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JOINT SEALANT EVALUATION IN COLORADO

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Activity Summary:

To review and evaluate the performance of various in-service sealant materials used by the Colorado Department of Highways a survey questionnaire was designed and sent to the District Materials Engineers and Maintenance Superintendents in all the districts. In addition, a field evaluation was conducted to visually inspect the condition of various in-service sealant materials in District I, IV, and VI. A number of research studies performed by various states and by research organizations were also reviewed. The following is the summary of all the findings:

- Among all the existing in-service sealant materials inspected in District I, IV, and IV, the silicone sealants exhibited the best performance. The members of the task force investigating the sealant materials recommended the use of silicone over the other sealants.
- The hot poured sealant (ASTM D-3405, and ASTM D-3406) showed poor performance mainly in the form of adhesion and cohesion failures. Intrusion of incompressibles was also evident in many locations.
- The plastic parting strip showed fair performance with low levels of spalling failures.
- Cleanliness of the joint should be closely monitored to ensure compliance with the specifications.
- Utah DOT conducted a study on the joint geometry. Their findings concluded that sections overfilled with the hot poured sealant exhibited significantly higher levels of performance than those sections filled flush or below the pavement surface.
- The performance of compression seals needs to be evaluated. Their use is recommended by FHWA and other agencies.

Keywords: Joint sealant, hot poured, silicone

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Joint Sealant Evaluation In Colorado
Quick-Study
April 1991

I- Background

The primary purpose of installing joint in a rigid pavement is to relieve the thermal stresses caused by the fluctuation of pavement temperature, and to accommodate plastic shrinkage. As concrete cures it shrinks and moves against the subsurface layer (base or subbase), and cracks will occur. The only way to prevent the cracks from happening is to pre-install transverse and longitudinal joints.

In order for the joints to perform as expected, they need to be sealed properly. The inadequately sealed joints in conjunction with unsuitable sealant material allow the Infiltrations of incompressible materials into the joints. The incompressible materials prevent the joint from working and in turn causes stresses to develop, and eventually lead to spalling, premature cracking, and blow-ups. In addition, water entering a joint can lead to pumping and faulting.

Very little is known about the effectiveness of various concrete joint sealant materials used by the Colorado Department of highways. All six engineering districts are using varieties of concrete joint sealants, and to date no study has been performed to determine their cost-effectiveness. Every year thousands of dollars are spent to repair the damages incurred by unsuitable joint sealant materials, and by improper installation procedures (primarily joint cleanliness, and joint geometry). It is apparent that any attempt to reduce the high costs of repairs will be a step in a the right direction.

In an attempt to resolve this problem, Staff Design requested the Research Branch to investigate the effectiveness of various concrete joint sealant materials currently used by the department.

II- Objective

The primary objectives of this study were:

1- To review and evaluate the effectiveness of existing joint sealant materials currently used by the department and other agencies.

2- To identify the most effective sealant, make recommendations for joint sealant selection, and installation.

III- Literature review

A number of research studies involving the evaluation of joint sealant materials, joint design, and installation procedures have been conducted by various states and by research organizations. The studies are widely varied in scope and methodology, but as will be discussed herein, the results are somewhat similar.

The Utah Department of Transportation initiated a study called "Evaluation Of Concrete Joint Sealants, Clear Creek Summit To Belknap Interchange" during the summer of 1984. Seven sealants, including, three silicone, three hot-pour (ASTM D-3405), and one PVC-coaltar (ASTM D-3406), were examined. All the materials were installed in 3/8" wide joints, and slab lengths varied from 12 to 18 feet. After two years, the silicone exhibited good performance with respect to adhesion and cohesion failures. Intrusion of incompressible was observed to be minimal. The occurrence of concrete failures near the joints was significant; However, it is uncertain at this time if the silicone material has directly caused the concrete failures (Ref. 1).

All three of the low modulus ASTM D-3405 materials performed poorly and failed in adhesion cohesion, and intrusion. Sections overfilled with the hot-pour materials exhibited significantly higher levels of performance than those sections filled flush with or below the pavement surface (Ref. 1).

The performance of ASTM D-3406 material was fair; However, intrusion of the incompressible seemed to be at the moderate to extensive levels (Ref. 1).

The Louisiana Department of Transportation conducted a research study entitled "Evaluation of Joint Sealant Materials". The following is a summary of some of their findings:

- The Neoprene compression seals are the best sealant materials for sealing contraction joints in pavement and expansion joints in bridge decks (Ref. 2).

- The asphalt-based joint sealants are ineffective in sealing a joint exhibiting movement, and these materials should not be used for this purpose (Ref. 2).

- Periodic cleaning and resealing of transverse contraction and expansion joints is both necessary and cost-effective (Ref. 2).

The following is a summary of a research performed by the Southwest Research Institute:

- Asphalt alone is a less than desirable pavement sealant material (Ref. 3).

- Silicone has worked very well in Florida, and also in Georgia where it has had outstanding success (Ref. 3).

- Rubberized asphalt in one form or another can be used successfully with longitudinal joints between PCC pavement and asphalt shoulders. However, the success of its use otherwise depended on how much and what kind of rubber was mixed into the asphalt. In an attempt to keep the cost down, many manufacturers were using too little rubber (Ref. 3).

Among the other research publications reviewed were, "Performance of Silicone Joint Sealers" and "Preformed Compression Seals for PCC Pavement Joints". The following is a summary of these two research studies:

- Silicone sealant can be applied without prior heating or cooling of the material. It is readily pumped using an air compressor and an air-powered dispenser. Silicone cures very slowly at or below 40° Fahrenheit. Curing rate decreases as the humidity and temperature decreases (Ref. 4).

- A shape factor (depth to width, D/W of 1:2 is recommended for silicone sealant. Generally, the lower this ratio, the lower the stresses in the sealant. However, cohesion failures resulted when the D/W ratio was less than 1:4 (Ref. 4)

- A recess in the range of 1/4 to 3/8 of an inch is generally recommended. the overall conclusion is that silicone sealant material has excellent resistance to extrusion (Ref. 4).

- Silicone will not bond to wet, damp, or green concrete It is essential that the contractor thoroughly clean the joint face for good adhesion (Ref. 4).

- Preformed compression seals should be designed so that the sealant will be in compression at all times. Generally, compression seals function best when compressed between 20 percent and 50 percent of their nominal width (Ref. 5).

- The joint faces must be vertical for the compression seals so that the seal does not work itself up and out of the joint (Ref. 5).

- It is not uncommon to find compression seals more than 10 years old still performing as well as newly installed seals (Ref. 5).

IV- Joint Sealant Evaluation in Colorado

A. Joint Sealant Survey

In an attempt to evaluate the performance of various in-service sealant materials used by the Colorado Department of Highways a questionnaire was designed and sent to the district materials engineers and maintenance superintendents in all the districts. (Appendix A). A total of 12 out of 15 questionnaires were returned. From the 12 returns, the following results were obtained.

Table 1
Results of Questionnaires

1. The magnitude of the sealant deterioration is low to moderate for all the districts except for district 6, which was indicated to be high by the Maintenance Superintendent.

2. Among all the districts, The sealant materials used the most are the varieties of hot poured.

3. The following is the summary of the nature of the problems reported by the respondents:

- cohesion 25 %
- adhesion 30 %
- intrusion 15 %
- extrusion 30 %

4. The only method used to control the quantity and the quality of the sealant material is by visual observation, reported by most respondents (the sealant material is pre-approved).

5. JOINT CLEANLINESS is the key to performance. Moisture and temperature are also important.

6. Among the sealants with poor performance are the hot poured materials (primarily ASTM D-3405 and ASTM D-3406).

B. Field Investigation

A field evaluation was conducted to visually inspect the condition of various in-service sealant material in district I, IV, and VI. Personnel performing the inspection were: Jerry Petersen, District I Lab; Sid Motchan, District VI Lab; Joe Intermill

District IV Lab; and Ahmad Ardani of the Research Branch. The following established criteria was used to inspect each site:

a. cohesion
b. adhesion
c. intrusion, and
d. extrusion

The silicone section on I-25 north of S.H. 34 was inspected first. The silicone at this location was installed in the 1984 construction season. However it appeared that the joints were recently sealed (Photograph 1). Some intrusion was noted, but it was not severe enough to have adversely effected The performance of the sealant. It is possible that the intrusion had happened before the silicone had fully cured. A portion of the silicone was cut and stretched about 50 percent to check for elasticity. It appeared that the silicone had uniformly cured and rebounded fairly quick (Photograph 2). At a few locations the concrete near the joint face found to have raveled (Photograph 3 and 4); ,however it remained bonded to the sealant. According to to a FHWA publication (Ref. 1) this type of failure is mainly due to the microcracks created during the joint sawing operation in cold weather. The panel member were pleased with the performance of the silicone at this location.

I-25 between mile post 252-255 was investigated next. The ASTM D-3406 used at this location was placed during the 1985 construction season. The principal failure mode observed at this location was adhesion failure at the sealant-joint interface (Photograph 5) with moderate extrusion failure (Photograph 6). Some cohesion was also detected. The intrusion of the incompressibles were minimal. The plastic parting strip used for the longitudinal joint at this location showed some minor spalling; however, for most part the performance was satisfactory (photograph 7).

ASTM D-3405 was used on I-70 between Tower Road and Colfax. In general the condition of this 2-year old sealant looked good. However, problems such as adhesion, cohesion, and the intrusion of the incompressibles were quite apparent in few isolated locations (Photograph 8 and 9).

Some minor adhesion failures were noted for the 4-year old silicone on C-470, between I-25 and Quebec Avenue. The failure was noted only in the right-wheel-path and the left-wheel-path in the driving lane (Photograph 10). The consensus are that the silicone was not either cured fully or it was installed at improper temperature. The curing rate of the silicone is dependent upon temperature and humidity: curing rate decreases as the humidity and temperature decrease. silicone cures very slowly at or below 40° Fahrenheit (Ref.1). The plastic parting strip that was used for the longitudinal joints showed good performance with very little spalling (photograph 11).

V- Recommendations And Conclusions

- Among all the existing in-service sealant materials inspected in District I, IV, and IV the silicone sealants exhibited the best performance. Occasional spall-related failure was noted near the joint. However, based on the literature reviewed and based on the consensus of the experts, these types of failures are primarily due to the microcracks created during the sawing operation in cold weather. Malfunctioning of the sawing machine may be another reason for such occurrences.

- The hot poured sealant (ASTM D-3405, and ASTM D-3406) showed poor performance mainly in the form of adhesion and cohesion failures. Intrusion of incompressibles were also evident in many locations.

- The plastic parting strip showed fair performance with low levels of spalling failures. Their use are recommended for longitudinal joints.

- Cleanliness of the joint should be closely monitored to ensure compliance with the specifications. According to a questionnaire survey conducted for this study cleanliness is the key to performance with close attention being paid to temperature and moisture. Cleanliness can be achieved by sandblasting of the joint face, followed by an airblasting.

- Preformed compression seals have been recognized by the FHWA (Ref. 2) and other agencies for their longevity and effectiveness, their use are recommended.

- Utah DOT conducted a study on the joint geometry. Their findings concluded that sections overfilled with the hot poured sealant exhibited significantly higher levels of performance than those sections filled flush or below the pavement surface. There appeared to be a difference of opinions regarding this issue among all the states.

VI- References

1. FHWA, "Silicone Sealant Performance Review", Pavement Division and Demonstration Projects Division, 1990.

2. Louisiana Department of Transportation, "Evaluation of Joint Sealant Materials".

3. FHWA, "Preformed Compression Seals For PCC Pavement Joints, Technical Paper 89-04,

4. Utah Department of Transportation, "Evaluation of Concrete Joint Sealants - Clear Creek Summit to Belknap Interchange.

5. Southwest Research Institute, "Using Chemically Modified Sulfur as A Joint Sealant, 1981.

Appendix A

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QUESTIONNAIRE

Joint Sealant Study

Name of Respondent --

District No. ------Title----------------------Phone------------

1- What is the magnitude of sealant deterioration in your district?

__ low

__ moderate

__ high

2- Of the following sealants which have you used the most?

__ plastic strip

__ silicone

__ varieties of hot poured

__ compression sealants

3- Of the following listed problems associated with the sealant materials which ones are experienced in your district? Check as many problems as applicable.

__ cohesion

__ adhesion

__ intrusion

__ extrusion

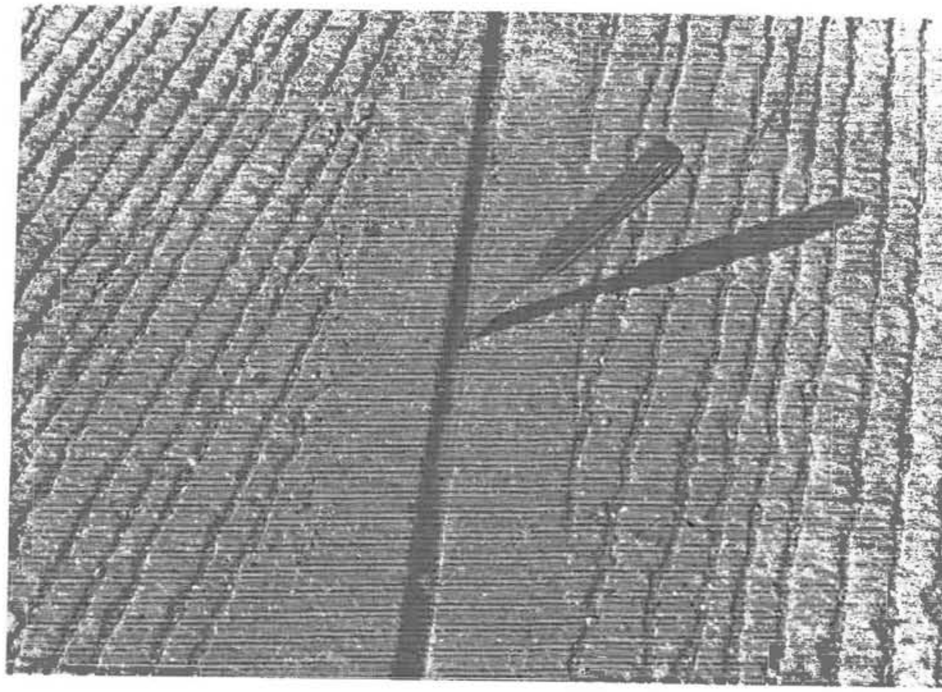
4- What methods of inspection do you use to control the quality and the quantity of the sealant material. Please explain?

5- On many occasions the design and the improper installation procedures (such as joint cleanliness, joint geometry, tining at the joint,) have been suspected in poor performance of the joint sealant material. What has been the experience of your district with respect to these factors?

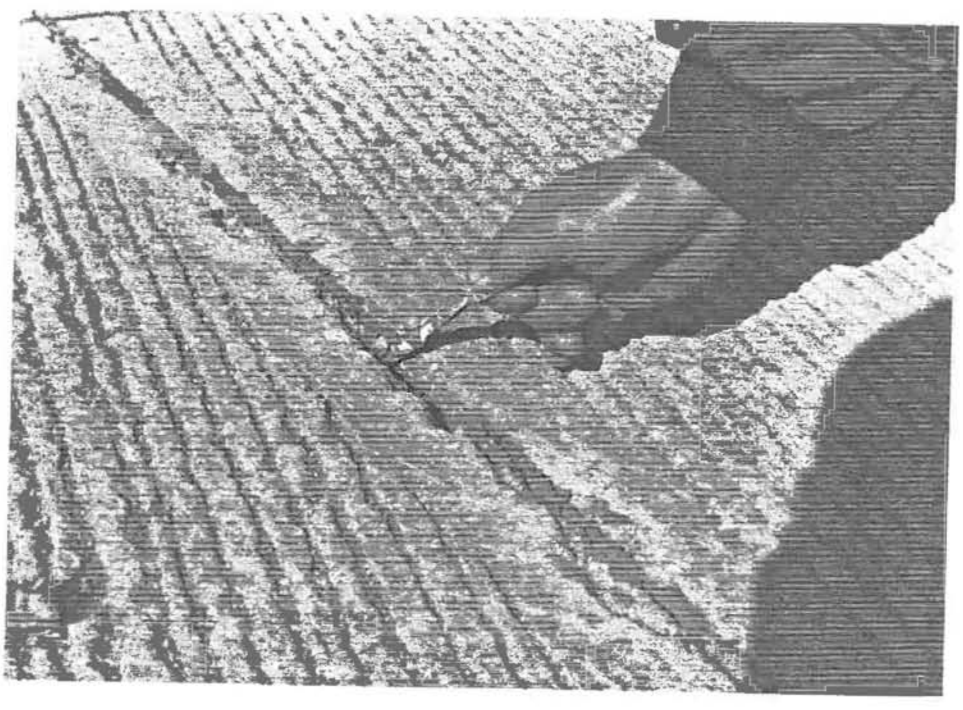
6- Which sealants have you had bad experiences with? What type of failures were they?

7- Please provide us with any suggestions or comments that you may have regarding joint construction, joint sealant materials, and joint sealant installation.

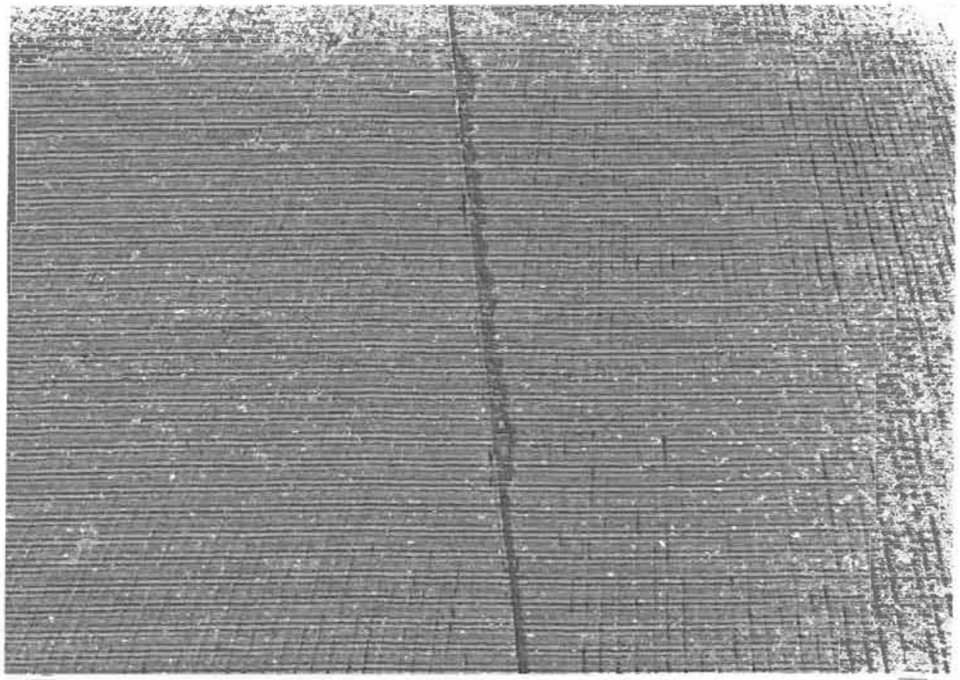
Appendix B

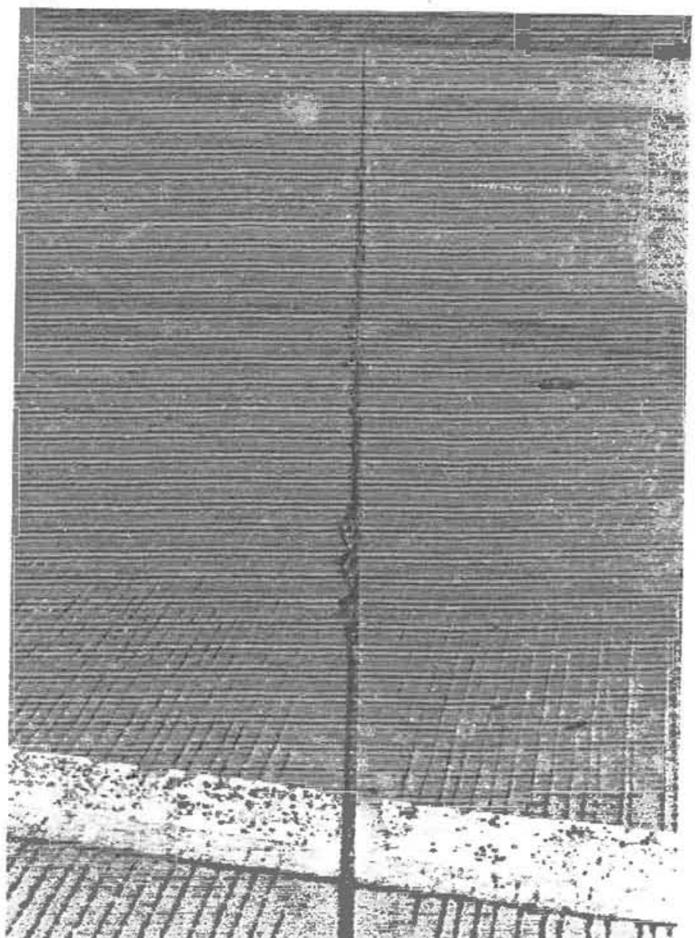


Photograph 1: 7-year old silicone on I-25 north of S.H. 34

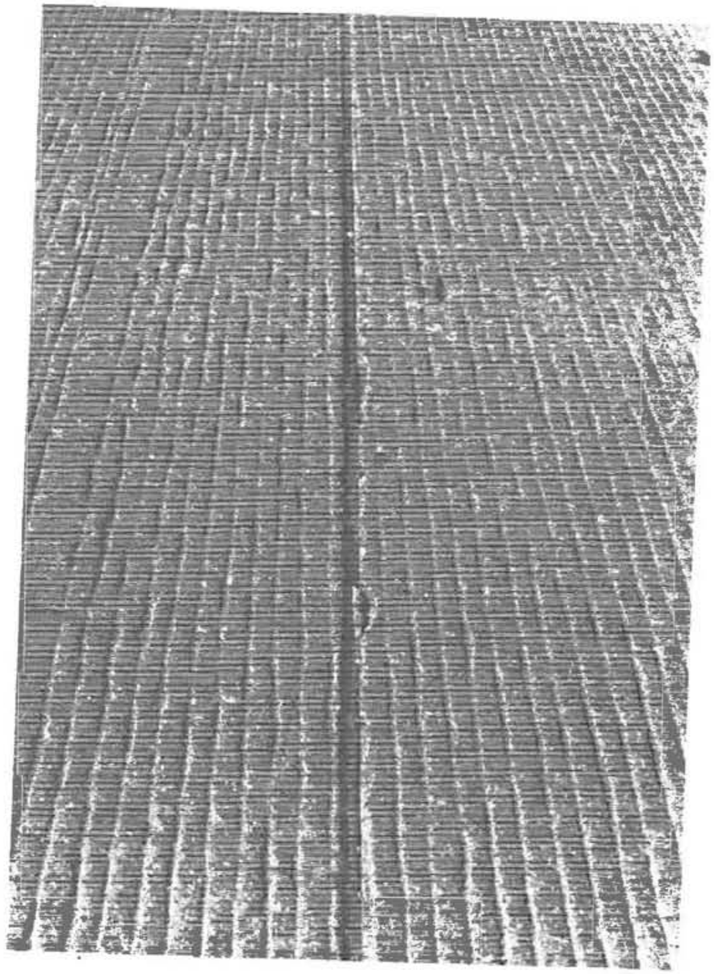


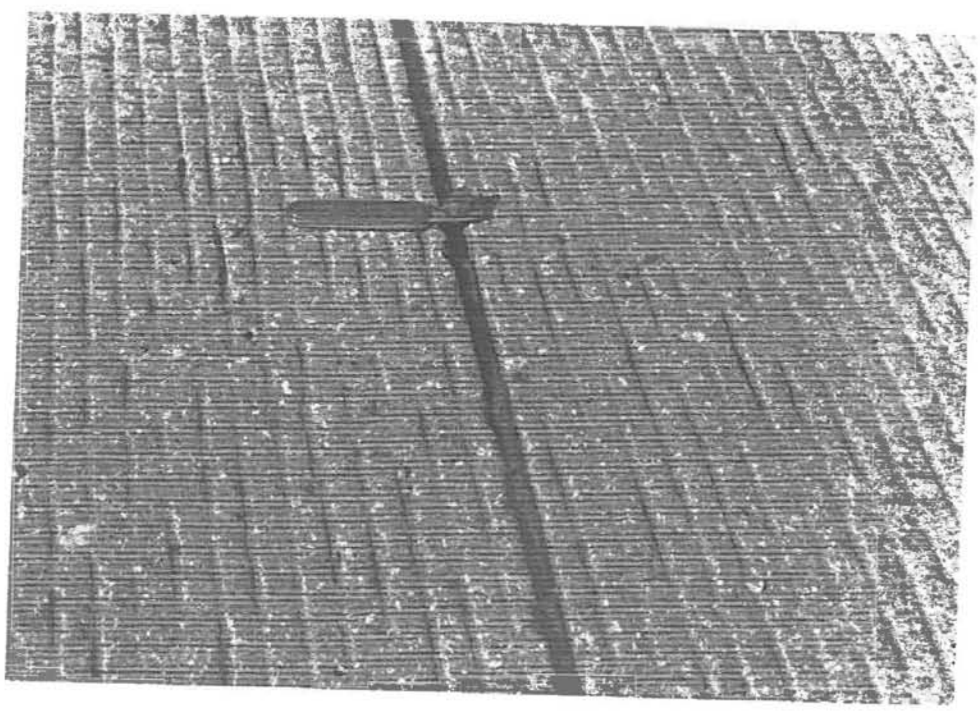
Photograph 2: Checking the elasticity of silicone



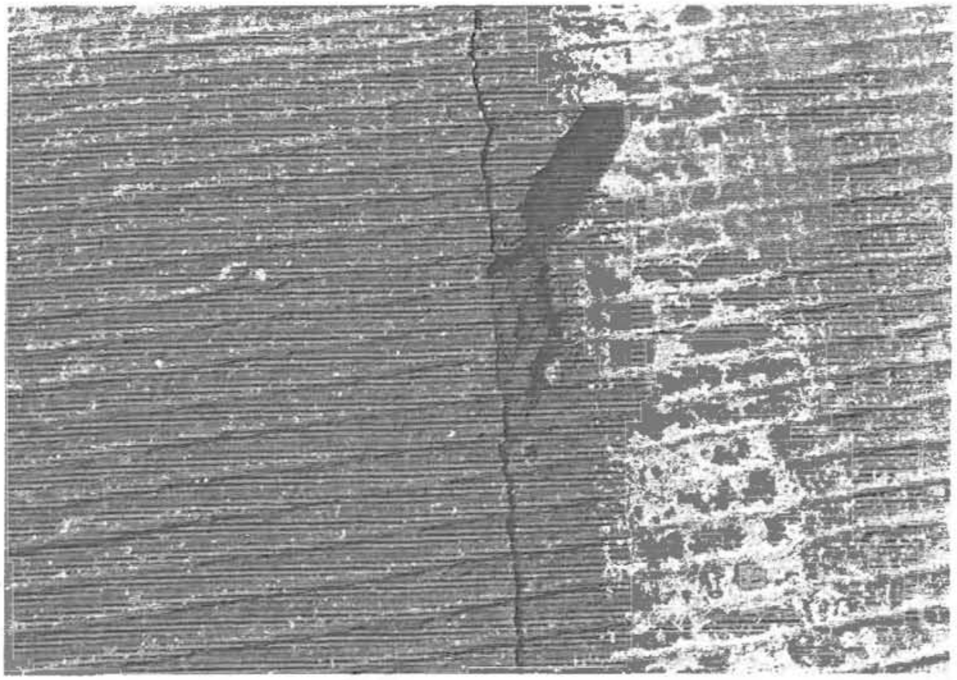


Photograph 3 & 4: Raveled concrete near the joints

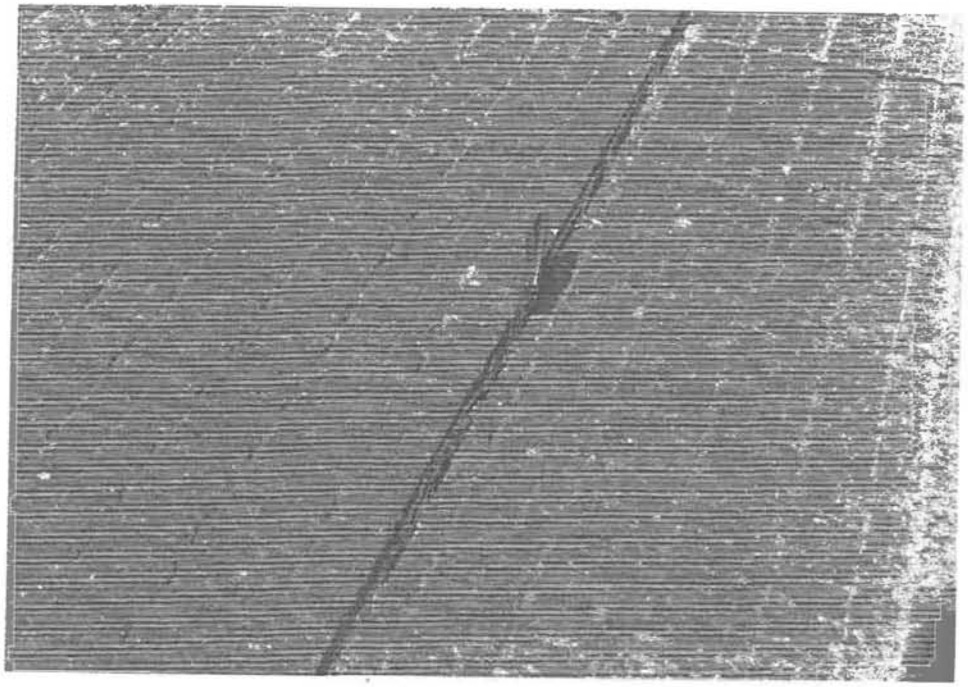


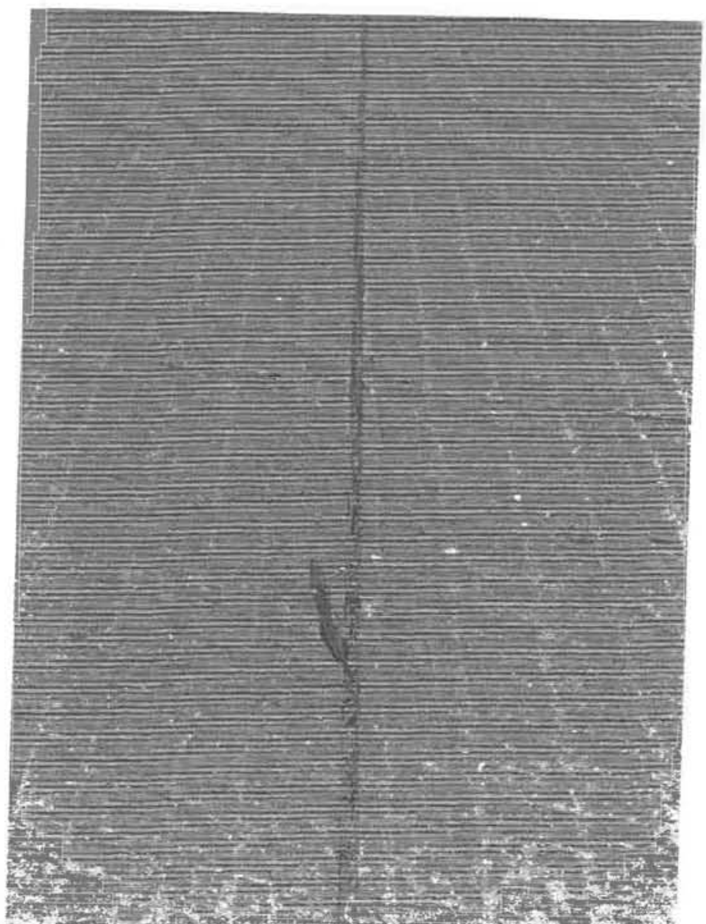


Photograph 5 & 6: Adhesion and extrusion failures on I-25

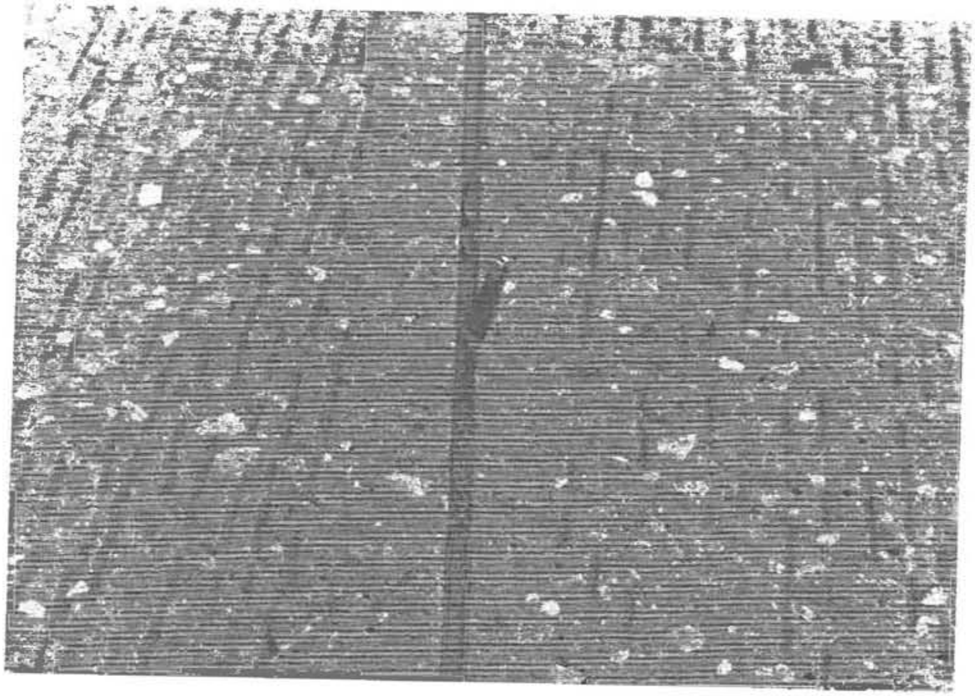


Photograph 7: Plastic parting strip on I-25

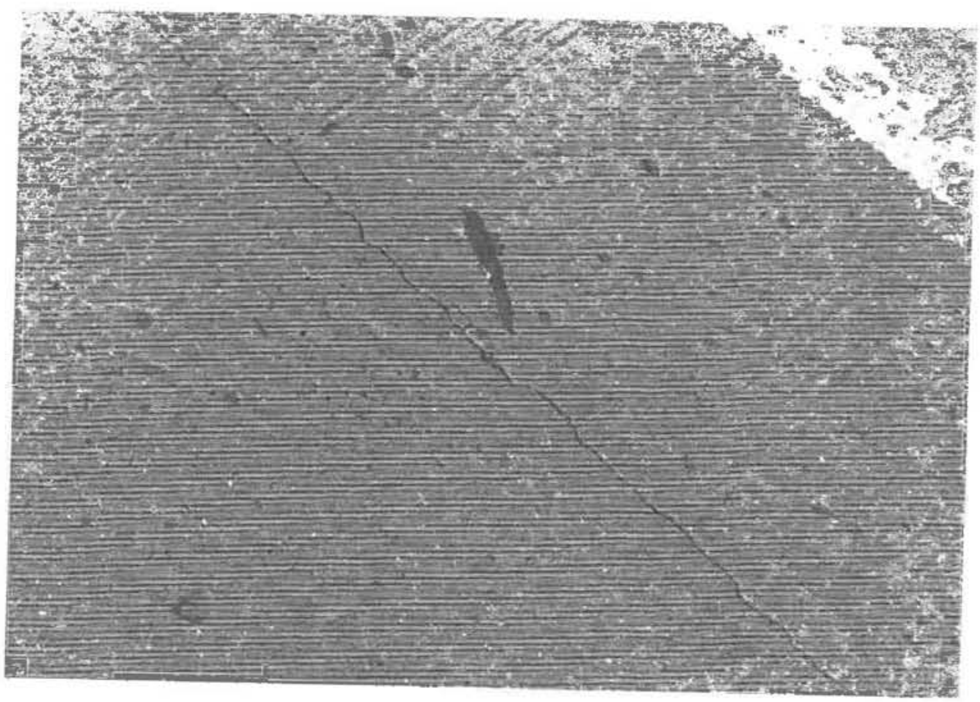




Photograph 8 & 9: Badly failed sealant on I-70 east of Denver



Photograph 10: Silicone at C-470 (presence of incompressibles in the right-wheel-path)



Photograph 11: Plastic parting strip on C-470