDDOT Section 870 Specification. These may need to be further evaluated by the Office of Materials & Surfacing to determine if the current

SDDOT specification should be modified to reflect changes in the types of silicone currently being used.

Selected Silicone Sealant Specifications

Specification	Tack Free Time	Cure Time	Tensile Stress	Elongation	Tensile Adhesion
SDDOT	20 - 75 Minutes (MIL-S-8802E)	7 Days	45 PSI Max (ASTM D412)	1000% Min (ASTM D412)	500 % (SDDOT Sec 870)
Crafco Roadsaver 902 NS	25 - 90 Minutes (ASTM C679)	14 Days Max	45 PSI Max (ASTM D412)	800% Min (ASTM D412)	400 % Min (ASTM D 5329)
Crafco Roadsaver 903 SL	3 Hour Max (ASTM C679)	21 Days Max	30 PSI Max (ASTM D412)	800 % Min (ASTM D412)	600% Min (ASTM D5329)
Dow Corning 888 NS	60 Minutes (Dow CTM 0095)	7 - 14 Days	45 PSI Max (ASTM D412)	1200 % Min (ASTM D412)	500 % Min (Not Available)
Dow Corning 890 SL	60 Minutes (Dow CTM 0095)	14 - 21 Days Max	9 PSI Max (ASTM D412)	1400 % Min (ASTM D412)	600% Min (Not Available)
Military Spec MIL-S-8802E	10 Hours or as specified	*To be determined	(Not Available)	(Not Available)	(Not Available)
ASTM D5893-96	5 Hours (ASTM C679)	21 Days (ASTM D5893)	45 PSI Max (ASTM D412)	600% Min (ASTM D412)	(Not Available)

Table 1 Comparison of Silicone Sealant Specifications (Test - Method)

Lab Tests

The Dow Corning 890 SL Silicone sealant has been evaluated in the SDDOT Materials Lab on several occasions. Following its reformulation in the early 1990's, the sealant was evaluated in the lab but failed to meet the manufacturer's specifications. On August 9, 1996, the SDDOT lab again evaluated the product. During that test, the silicone sealant required over five hours to become tack-free. The product also failed its specific gravity test. Lab results showed a specific gravity of 1.0 as compared to the manufacturer's specification of 1.26-1.34.

In January 1997 the researcher contacted the Dow Corning supplier to obtain an additional sample of the 890 SL Silicone for evaluation. The sample was received on January 17, 1997.

The following week, the researcher received a call from the supplier and was told that the sample was bad and the SDDOT should not conduct lab tests on the product. A new sample was sent to the Office of Research on March 6, 1997.

Crafco Incorporated was also contacted to obtain a sample of the Crafco Roadsaver 903 SL Silicone. The researcher received a sample for evaluation on February 20, 1997. Shortly thereafter, a representative from Crafco Incorporated met with the researcher to discuss the evaluation of their products. During that meeting, the company representative indicated that the company would prefer that the Crafco Roadsaver 903 SL Silicone product not be used to seal a PCCP/AC shoulder joint. While the 1995 Crafco Incorporated Roadsaver 903 SL Silicone Sealant product literature stated that the silicone sealant could be used in all typical concrete/asphalt joints, the literature was changed in 1996 to delete this reference.

On April 14, 1997 the SDDOT Materials Lab tested the Dow Corning 890 SL and the Crafco Roadsaver 903 SL silicones. Neither product was considered tack-free after three hours. At approximately three hours into the test, the Crafco Roadsaver 903 SL Silicone was developing a very light skin, however it would still stick to your finger when touched lightly. At approximately three and one-half hours into the test, the Dow Corning 890 SL Silicone was developing a very light skin, but it would still stick to your finger when touched lightly. The SDDOT Bituminous Lab Supervisor considered neither product to be tack-free.

After 21 days of curing time, both products were tested according to the SDDOT Section 870 requirements. The Dow Corning 890 SL Silicone had a durometer reading of 5. The SDDOT 870 specification requires a minimum durometer reading of 10. In addition, the bond to briquettes test had a reading of 44. The SDDOT 870 specification requires a minimum bond to briquette reading of 50. The Bituminous Lab Supervisor stated that the specimens used in the bond test did not appear to be completely cured.

The Crafco Roadsaver 903 SL Silicone had a durometer reading of 6, as compared to the SDDOT 870 specification requiring a minimum of 10. It should be noted that the bond to briquettes test resulted in a reading of 90, which is above the SDDOT minimum requirement of 50.

Neither of the two SL silicone sealant samples met their manufacturer's specified tack-free times. The Crafco Roadsaver 903 SL Silicone has a 3-hour maximum tack-free time specification for 1999. This is up from the 1997 Crafco tack-free time specification of 2 hours. The Dow Corning 890 SL Silicone has a manufacturer's tack-free time specification of 60 minutes.

Crafco Inc. Letter on Sealing Shoulder Joints

The Office of Research received a letter from Crafco Incorporated dated March 28, 1996. The letter reviews the 1991-1992 Strategic Highway Research Program (SHRP) evaluation of the performance of various sealants in AC pavement. The letter also reviews the average overall percentage of failures when using silicone Vs the manufacturer's specified hot-pour products.

The following two paragraphs state the manufacturer's concerns with the use of silicone to seal edge joints between PCCP and AC pavement:

> "The major mode of failure with silicone in AC pavement is edge deterioration. Edge deterioration is described as secondary cracks that develop adjacent to the original crack or joint face. This cracking can begin during hot summer weather when the tensile strength of silicone becomes stronger than the AC pavement. These cracks become more noticeable when the pavement contracts during colder weather. Modulus of hot-applied sealant and AC pavement change proportionally, silicone does not. Consequently, edge deterioration in AC pavement rarely occurs when a high quality hot-applied sealant is utilized."

> "Crafco Roadsaver Silicone adheres well to AC like most silicones, however, we recognized this tensile strength deficiency and potential high rate of failure long ago. Crafco believes that to best serve the industry, silicone sealant should only be promoted for use in PCCP joints where its properties enable it to be one of the best performing most cost efficient formed-in-place joint sealants available."

Other State's Practices

Neighboring states were contacted to determine if they used silicone sealants to seal longitudinal joints between PCCP and AC. The results of that survey are as follows:

Nebraska Department of Roads, Scot Grosenbacker, indicated that NDOR uses hot-pour only to seal longitudinal joints. The sealants must meet ASTM D5078 *Standard Specification for Crack Filler, Hot-Applied, for Asphalt Concrete and Portland Cement Concrete Pavements.* The hot-pour sealants are either tested in-house and must meet the specifications, or the NDOR must get a letter of compliance that the products meet the specification. The projects are bid by specification since the NDOR does not have an approved products list. Mr. Grosenbacker indicated that the NDOR was not satisfied with the performance of Dow Corning 890 SL so very little of the product has been used.

Wyoming Department of Transportation, Bob Rothwell, indicated that WYDOT has used silicone sealants mainly on urban projects. They do not use silicone on rural projects. Their specifications will allow NS silicone on PCCP transverse joints.

Minnesota Department of Transportation, Roger Olson, stated that they hardly ever seal longitudinal joints between AC and PCCP. They currently use a very narrow cut and are having a lot of problems with shoulder subsidence. He expects that they will start sealing these joints soon and will be using Crafco 231 hot-pour. He doesn't anticipate the use of silicone sealants. Edge drains are also being used but they are having problems with them as well, including swelling during freeze-thaw cycles.

North Dakota Department of Transportation, Clayton Schumaker, stated that they use Crafco 231 hot-pour for their longitudinal joints. They have used silicone sealants on transverse joints but

have had many problems with leaks developing. The NDDOT has used Dow Corning 888 NS Silicone Sealant, but they have not used the 890 SL sealant. They are currently experimenting with a 1/8-inch cut and no seal on PCCP projects with PCCP shoulders. They do not have an approved products list and require products to be certified.

Iowa Department of Transportation, Kurtis Younkin, stated that the IDOT has not had much success with silicone or neoprene sealants. He stated that they can't justify the high cost of silicone for sealing longitudinal joints. The IDOT mainly uses hot-pour 3405 modified materials for sealing longitudinal joints, including both Crafco and W. R. Meadows products.

Montana Department of Transportation, Ken Neumiller, stated that they have a Special Provision that calls for a hot-pour rubber-asphalt compound joint sealant material that meets the requirements of ASTM D3405 for sealing shoulder joints.

SDDOT Certification Section Approved Product List

The SDDOT Materials & Surfacing Section has compiled a list of approved products for sealing joints. The documentation states that the following Low Modulus Silicone Sealants have been approved: Crafco, Inc. Roadsaver Silicone Sealant, and Dow Corning Dow 888. Both of these are NS Silicone Sealants. No SL Silicone Sealants are allowed at this time.

The following Hot-Poured Elastic Joint Sealer Meeting ASTM D3405 are allowed: Crafco, Inc. 221; Koch Materials 9005; W.R. Meadows, Inc. Hi-Spec; and W.R. Meadows, Inc. Sealtight 3405.

The following Hot-Poured Elastic Joint Sealer Meeting ASTM D3405 With Modifications For Penetration and Bond are allowed: Crafco, Inc. 231; W.R. Meadows, Inc. Sof-Seal; and W.R. Meadows, Inc. Sealtight 3405 Modified.

A review of Strategic Highway Research Program (SHRP) data as furnished in a 1997 report from ERES Consultants, Inc. shows that some products do perform better than others. Depending upon the location of the test site and the installation method for PCCP joint sealants, data shows that the Koch Materials 9005, Crafco 221 and 231, Dow Corning 888 NS, Crafco Roadsaver NS Silicone Sealant, and Mobay 960 all had varying rates of success. These products seemed to out-perform the other products that were tested.

It is interesting to note that these same products, with the exception of the Mobay 960, are all on the SDDOT approved products list. So even though we continue to have problems in the field, we are currently specifying the products that are performing the best in the SHRP studies.

The researcher attended the 1997 Transportation Research Board meeting in Washington D.C. where several sessions were conducted on the performance of joint sealants. The speakers for Session 264 *Performance and Cold Temperature Specifications of Bituminous Crack Sealants; and Crack Sealant Performance in Cold Urban Conditions* indicated that 12 different sealants were evaluated in the lab and in the field. The results showed that in the short term early sealant

failure was common even with strict adherence to installation guidelines. Long term evaluations between 1992 and 1995 showed that all sealants had failures. The studies did show that sealants in transverse cracks show more failure than longitudinal cracks. The speakers did not say if any of the tested sealants were used on longitudinal joints between PCCP and AC pavements.

Conclusions and Recommendations

While one of the original tasks of this research project was to evaluate the products in the field, this was not completed because the two SL silicone sealants that were tested in the SDDOT Materials Lab did not meet their own manufacturer's specifications. The Dow Corning 888 NS Silicone and the Crafco Roadsaver NS Silicone were not evaluated in the lab because both of these products are currently on the SDDOT Approved Products List and can be used to seal PCCP transverse and longitudinal joints. However, neither of these products is allowed on shoulder joints between AC and PCCP.

A review of other state's practices and the March 28, 1996 letter from Crafco Incorporated indicate that the use of silicone sealants on asphalt concrete pavement joints is not an acceptable alternative to the use of hot-pour materials. Furthermore, the SHRP studies verify that the Hot-Pour products that the SDDOT currently uses are the most cost-effective materials available for sealing longitudinal joints between PCCP and AC pavements.

Finally, a review of the SDDOT Section 870 Concrete Joint Sealer Specifications indicated that several areas of part B of the specification are different than the manufacturer's silicone sealant specifications as well as the Military Specifications and ASTM D5893-96. These may need to be further evaluated by the Office of Materials & Surfacing to determine if the current SDDOT Section 870 Specifications should be modified to reflect changes in the types of silicone sealants currently being used.

Based on the literature review and lab tests completed for this research project, the following recommendations are offered for consideration by the South Dakota Department of Transportation Research Review Board:

1. **The SDDOT should only allow the use of approved hot-pour sealants for PCCP/AC longitudinal joints until other cost-effective products can successfully be demonstrated.** The March 28, 1996 Crafco Incorporated letter reflects the current industry recommendations with regards to the use of silicone and hot-pour sealants on PCCP/AC joints. While silicone is accepted on PCCP pavements, the industry does not recommend its use on AC pavements. In addition the SDDOT Approved Products List identifies the hot-pour products that showed the most success during the SHRP studies.

2. **The SDDOT Office of Materials & Surfacing should review Section 870, Concrete Joint Sealer, to determine if the tack-free time and curing time for silicone sealants as designated in ASTM D 5893-96 should be incorporated into the SDDOT Specification.** The ASTM specification covers cold applied, single component, chemically curing silicone

sealants including both non-sag and self-leveling types of sealants. Since the SDDOT already has Crafco Roadsaver NS Silicone and Dow Corning 888 NS Silicone on its approved product list, it may be important to have an ASTM Specification that actually references a "single component" rather than a "freshly mixed sealing compound" as referenced in the Military Specifications. In addition, the Crafco Roadsaver NS Silicone has a manufacturer's recommended cure time of 14 days maximum, and a tack free time of up to 90 minutes, both of which are different than the SDDOT Section 870 Specifications. However, it should be noted that when these products are used on South Dakota Highways, they must meet the current SDDOT 870 Specification.

3. **The SDDOT Office of Materials & Surfacing should continue to monitor the development and use of both SL and NS Silicone Sealants.** While the SL samples that were evaluated as a part of this project failed to meet their manufacturer's specifications, they do represent a change in the silicone industry that should be monitored by the SDDOT on a continuing basis.