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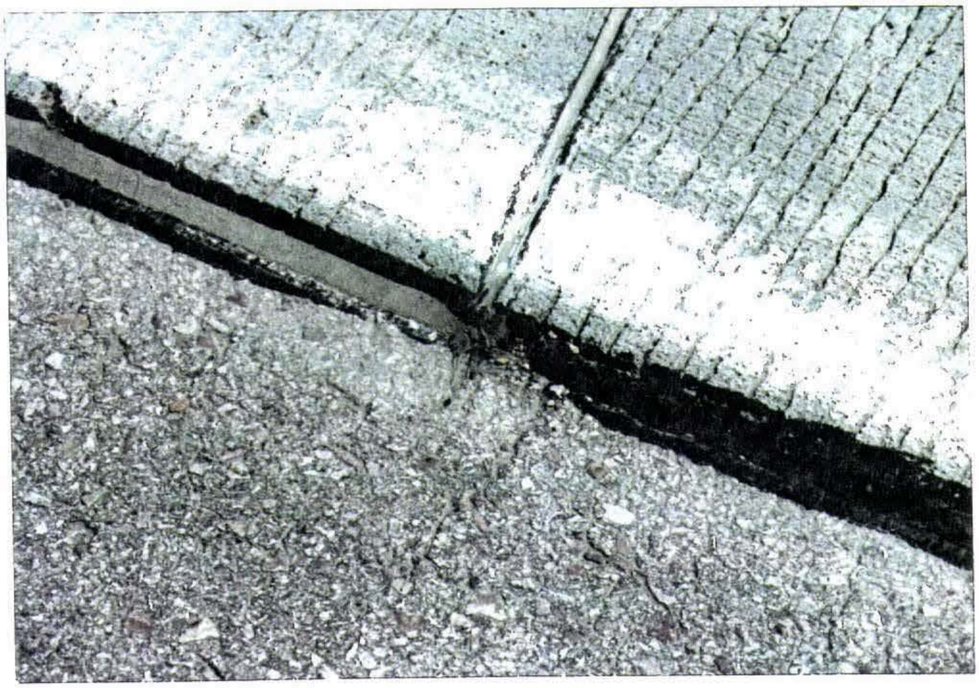

PCC/AC Shoulder Joint Seal Evaluation

Study SD90-13
Final Report

Prepared by
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DISCLAIMER

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16. Abstract

In July, 1989 a test section of Dow Corning 890SL self-leveling silicone joint sealant was installed on Eastbound Interstate 90 near the Tilford Weigh Station. The application involved the routing and sealing of a 450 foot stretch of asphalt shoulder adjacent to the jointed plain PCC pavement. Two different vessel widths -2" and 1¼" -were used. Sealant depth varied between ¾" and 1" with the seal recessed about ½" below the pavement edge to avoid adhesion problems due to residual sealant which had been previously used in the shoulder joint. A ¾" bond-breaking tape was placed on the vessel bottom to prevent three-sided adhesion of the sealant. A short section of the seal was placed without tape to determine whether use of a bond-breaker is critical. Installation of the sealant was cumbersome due to both the difficulty in routing the vessel and the relatively slow placement of the self-leveling sealant. None of the equipment used was appropriate for this application including the router head,the pump and the sealing tip.The test section was monitored twice yearly for 5 years and during this period all sections performed well with no loss of adhesion or penetration of debris through the sealant. The ultra-low modulus of the material apparently prevents stress concentration at the pavement-shoulder interface and the material is compatible with both the PCC and the AC. The minor drawback of inefficient installation could probably be addressed with appropriate modifications to existing equipment without undue difficulty. The major drawback to the use of this material for routine PCC/AC shoulder joint sealing is the cost associated with the relatively large volume of the sealant vessel. It would take approximately 5.5 times more sealant material to seal the shoulders of one mile of PCC than is required to seal " transverse joints at a 20 foot joint spacing. This material is not recommended for shoulder joint sealing owing to its high cost. Use of smaller vessel dimensions may make its future use cost effective.

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Introduction

In 1988 the South Dakota Department of Transportation installed several test sections of a new, self-leveling silicone joint sealant developed by Dow Corning—Dow 888SL. At that time representatives from Dow Corning indicated that another new sealant material specifically designed for sealing the shoulder joint between an asphalt concrete shoulder and a portland cement concrete pavement was in the final stages of development. They invited our participation in a test installation during the summer of 1989 using their new material—Dow 890SL. The material has an extremely low modulus and is capable of bonding to both portland cement and asphalt concrete. This research was developed to monitor the performance of Dow Corning 890SL and to evaluate its potential use as a shoulder joint sealant.

Objectives

1) To determine if Dow Corning 890SL works.
2) To determine the optimum shape factor for the material using a minimum of material.
3) To determine actual water infiltration at a treated joint in the field.

Tasks

1) To monitor the performance of the existing test section.
2) To conduct laboratory tests on different joint vessel designs to see what vessel shape factor works using a minimum of material.
3) To install another test section of Dow Corning 890SL on a pavement fitted with edge drains and monitor outflow.

Test Section Installation

On July 12, 1989 a test section was placed along the shoulder of the eastbound driving lane of I-90 near the Tilford weigh station. The section is located at MRM 37.7 (begin station 327+05), extends along the shoulder for 450 feet (end station 331+55) and can be easily found by stopping at the "Weigh Station 1 Mile" sign on I-90. The 24' wide pavement is 10" jointed plain portland cement concrete over a 4.5" granular base with 4" asphalt concrete shoulders over a 6" subbase and was built in 1981.

The application of the Dow 890SL began with the routing of a suitable vessel for the sealant along the asphalt shoulder edge. Initial efforts to route the vessel in the asphalt concrete adjacent to the portland cement concrete (PCC) pavement edge resulted in an extremely wide (2") vessel for the first 22.5 ' of the test section. Adjustment of the routing procedure yielded a uniform vessel width of 1¼" for the rest of the segment. The equipment used for cutting the vessel consisted of a concrete saw for establishing the vessel edge in the asphalt concrete (AC) and a router which was not designed specifically for this type of application. As a result the routing was somewhat cumbersome. Modifications in equipment and procedures would be required before shoulder vessel routing could be accomplished as a routine, timely operation.

The original vessel parameters called for a nominal 1" depth but the softseal previously applied to the shoulder edge could not be removed using available equipment. The Dow-Corning representative, Cullen Case, felt that placement of the 890SL against the residual softseal would compromise the adhesion of the silicone and provide a template for sealant failure so the vessel depth was changed to 1¼" along the face of the PCC to insure that the top of the sealant was a minimum of ½" below the pavement edge. In future applications the edge of the PCC should be ground to remove all traces of 3405 modified softseal. The final depth of the vessel varied from 1¼" at the PCC joint to ¾-1" in the AC to avoid any adhesion loss due to the softseal.

Prior to placement of the sealant the vessel was cleaned with an air blast. The 890SL was applied using a standard silicone sealant pump with the pressure adjusted downward to 40 psi from the 80 psi normally used for Dow 888 silicone. After the follow plate was cleaned, four gallons of material were wasted through the lines to flush out the last traces of another silicone sealant Mobay 930 Baysilone. It was feared that the presence of this other sealant would interfere with the curing of the 890SL The 890SL is compatible with the other Dow silicone sealants so that flushing would not be necessary if these had been used prior to the 890SL.

Before the sealant was placed a ¾" bond-breaking tape was affixed to the vessel bottom to prevent three-sided adhesion of the silicone. The last fifteen feet of the test section did not have tape to determine how necessary a bond-breaker really is for this ultralow-modulus material. The tape was used as a substitute for conventional 1¼" backer-rod usually recommended for silicone joint seals because the depth required would have been in excess of 2". This would have substantially increased installation costs.

The application of the 890SL sealant went relatively well considering the operator was using a standard concrete joint tip and had some difficulty holding the edge. The application rate of this material at a nominal bead thickness of ½" was in the range of 10-15'/minute. The self-leveling occurred rapidly and with very little tendency for bubble formation or zoning. The surface of the sealant was recessed ½" below the pavement edge which made it difficult for the operator to judge whether enough material had been placed and created an illusion of nonuniform depth. Routine applications of this material without a recessed vessel should not be a problem. The last 16.4' of the test section was placed using using tubes of material instead of pumping from a drum which resulted in a slightly greater tendency for bubbling and variable bead thickness. An attempt to touch up "visually" low spots in the test section using silicone tubes was halted when a check of bead thickness indicated that the "low" spots were not short of material.

The only problem with the 890SL was its much slower curing rate compared to conventional silicone. The sealant did not skin over very rapidly and took 68 minutes to become tack-free. Even after a skin had formed the sealant remained extremely tender and could be punctured with minimum effort. Under no conditions should this material be placed until loose gravel and debris have been cleaned from adjacent areas. The sealant had not toughened up even twenty hours after completion of the test section. A check of the material two weeks after installation showed curing had occurred with substantial resistance to penetration, tremendous flexibility and only one area where a caulking tube cap had been driven, pointed-end first, through the seal.

A second test section was to be installed on a stretch of PCC/AC shoulder already fitted with retrofit edge drains. This section was to be placed in conjunction with another research project—SD90-06 *Evaluation of PCC Edge Drain Effectiveness*—using water outflow data from edge drain sections to determine the level of water intrusion with and without the silicone sealant on the shoulder. Unfortunately a combination of unavailability of the sealant due to an attempt to reformulate (to eliminate the problem with tack-free time), design changes to the edge drain backfill and the transfer of its principal investigator to another position made this proposed installation impossible. The lack of available sealant material from Dow Corning also made a laboratory investigation of the effect of shape factor difficult and the laboratory testing was eventually cancelled. Reformulating of the silicone sealant would have led to questions concerning the future performance of the material compared to the actual performance observed at the I90 test site.

Performance Evaluation

The test section was monitored semiannually until June, 1994 to determine whether the 890SL would maintain adhesion and act as a seal against water intrusion. The adjacent conventional 3405 modified softseal-treated shoulder joint was also monitored to note any differences in performance. The test site chosen for the installation showed no evidence of shoulder distress over the monitoring period and there was no sign of the typical shoulder subsidence commonly observed in eastern South Dakota. Throughout the five year period there were no failures in adhesion in the entire 450' test section regardless of vessel width or the presence of a bond-breaker. The softseal joint, on the other hand, failed in adhesion soon after installation and allowed water into the PCC/AC joint to a limited extent.

The appearance of the 890SL-sealed joint did not vary seasonly whereas the softsealed-joint looked much better in summer when the softening of the material and expansion of the pavement and shoulder provided the illusion of a seal. The softsealed-joint in winter was visually failed in adhesion. The recess in the silicone sealant test section acted as a trap for debris of all kinds-especially sand from winter maintenance operations. None of this debris penetrated the silicone over the entire test section and the resiliency of the material made forced penetration even under heavy truck loading unlikely. The performance of the Dow-Corning 890SL silicone joint sealant can be characterized as excellent.

One unfortunate drawback of this test section is its location. The rainfall at this location is only 20"/year and there is no evidence of hydraulic pumping or faulting of the pavement. As a result the silicone sealant was not exposed to any substantial shear forces. The low modulus sealant combined with the shape factor and lack of three-sided bond all act to concentrate stress due to thermal changes in the center of the sealant away from the vessel wall. The performance of silicone or any other sealant under vertical shear due to significant pavement deflection will radically degrade as the shear forces concentrate at the sealant/vessel wall interface and act to destroy the adhesion of the sealant to the pavement. The Dow 890SL was never subjected to this type of condition so its performance under vertical shear is unknown. A second test section with severe faulting and shoulder subsidence was proposed but never built due to delays and inability to obtain sealant.

Sealant Cost

A comparison of materials and installation costs for silicone sealant versus conventional softseal is difficult especially considering that there were no cost data available for the test section installation. The following cost analysis is estimated using SDDOT's current unit costs for joint and shoulder sealing on a primary two-lane highway.

The materials cost for the 890SL can be roughly estimated based on known costs for concrete silicone joint sealant. The current price of silicone is approximately $28/gallon and one gallon seals roughly 100 linear feet of " transverse joint. Assuming a nominal depth of ½" for a standard concrete joint seal the amount of material required to seal one mile of concrete joints would be 52.8 gallons. The amount of silicone required to seal one mile of PCC/AC shoulder joint with a width of 1¼" and depth of ½", on the other hand, would be 171.4 gallons. This equates, for a typical 12 mile 2-lane paving project, to:

Length of Project	12 miles
Concrete Joint Spacing	20 feet
Total length of Concrete Joints	76,032 feet
Total Length of Shoulder Joints	126,720 feet
Total Silicone Required (Concrete)	760.3 gallons
Total Silicone Required (Shoulder)	4113.6 gallons
Total Silicone Cost (Concrete)	$21,289
Total Silicone Cost (Shoulder)	$115,180
Total Softseal Cost (Shoulder) (@$.285/linear foot installed)	$36,115

The cost for the silicone alone on a primary highway shoulder sealing job is more than three times the entire installation cost of a softseal sealant installation. The installation cost of the silicone joint sealant is unknown but for comparison purposes the current total costs for concrete joint sealing are:

$1.25/linear foot (Primary)=$0.97/linear foot installation+$0.28/linear foot silicone

$2.00/linear foot (Interstate)=$1.72/linear foot installation+$0.28/linear foot silicone

(Note: The price differential between Primary and Interstate pavements is mostly due to mobilization and traffic control costs)

Using an average installation cost of $0.97/linear foot and a silicone material cost of $0.91/linear foot means that the estimated cost of installing silicone shoulder joints on the above 12 mile project would be $1.88/linear foot or $238,233. The cost of installing retrofit edge drains on this project at $2.34/linear foot (Primary) would be only $296,525 or $58,292 more than the silicone shoulder joint seal. This difference is insufficient to justify the use of the silicone when the edge drains provide the additional benefit of draining the base and minimizing the likelihood of pumping or faulting.

New Dow-Corning 890SL Joint Sealant

A check with Dow-Corning reveals they have reformulated the 890SL to decrease the skin-over time and tenderness of the silicone at early ages. Table I lists the comparative physical properties of 890SLin 1989 and 1993 and serves as a guide to how much of a change in properties occurred as a result of reformulation. The new sealant is still an excellent low modulus material but the slightly lower values indicate that the "new" 890SL may not have quite the capacity for movement that the original had. If this material were to be considered for PCC/AC shoulder joint sealing, a series of new test sections with different joint widths and sealant thicknesses would have to be installed and monitored over at least one winter before recommendations for use could be made. The volume of the sealant vessel would have to be significantly reduced to remove the economic constraints to its routine utilization as a shoulder joint sealant. These test sections should be located in an area of high rainfall where asphalt shoulder subsidence is a problem and repeated shoulder joint repair and resealing are common.

Table 1: Comparison of Dow-Corning 890SL, 1989 & 1993

Physical Property	Dow-Corning 890SL (1989)	Dow-Corning 890SL (1993)
Percent Solids, %	97	96
Specific Gravity	1.3-1.4	1.3-1.4
Skin-Over Time at 25°C, minutes	30	60
Cure Time at 25°C, days	14	14
Full Adhesion, days	14-21	14-21
Elongation, percent	1600	1400
Modulus @ 50% Elongation, psi	8	7
Modulus @ 100% Elongation, psi	9	8
Modulus @ 150% Elongation, psi	10	9
Adhesion to Concrete, min. % Elongation	+600	+600
Adhesion to Asphalt, min. % Elongation	+600	+600

Conclusions

1. The performance of the Dow-Corning 890SL PCC/AC silicone shoulder joint seal was excellent over the 5 year monitoring period with no adhesion failures or distress.

2. The performance of the Dow-Corning 890SL under conditions of vertical shear is unknown.

3. Efficient installation of silicone shoulder joint sealant will require modification or development of suitable equipment including a router head and a sealant tip.

4. The proposed silicone shoulder joint sealant installation on a project with edge drains was not accomplished due to lack of material and difficulties in coordinating the work.

5. The proposed laboratory testing of the Dow-Corning 890SL to dtermine the most economical shape factor was not done because of inability to obtain material.

6. The cost of installing silicone shoulder joint sealant with the design parameters of the test section is roughly estimated at $1.88/linear foot which makes it unattractive as an alternative to the existing 3405 modified softseal system or edge drains from a cost benefit standpoint.

7. Test sections using much smaller vessel sizes of the "new" Dow Corning 890SL will have to be installed and monitored for at least one winter before any recommendations for use can be developed. These sections should be sited in an area of high rainfall where AC shoulder subsidence is a common maintenance problem.

Recommendations

1. Use of a silicone PCC/AC shoulder joint sealant is not recommended for routine construction or maintenance of PCC pavements.

2. Test sections using the reformulated sealant should be installed in smaller vessels requiring much less sealant in an area of the state with high rainfall where AC shoulder subsidence problems are prevalent. These sections should be monitored for at least one winter before any further recommendations for use are made.