Joint and Crack Fillers
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Nine experimental joint sealants were installed in a one-mile long section of Interstate 94 near Sauk Centre, Minnesota. The sealants were evaluated for five years, beginning in 1988, and compared for performance against Dow Corning 888, the only silicone joint sealant currently approved for use on transverse joints by the Minnesota Department of Transportation.

The sealants tested included three silicones, one urethane, one polyurethane, one nitrile rubber, one rubberized polypropylene, one polysulfide and one hot-pour asphaltic sealant. An additional section evaluated consisted of several joints sealed with Dow Corning 888 in 1976.

Inspections were generally done in the winter and summer. The sealants were evaluated based on adhesion, cohesion and effectiveness of preventing the entry of moisture and incompressibles into the joint.

A goal of this research project was to identify products that would provide effective long-term performance, hopefully for up to ten years.

This report describes the changes in performance of the sealants during the evaluation period. Also included is a rating procedure for quantitatively evaluating joint sealants.

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The author and the State of Minnesota do not endorse products or manufacturers. Trade names of manufacturer’s names appear herein solely because they are considered essential to the objective of this report.
ACKNOWLEDGEMENTS

The author wishes to acknowledge the contributions of the initiator of this research project, Andrew Halverson; the Mn/DOT District 3 construction personnel who aided in the design and installation of the project and the various Research and Concrete personnel who assisted in the monitoring of the research project; and Glenn Engstrom, who developed the sealant rating form.
EXECUTIVE SUMMARY

Nine experimental joint sealants were installed in a one-mile long section of Interstate 94 near Sauk Centre, Minnesota. The sealants were evaluated for five years, beginning in 1988, and compared for performance against Dow Corning 888, the only silicone joint sealant currently approved for use on transverse joints by the Minnesota Department of Transportation.

The sealants tested included three silicones, one urethane, one polyurethane, one nitrile rubber, one rubberized polypropylene, one polysulfide and one hot-pour asphaltic sealant. All test sealants were placed in the driving lane. The passing lane joints, sealed with Dow Corning 888 at the same time as the experimental sealants, served as the control section. An additional section evaluated consisted of several joints in the driving lane that were sealed with Dow Corning 888 in 1976.

Inspections were generally done in the winter and summer. The sealants were evaluated based on adhesion, cohesion and effectiveness and preventing the entry of moisture and incompressibles into the joint.

Conclusions that appear justified are:

- A goal of this research project was to identify products that would provide effective long-term performance, hopefully for up to ten years. However, none of the experimental sealants were considered to have performed well enough to be recommended for approval.

- The performance of several of the products, notably Mobay Baysilone 960 Silicone Sealant and Crafco Roadsaver Low Modulus Silicone Sealant, would likely have benefited from an improved or more production-like installation procedure. However, it was not the intention of this study to rate application methods.

- None of the experimental sealants were considered to perform as well as the Dow Corning 888 in the driving lane.

- The Dow Corning 888 installed in 1976 appears to be performing better than any of the experimental sealants.
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INTRODUCTION

Background

There are approximately 1,900 miles of jointed portland cement concrete (PCC) pavement in the Minnesota Trunk Highway System. The Minnesota Department of Transportation (Mn/DOT) seals the joints the contraction joints in their PCC pavements and maintains these seals.

Various methods have been used for joint sealing. Hot-pour sealants were commonly used until about 1985. They were found to typically last about three years on transverse joints. They do work well on the non-working longitudinal centerline joint and are still used for that purpose.

Preformed neoprene joint sealers were used on transverse joints beginning in the early 1970's. They were effective at keeping out incompressibles but tended to leak water, and could also take a compression set. Use of neoprene joint sealers were generally discontinued by the mid-1980's.

Silicone sealants have been used occasionally since the mid-1970's. Performance in trial applications has been mixed. The cost has been a drawback. At this time only one silicone sealant, Dow Corning 888, is on the current Mn/DOT approved products list.

The appearance of several new joint sealants on the market encouraged Mn/DOT to initiate a research project to investigate some of the more promising materials. The purpose of this research investigation was to identify new sealants, not exclusively silicones, whose field performance would warrant being added to the approved products list. Additional approved products may also lead to lower costs.

Scope

Nine experimental joint sealants were installed in June of 1988. All experimental products were applied in transverse joints in the driving lane. Each sealant was placed in from seven to thirteen joints. Any mid-panel cracks within a test section were also filled with the test sealant. A diagram of the research project is provided in Figure 1.

At the east end of the research section were several joints which had been sealed with Dow 888 in 1976. These joints were also inspected and compared with the performance of the experimental sealants.

All joints in the passing lane were sealed with Dow 888. While
the traffic conditions are acknowledged to be different in the
passing lane versus the driving lane, the passing lane was used
as the control section.

The sealants were evaluated for five years. Examinations were
generally done in summer and winter, when the joint openings
would be at their minimum or maximum and when the sealants would
be subjected to the most extreme conditions.
Figure 1. Layout of experimental joint sealant test sections.
Project Description

The research project was incorporated into a joint rehabilitation project extending 12.5 miles east from the Douglas-Todd County line on Interstate 94 in central Minnesota. The research section is located about one mile west of Sauk Centre in the eastbound lanes.

The pavement was constructed in 1968. It is nine inches thick with 39-foot panels. In 1978 the joints were cleaned, resawed and sealed by Mn/DOT maintenance. By the time this research project had started, the pavement had been programmed for an extensive joint rehabilitation in 1996. Thus, it was hoped the experimental joint sealants would provide adequate service for at least eight years.

Most of the inplace joints on this project were 5/8" wide. These were widened to 7/8". Inplace joints of other widths were sawed 1/4" wider. The joint sawing and backer rod placement were completed by the joint rehabilitation contractor. The joint profile is shown in Figure 2.

The experimental sealants were all placed in the driving lane. The passing lane was sealed with Dow 888 silicone.
Nine experimental sealants were placed. The materials were:

- Sonneborn Sonolastic Paving Joint Sealant self-leveling two-component urethane. Additionally, a primer was applied to the concrete joint faces. This was the only sealant requiring a primer.
- Mobay Baysilone 960 Silicone Sealant.
- Crafco Roadsaver Low Modulus Silicone Sealant.
- H. B. Fuller hot pour rubberized polypropylene.
- Sika Sikaflex - 15M polyurethane.
- W. R. Meadow Extra Low Modulus Hot Pour No. 2486.
- W. J. Rusco Nitrile Rubber.
- Dow-Corning X3-5855 self-leveling silicone sealant.
- Koch 9020 two-part cold-pour polysulfide.

At the request of the Sonneborn representative their material was placed by Physical Research personnel. The other sealants were installed either by the respective manufacturers' representatives or contractors.
Figure 2. Profile of rehabilitated joint.
The joint sealants were evaluated by visual inspection. The sealants were inspected for adhesion, cohesion, presence of incompressibles and moisture in the joint, resistance to tearing and cracking and shape factor.

In March 1993, a final evaluation was done. This evaluation was done in a somewhat different fashion from the previous surveys, in that a new rating form was used that applies a more quantitative approach to sealant evaluations than was done previously. The form scores the sealant based on a variety of distress types. The maximum rating is 100, with a rating of 95 or better being recommended for approval. A sample of the rating form is shown in Figure 3. The results of the survey are given in Table 1. The criteria used for rating the sealants are described below.

Rating Criteria Definitions

Bubbles and Blisters - Exposed surface air bubbles in the sealant. Bubbles should have a diameter of at least 2 mm. The larger the bubble density the higher the severity.

Surface Hardening - The surface of the sealant has hardened more than the underlying sealant. Surface cracks should develop when the sealant is pressed with a blunt object. The harder and thicker the surface hardening the higher the severity.

Embedded Material - Any material exceeding a 4 mm diameter embedded in the sealant. The larger the density of embedded material the higher the severity.

Tracking - The sealant has been removed by traffic and has been deposited downstream of the joint. Severity will be determined by the amount of tracking visible downstream.

Sinking Into Joint - The sealant has flowed or dropped down into the joint and is not holding its shape factor. Severity will be judged on how far the sealant has slipped into the joint past the backer rod.

Migration (Flow) - This is intended to measure if the sealant has flowed laterally along the joint and eventually out onto the shoulder. The severity will be judged on an estimate of total sealant moved.

Edge Raveling - Refers to the deterioration of the edges of the pavement at the joint. It involves material within about two inches of the joint. Severity will vary with the width of the spall.
Bond Failure - The adhesion between the concrete and sealant no longer exists. The severity will be determined by the depth and width of the debonding.

Parallel Cracking - Refers to the formation of parallel cracks in the sealant due to a lack of cohesion. Severity will vary with the depth and width of the crack.

Severity Ratings

Most of the severity ratings for the distress types are subjective in nature. In an attempt to reduce some of the variance in ratings the following definitions will be used for each category.

- **Slight** - The distress is only apparent after close examination.
- **Moderate** - The distress is apparent but does not currently affect joint performance.
- **Heavy** - The distress is easily apparent and affecting joint performance.
- **Severe** - The distress is very apparent and the joint has failed.
<table>
<thead>
<tr>
<th>DISTRESS TYPE</th>
<th>SEVERITY FACTOR - A</th>
<th>EXTENT FACTOR - B</th>
<th>IMPORTANCE FACTOR - C</th>
<th>PRODUCT A<em>B</em>C</th>
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<tr>
<td>TRACKING</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>SINKING INTO JOINT</td>
<td></td>
<td></td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>MIGRATION (FLOW)</td>
<td></td>
<td></td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>EDGE RAVELING</td>
<td></td>
<td></td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>BOND FAILURE</td>
<td></td>
<td></td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>PARALLEL CRACKING</td>
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<td></td>
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SUM =

RATING = [(500 - SUM) / 500] * 100 =

**Severity Factor Key - A**

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<th>Heavy</th>
<th>Severe</th>
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**Extent Factor Key - B**

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<th>15 - 20%</th>
<th>25 - 40%</th>
<th>45 - 65%</th>
<th>70 - 100%</th>
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Figure 3. Concrete joint sealant rating form.
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<th>Bubb. and Blist.</th>
<th>Surf. Hard</th>
<th>Embed Mtl.</th>
<th>Track</th>
<th>Sink into Joint</th>
<th>Flow</th>
<th>Edge Ravel</th>
<th>Bond Fail</th>
<th>Par. Crack</th>
<th>Rating</th>
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<td>-</td>
<td>-</td>
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<tr>
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<td>-</td>
<td>-</td>
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<td>80</td>
<td>80</td>
<td>48.0</td>
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</table>

This is a two part sealant, consisting of a base and an activator. A light gray coloring agent was also added. The components were mixed using an electric drill and paint mixer while a primer was applied to the joint faces. The sealant was then hand placed by Physical Research personnel using a bucket and a funnel. It was a messy and cumbersome operation, but went fairly well, with no problems with the leveling and shape factor. Before the sealant was completely cured, some sand had blown over it and stuck to the surface. The sand did not appear to penetrate into the sealant or cause problems.

After three years, there was good bond to the concrete, even to some slight spalls located near the shoulder. The material remained pliable and soft in both hot and cold weather. It could be depressed easily by pushing on it with a finger, and would rebound quickly.

The five year evaluation showed minor amounts of bubbles and sinking into the joints. Edge raveling, parallel cracking and bond failures were noted on 15-20% of the joints. Sonneborn urethane received a rating of 92.1.

Sonneborn was considered to be the best performer of the experimental materials. After the third year it was tentatively added to the approved products list, based on adequate performance at that time. However, it did not do as well at the five year evaluation and would not now be recommended.

Mobay Baysilone 960 silicone.

This sealant was supplied in 5-gallon buckets. It was installed with a 1-quart caulking gun. The material had to be hand-packed into the gun, a slow and messy procedure. The sealant was installed somewhat unevenly, and after tooling with a backer rod some material had been pushed up onto the pavement surface. This was more common on the first several joints.

About one month after installation some of the overfilled material was starting to ravel off, but without affecting the bond of the sealant in the joint at that time. After one year some debonding of the sealant from the upstream joint face in the wheel tracks was noted. The debonding went down about 1/4-inch from the pavement surface. By the end of the three year investigation some of the debonding had progressed further down into the joint. Despite this debonding, no incompressibles were seen in the joints.

Mobay was found to be soft and pliable in both summer and winter.
examinations. With the exception of the debonding noted above, Baysilone 960 seemed to perform well. It was rated the second best experimental sealant after three years.

After five years, severe edge raveling was observed on about 15% of the joints. Severe bond failures were noted on about two-thirds of the joints. Mobay silicone was rated 84.8.

**Crafco Roadsaver Low Modulus Silicone Sealant.**

This sealant was placed with a pump and wand. The shape factor was generally acceptable, but some of the joints were overfilled. In the summer when the joint width was at a minimum the sealant had bulged up slightly higher than the pavement surface.

Crafco seems to be softer than the Mobay silicone. It also appeared to debond more than the Mobay silicone. This occurred particularly where the joints were overfilled. Debonding was noted in the wheel paths and near the shoulder. Incompressibles were seen to be getting into the joints.

The final evaluation found a slight amount of sinking into the joint. There was moderate edge raveling on about 15% of the joints. Severe bond failures were noted on about 75% of the joints. Crafco silicone rated 87.3.

**H. B. Fuller hot pour rubberized polypropylene.**

This sealant was pumped from a kettle and applied with a wand. It flowed easily and leveled nicely. There was a problem with the sealant draining out of the joint at the pavement-shoulder interface. A second application was necessary for these joints. Some bubbling was seen in the second application. This was apparently the result of sealant and air being combined at the bottom of the kettle as the supply of material ran out.

Evidence of bond failure was noted about one month after installation. At that time it was seen that the sealant was debonding about 1/4" down from the pavement surface. After two months it was debonded on both sides of the joint down to the backer rod.

The survey done the first winter showed almost total sealant failure. The material had become stiff and brittle with little bond remaining. The sealant was extensively cracked with several pieces removed from the joint by traffic.

In warmer weather the material again became soft and sticky, but the bond with the concrete remained poor. By the third year the remaining sealant could be easily removed from the joint by hand.
The five year evaluation found distresses of many types. There was a slight amount of bubbling, and moderate amounts of tracking, sinking into the joint and edge raveling. Moderates amounts of embedded material were observed in much of the sealant. There were extensive amounts of bond failure, surface hardening and cracking of the sealant. H. B. Fuller received a score of 53.7.

There was one mid-panel crack within this test section filled with H. B. Fuller rubberized polypropylene. While this material performed very poorly in joints, the sealant in the mid-panel crack appeared to be working very well. This is apparently not a working crack.

**Sika Sikaflex 15M polyurethane.**

Sikaflex was supplied in 1/10-gallon "sausages" and was installed by hand with a caulking gun. It was tooled with a length of backer rod.

The bond to the concrete was good and the sealant remained pliable in cold weather. There were some air bubbles within the sealant; these had burst and were filled with sand.

For the first two years of the study Sikaflex was rated the best of the experimental products. After the second year the sealant had developed some surface hardening with considerable cracking and tearing of the surface. The long term tensile strength of this material seems to be a problem.

After five year, a moderate amount of sinking into the joints and edge raveling were seen, as well as a significant amount of bond failure and considerable parallel cracking. Approximately 20% of the sealant is missing. Sika polyurethane was rated 69.2.

**W. R. Meadows Extra Low Modulus Hot Pour No. 2486.**

This sealant was pumped from a kettle and applied with a wand. The shape factor was satisfactory.

Some debonding was observed during the first summer. This increased considerably by the first winter. There was little bond to the concrete after this time. The material was soft but not especially sticky. The sealant could be slightly pulled back from the concrete faces to reveal sand getting into the joints.

During the first summer the material was noted to contain many blisters. When broken with a finger, these blisters were found to be full of water. The survey done the first winter found the surface was pockmarked with many broken bubbles. Subsequent
trips during warm weather found the sealant again to be taking on water.

The five year evaluation showed moderate amounts of embedded material in the sealant and of sinking into the joints. There was a slight amount of edge raveling. This sealant had the most severe bubbling and blistering. There was also almost no bond to the concrete. Meadows hot pour received a rating of 72.9.

W. J. Ruscoe nitrile rubber.

This sealant did not perform well at all. It is a solvent-based joint material, and shrank considerably while curing. By the first winter there was little bond and the material was hard and cracked.

The nitrile rubber appeared progressively worse over the three year evaluation period. After one year there was almost no bond to the concrete and incompressibles have penetrated. Some of the failed sections were resealed with Dow 888.

After two years there were several joint failures in this section, with spalls extending the width of the lane and one to two feet longitudinally into the panels. Four of these failures are at repaired joints and three at original pavement joints. The spalls were repaired with bituminous patch.

The final evaluation showed severe and total amounts of surface hardening, edge raveling, parallel cracking and bond failure. Of thirteen joints originally sealed with this material, only two remain. The other eleven have deteriorated and been patched with bituminous. This distress is confined to the driving lane; there is no similar pattern in the passing lane sealed with Dow Corning 888 silicone. Rusco nitrile rubber received a rating of 48.0.

Dow Corning X3-5855 self-leveling silicone.

The bond was generally good through the first three years. Some debonding was observed where the sealant was high and at spalls. It appears to debond more at the small spalls than do the other silicone and urethane products.

The material did not flow to the proper shape factor as well as it should have. There were some low spots and some bulging. The material has an odd appearance, with a ridge along the middle of the joint. After the first year some yielding was observed in the middle of the joints. Bubbles were noted in the last few joints.
Three of the joints have some spalling, the spalls extending two to three feet transversely along the joints, and about one foot longitudinally into the panel.

The material was soft, even in the winter. On each of the first two joints a marble-sized rock was embedded in the sealer. Several of the other joints also had embedded incompressibles. There were voids where it could be seen that rocks had been embedded and later removed.

After five years, at least 50% of the total joint length in this test section have spalled and been patched with bituminous, including three joints totally gone. There is severe bond failure and edge raveling, and some areas of the sealant have sunk into the joints. Dow Corning self leveling silicone received a score of 74.2.

Koch 9020 two-component cold pour polysulfide.

The sealant originally installed in June 1988 had to be removed. There was a problem with the pumping equipment, resulting in only one of the two components being placed. This test section was redone in August 1988.

The August application went moderately well with the material going in easily but somewhat unevenly. It self-leveled to some extent so the final appearance was fairly even. It did not set up as quickly as was anticipated. The sealant was expected to cure in about half an hour, but after two hours it was still tacky, and would leave a black smudge when touched. The surface was retaining some sand and other blowing debris.

The first winter inspection showed the sealant to be soft and intact. Some debonding was noted. It appeared to be doing a good job of keeping incompressibles out, but not water.

After one year the material was very soft and sticky. It was bleeding (the surface was cracked and a wet black substance was coming out) and did not appear to have completely cured. It was pulling away to about 1/4 inch below the pavement surface, allowing some dirt to get in, but below this the bond was good. There was one crack noted at the concrete-sealer interface.

After three years the polysulfide was still soft. Some sand was sticking to the sealant. There was considerable debonding. The bleeding observed in the past was not noted this time.

The five year evaluation showed several types of distress. There were considerable quantities of edge raveling and bond failure, and lesser but still severe amounts of embedded material and sinking into the joints. Small amounts of surface hardening and
blistering were observed. Two joints have totally deteriorated and been patched, while several others are partially gone. Only one joint in this section did not show this type of distress. Koch polysulfide was rated 61.9.

"Old" Dow Corning 888 silicone.

While not officially a part of the research project, these joints were also inspected to measure the performance of the experimental sealants.

This joint sealant was applied in 1976. Some debonding has occurred at the upstream side of some joints, but is limited to approximately the top 1/4" of the sealant. In general the bond looks good. The material has become fairly hard and is slightly bulged. It appears to be performing as well as any of the experimental products.

The March 1993 evaluation used the rating form to verify the "old" Dow 888's performance with respect to the experimental products. A slight amount of embedded material was found, along with some minor bond failure and a moderate degree of edge raveling. This sealant was rated at 94.6.

Dow Corning 888 silicone. (control section)

This material was used to seal the joints in the passing lane in the research section. It was also used to repair joints in the experimental sections if test sealants had been removed and the concrete remained sound.

There were no problems observed with Dow Corning 888 through the first three years of the evaluation period. Bond and shape factor remain good. At locations where joints with experimental sealants failed, the adjacent joints in the passing lane sealed with Dow Corning 888 remain in good condition.

The five year evaluation noted a slight amount of bond failure and some slight edge raveling. No other distress was observed. Dow Corning 888 (placed 1988) was rated at 97.8.

RECOMMENDATIONS

Further Research

Further research is recommended to identify additional sealants which may provide ten years of acceptable service. To this end, a new joint sealant research project was constructed in 1991 on I-94 near St. Joseph, Minnesota. Sixteen products are included
in this new study.

It is felt that some products in the Sauk Centre project suffered from an inadequate installation procedure, particularly Crafco and Mobay silicones. It is recommended that sealants in future experiments be installed in a production-like manner, so that it is the sealant which is being evaluated and not the applicator.

New product evaluation is an ongoing process. It is expected that this type of research project will be repeated every few years, as new sealants come to Mn/DOT's attention.